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Functional properties and Anti-nutritional factors of five wild seeds (*Borassus aethiopum*, *Bombacopsis glabra*, *Entada africana*, *Entada gigas* and *Myrianthus arboreus*)

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ABSTRACT

Functional properties and anti-nutritional factors of five wild seeds (*Borassus aethiopum*, *Bombacopsis glabra*, *Entada africana*, *Entada gigas* and *Myrianthus arboreus*) were carried out using standard methods. Functional properties of` the flour showed that the least gelation concentration for *B. aethiopum*, *B. glabra*, *E. africana* and *M. arboreus* were 10%, 6% 6% and 18% respectively. *E. gigas* flour however did not gel at 20%. *B. aethiopum* had the least foaming capacity 1.85% while *B. glabra* had the highest 27.27 %. Water absorption capacity ranged between 3.00% in *M. arboreus* and 30.0% in *E. africana*. Oil absorption capacity was between 13.00 % in *M. arboreus* and 22.00% in *E. africana*. Protein solubility increased with increase in pH in acidic medium and reached the peak at pH 7 (*E africana* exempted) before solubility began to decrease with further increase in pH at alkaline medium. Antinutrient content showed that saponin ranged between 0.29% in *E.africana* and 0.42% in *B. glabra*. Phytate was between 0.14mg/g in *E. africana* and 6.56mg/g in *E. gigas*. *E. gigas* had tannin content of 0.45mg/g, while *M. arboreus* had 4.87mg/g,*B. aethiopum* had the lowest oxalate 2.25mg/g while *M. arboreus* had the highest of 7.19mg/g.

Introduction

Functional properties denote those physico-chemical properties of food protein that determine their behaviour in food during processing, storage, preparation and consumption (Kinsella *et al.*, 1976). These include protein solubility, water and oil absorption capacity gelation or coagulation, foaming, viscosity, texture, adhesion or cohesion and film gelation. These properties and the way in which protein relates with other food constituents directly and indirectly affect the processing method, food quality and ultimate acceptance. The good knowledge of the functional properties of food makes it to be widely used in various food formulations and baked products.

Antinutrients are natural or synthetic compounds that interfere with the absorption of nutrients (*Oxford*, 2006).These compounds chelate metals such as iron and zinc and reduce the absorption of these nutrients, but they also inhibit digestive enzymes and may also precipitate proteins. However, polyphenols such as tannins have anticancer properties, so drinks such as green tea that contain large amounts of these compounds might be good for the health of some people despite their antinutrient properties (Chung *et al.*, 1998).

Antinutrients are found at some level in almost all foods for a variety of reasons. However, their levels are reduced in modern crops, probably as an outcome of the process of domestication. (Welch and Graham, 2004) Many traditional methods of food preparation such as fermentation, cooking, and malting increase the nutritive quality of plant foods through reducing certain antinutrients such as phytic acid, polyphenols, and oxalic acid. (Hotz and Gibson, 2007), (Oboh and Oladunmoye, 2007).

In this work, the seed flour of five wild plants seeds *B. aethiopum*, *B. glabra*, *E. africana*,*E. gigas* and *M. arboreus* have been investigated for their functional properties in order to evaluate their potentials in the food industries.

Materials and Methods

Sample Collection

Mature fruit samples of *B. aethiopum*, *B. glabra*, *E. africana*, *E. gigas and M. arboreus* were collected from forests between Iworoko-Ekiti-Ifaki-Ekiti and Ifaki Ekiti-Orin-Ekiti in Ekiti North Senatorial District in Ekiti State between July 2009 and January 2010.The samples were identified at the Department of Plant Science Ekiti State University, Ado-Ekiti.

Samples Preparations

Seeds from the fruits were oven dried at $60^{O}C$. The dried seeds were milled in an Excella Mixer Grinder to pass a 0.8-mm mesh sieve and stored in cleaned dried double cork plastics until use.

Preparation of fat free sample

20g of the sample were defatted with 500ml of petroleum ether using a soxhlet apparatus.

Determination of Functional Properties

Gelation properties was determined by the method of (Coffmann and Garcia, 1977),

Foaming capacity was determined by the method of (Coffmann and Garcia, 1977).

The water absorption capacity of the sample flour was determined by the method of (Sathe *et a.l*, 1982)

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Table 1. Functional Properties (%).

Sample	LG (%)	FC (%)	WAC (%)	OAC (%)	PS pH 3	PS pH 5	PS pH 7	PS pH 9	PS pH 11
B. aethiopum	10.00^{d} ±0.01	1.85^{d} ±0.19	21.00^{c} ±1.00	22.00^{a} ±1.00	1.57^{e} ±0.03	2.52^{e} ±0.01	8.52^{b}. ±0.29	1.09^{e} ±0.03	3.57^{d}. ±0.08
B. glabra	6.00^{d} ±0.01	$27.27.^{a}$ ±1.82	12.00^{d} ±1.00	15.00^{c} ±1.00	6.06 ±0.00	7.16^{b} ±0.15	$10.21.^{a}$ ±0.21	6.18^{b} ±0.26	7.27^{b} ±0.03
E. Africana	6.00^{d} ±0.01	1.89^{d} ±0.19	30.00^{a} ±1.00	19.00 ±1.00	8.61^{a} ±0.10	13.14^{a} ±0.15	6.32^{d} ±0.01	11.00^{a} ±0.0	13.41^{a} ±0.40
B. gigas	ND	16.36^{c} ±1.82	27.00^{b}±1.00	14.00^{d} ±1.00	1.76 ±0.02	4.28^{d} ±0.24	6.74^{c} ±0.04	4.24^{d} ±0.05	4.04^{c} ±0.05
M. arboreus	18.00^{d} ±0.01	20.2^{b}±2.02	30.00^{a} ±1.00	13.00^{e} ±1.00	6.24^{b}±0.05	6.49^{c} ±0.03	8.30^{b} ±0.10	5.97^{a} ±0.08	3.60^{d}. ±0.06

Results are mean of triplicate determinations.

Means in each column follow by the same letter(s) are not significantly different by Duncan's Multiple Range Tests it brief of probability.

NOTE: LG: Least Gelation Concentration FC: Foaming Capacity WAC: Water Absorption Capacity
OAC: Oil Absorption Capacity PS: Protein Solubility

The oil absorption capacity of each sample flour was determined by the method of (Sathe *et al*., 1982).The protein solubility with pH was determined using the method of (Sathe and Salunkhe, 1981) but with slight modification.

Determination of Antinutrients

Alkaloids determination was carried out as described by (Harborne, 1973);(Obadoni and Ochuko, 2001).Tannin determination was carried out on each extract using standard procedure described by (Obadoni and Ochuko, 2001) Saponin determination was carried out on each extract using standard procedure described by (Harbone, 1998); Obadoni and Ochuko, 2001). The entire tests were performed in triplicate. The presence of phytate was determined according to the method of (Wheeler and Ferrel , 1971)

Oxalate content was Determined according to the standard method described by (Day and Underwood, 1986).

Foaming capacity was determined by the method of (Coffmann and Garcia, 1977).

The water absorption capacity of the sample flour was determined by the method of (Sathe *et a.l*.,1982).The oil absorption capacity of each sample flour was determined by the method of (Sathe *et al*., 1982).The protein solubility with pH was determined using the method of (Sathe and Salunkhe,1981) but with slight modification.

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Oxalate content was Determined according to the standard method described by (Day and Underwood, 1986).

Result and Discussion

Functional Properties of the Seeds Flour

The results of functional properties of the seeds flour are presented in Table 1.

Least gelation

Least gelation concentrations for the seeds flour presented in Table 1 were found to be 10%, 6%, 6%,and 18% respectively for *B. aethiopum, B. glabra, E. africana* and *M. arboreus* respectively. *E. gigas* did not gel at 20%. Least gelation concentration of *B. aethiopum* was in agreement with that of *Phaselous vulgaris* 10% (w/v) (Sathe and Salunke, 1981) and Mung bean protein isolate 10% (Lottman & Garra, 1977). Least gelation concentration for B. glabra and E. africana are lower to that of *Pigeon pea* flour 12% (w/v) (Oshodi and Ekperigin,1989) but higher than that of *Leucaena leucocephala* seed flour 2% (Amoo et al, 2006) . The least gelation concentration for *M. arboreus* was higher than that of Lupin seed protein 14% (w/v) (Sathe et al., 1982) but it was in perfect agreement with that of black grain flour 18% (w/v) (Sathe et al., 1982).

The ability of protein to form gels and provide a matrix for holding water, flavours, sugars and food ingredients is useful in food applications and in low product development. The low gelation concentration 6% for *B. glabra* and *E. africana* will render them useful in the production of cord or as an additive to other materials for gel formation in food products.

It was observed that *B aethiopum* flour had high binding ability despite the fact that its protein content 10.46% was low compared to *E africana* protein content 51.28%. (Solsulski *et al*., 1976) made similar observations between Great Northern bean (less protein) and Lupin seed flour with higher protein. The variation was attributed to the relative ratios of different constituents' proteins, carbohydrates and Lipids in the seed flours. Least gelation concentration obtained was significantly different from one another.

Water Absorption Capacity

The water absorption capacity ranged between 12.00-30.00%. These values are lower compared to the value obtained for Soy flour protein concentrate (130%) (*Lin et al*., 1974), *T. durum* flour (141%) (Adeyeye & Ayejuyo, 2005) and fluted pumpkin concentrates (85%) (Oshodi & Fagbemi, 1992), (Whitney and Rolfes, 2005) showed that water absorption property enables bakers to add more water to dough to improve its handling characteristics and maintain freshness in bread. (Oshodi et al., 1997) observed that water absorption capacity is considered a critical function of protein in viscous foods, like soups, gravies, dough, baked products etc. hence none of the flour sample in this work may be useful in the production of soups, gravies, dough, baked products. The highest Water Absorption Capacity was 30% in *E. africana* and *M. arboreus*. These were significantly higher than *E. gigas* 27%.This 27%was higher than 21% in *B. aethiopum* which is also significantly higher than 12% in *B. glabra.*

Oil Absorption Capacity

The oil absorption capacity as shown in Table 1 was between 13.00% - 22.00% the result was lower than that of soy flour (84.2%) (Lin *et al*., 1974) *Pigeon pea* (89.7%) (Oshodi and Ekperigin, 1989), gourd seed flour (96%) (Olaofe *et al*., 2008) the oil absorption capacity is an important functional property, since oil acts as a flavour retainer and improves the mouth feel of foods (Kinsella *et al*., 1976). The value obtained for *B. aethiopum* 22% was the highest and was significantly higher than 19% obtained for *E.* africana, 15% for B. glabra and this was significantly, 14% for *E. gigas* and 13% for *M. arboreus.*

Foaming Capacity

The results of foaming capacity for the seeds flours were between 1.85% and 27.27%. *B. aethiopum* 1.85% and *E. africana* 1.89 were far lower than the values reported for *Daniella. olivieri* 6.9% and *Adasonia digitata* 12.4% and that of plasma protein concentrate 31.5% (Oshodi and Ojokan, 1996). The values for *E gigas* 16.36% and *M. arboreus* 20.26% are closer to that of Benniseed flours 18.00% (Adeyeye and Ayejuyo, 2005). Foaming capacity for *B. glabra* 27.27% is closer to that of Bovine (Kinsella, 1976). The foaming capacity of *B. glabra* 27.27%will enhance the seed flour ability in its uses for the production of cakes (Johnson et al., 1979; Lin et al., 1974) and whipping topping where foaming is an important property (Kinsella, 1976).

Protein Solubility

Table 1shows the protein solubility of the seeds floor. With the exception of E. africana, the other seeds have highest protein solubility at pH 7. For all the studied samples, the highest protein solubility was observed in E africana 13.41% at pH11 while the least was observed in B. aethiopum 1.57% at pH 3.It was observed from the table that protein solubility increases with increase in pH at acidic medium. This observation agreed with that of boyine plasma protein concentrate, Pigeon pea and Benniseed flour(Oshodi and Ojokan,1992) and (Oshodi and Asa,1993) respectively. The solubility of protein depends on hydration and the degree of hydrophobility of the protein molecules (Sathe and Salunkhe, 1981).

In the alkaline medium likewise, protein solubility increases with increase in pH. (E. gigas exempted), this agreed with (Pearson, 1976) which emphasized that the electrostatic interaction (ionization of interior non –polar groups) are more important in hydration of proteins than the surface charge. This may contribute to the improved solubility obtained in the alkaline region.

This agreed with (Von Hippel and Scheleich, 1969) that neutral salt are known to exert striking effect on the solubility of protein, polypeptides and nucleic acids. Protein solubility at pH 3 (PS3) were significantly different from one another, the highest was 8.61% in E. africana while the least was 1.57% in B. aethiopum. At pH 5, the highest was 13.14% which was significantly different from Protein order while the least PS5 was 2.52% in B. aethiopum. For pH 7, the highest was 10.21% in B. glabra, this was significantly different from 8.30% in M. arboreus and 8.52% in B. aethiopum which were not significantly different from them but were significantly different compared to 6.74% in E. gigas, and this was also significantly different from the least 6.32% in E. africana which was the least. Protein Solubility at pH 9 was significantly different from one another. The highest value was obtained in E. africana 11% while the least 1.07% was obtained in B. aethiopum. At pH 11 Protein Solubility was significantly different among the samples. The highest value was 13.41% in E. africana. This was significantly higher than 7.27% in B. glabra which was also significantly different from 4.04% obtained in E. gigas. The values obtained for M. arboreus 3.60% and B. aethiopum 3.57% were not different among themselves.

Antinutritional Factors

Quantitative estimation of the antinutrients components of the studied seeds presented in Table 2 showed the presence of saponins, phytate, alkaloids , tannin and oxalate.

Table 2. Antinutrient concentrations in the samples flour.

Sample	**Saponins(%)**	**Phytate (%)**	**Alkaloid (%)**	**Tannins (mg/g)**	**Oxalate (mg/g)**
B. aethiopum	$0.38^{b}\pm0.00$	$0.25^{a}\pm0.01$	$0.93^{d}\pm1.75$	$0.52^{d}\pm0.01$	$2.25^{d}\pm0.01$
B. glabra	$0.42^{a}\pm0.01$	$0.18^{c}\pm0.01$	$5.67^{a}\pm0.01$	$3.67^{b}\pm0.04$	$4.64^{c}\pm0.05$
E.africana	$0.33^{c}\pm0.01$	$0.14^{d}\pm0.00$	$2.66^{c}\pm0.01$	$0.68^{c}\pm0.02$	$3.66^{d}\pm0.05$
E.gigas	$0.29^{d}\pm0.00$	$0.21^{b}\pm0.40$	$2.96^{c}\pm0.02$	$0.45^{e}\pm0.05$	$6.56^{b}\pm0.02$
M. arboreus	$0.33^{c}\pm0.01$	$0.11^{e}\pm0.23$	$3.97^{b}\pm0.37$	$4.87^{a}\pm0.01$	$7.19^{a}\pm0.02$

Results are means of triplicate determination.

Means in each column followed by the same letter(s) are not significantly different by Duncan's Multiple Range Test.

The concentration of saponin ranges between 0.29%.to 0.42% This is lower than the value reported for *African oil bean* seed (2.1%), rubber seed (2.5%)(Achinewhu,1983), *Mucuna* 0.52% to 3.00% (Adebowale et al., 2005) and Sesbania seed (0.50%-1.46%) (Hossain and Beecher, 2003). The levels of anti-nutrients in the result were significantly different. In saponins, *B.glabra* (0.42%) was the highest which was significantly different from 0.38% in *B.aethiopum* this was significantly higher than *E. africana* 0.33% and *M.arboreus* 0.33% which were not different among themselves but higher than the least value 0.29% in *E.gigas*. Phytate level of the flour ranges between 0.14%-.6.56%. Phytate in *E. gigas* 6.56 was higher than *Canavalia braziliensis* 5.35% (Oseni *et al*,2011) and significantly different from remaining seed which are 2.25-0.14%,these values are lower than that of *Sesbania* seed 2.37-1.89% (Hossain and Beecher,2003) and *Mucuna* species 2.56-1.23%(Adebowale et al,2005). Phylate chelate di and trivalent minerals ions such as Ca^{2+},Mg^{2+},Zn^{2+} and Fe^{3+} resulting in reduced bioavailability of these minerals to the consumers. (Esenwah and Ikenebomeh, 2008). Phytic acid has a negative effect on amino acid digestibility thereby posing problems to non-ruminant animals due to insufficient amount of intrinsic factor of phytase necessary to hydrolyse the phytic acid complexes (Marounck , 2001). Phytate contents in all the five samples were significantly different. *B. aethiopum* 0.25% being the highest was higher than 0.21% in *E. gigas*, this was higher than 0.18%, 0.14% and 0.11% found in *B. glabra*, *E. africana* and *M. arboreus* respectively. There were significant differences in the alkaloids contents. Alkaloids content in *B. glabra* was the highest with 5.67% which was significantly higher than that of *M. arboreus* 3.97%, this was higher than that of *E. gigas* 2.97% and *E. Africana* 2.66%. The mean of the two samples were significantly higher compared to that *B. aethiopum* 0.93%.which was the least. The concentration of tannins are between 4.87-0.4mg/g. these value are lower than that of *Mucuna* species 7.75-4.34% (Adewole *et al*., 2005).With the exception of *M. arborens* 4.87% and *B. glabra* 3.67%, all other were lower than that of *Vigina radiate* 2.00% (Tareck,2002).The value in *M. arboeus* 4.87% is compared to dehusked seed of *Canavalia braziliensis* 4.90% (Oseni *et al*.,2011) but less than that of *B.aegyptiaca* 7.40%(Umaru et al., 2007).Tannic acid may decrease protein quality by decreasing digestibility and palatability .Other nutritional effect of tannin include damage to the intestinal tracts , interference with the absorption of iron and possible carcinogenic effect (Malik, 1982).Tannins result obtained in all the five samples were different from one another, *M.*

arboreus (4.87 mg/ml) was significantly higher than *B. glabra* (3.67mg/ml).

The oxalate content of the seeds is between 2.5mg/g-7.19. The values with the exception of *B. aethiopum* are higher compared to soya bean (2.54mg/g) and pigeon pea (2.86mg/g), though lower than that of cowpea (7.34mg/g) (Aletor and Aladesanmi, 1989). The value for *E. gigas* 6.56 ^{b}±0.02mg/g is close to that of whole seed of *C. braziliensis* 6.4mg /g and The value for *B.glabra* 4.64^{c}±0.05 is also closer to dehusked seed of *C. braziliensis* 4.8mg/g. (Oseni et al, 2011) .Oxalic acid has the ability to bind some divalent metals such as Ca and Mg present in food thereby rendering them unavailable for normal physiological and biological role such as maintenance of strong bone and teeth, cofactor in enzymatic reaction, nerve impulse transmission and as clothing factors in the blood,(Mann *et al*,2003).Insoluble calcium oxalate may also precipitate around soft tissues such as kidney causing kidney stones (Nwokolo and Bragg ,1977). Oxalate content in *M. arboreus*, 7.19mg/g was the highest , this was significantly different from 6.56mg/g in *E. gigas*, 4.64mg/g in *B. glabra*, 3.66mg/g in *E. Africana* and 2.55mg/g in *B. aethiopum*.

Conclusion

The study presented data on the functional properties and antinutrient activities of the seeds flour of five plant seeds – *B. aethiopum, B. glabra, E. africana, E. gigas* and *M. arboreus.* The result obtained for functional properties suggested that the seeds flours are not useful in enhancing the functional quality of food formulation like baking, salad dressing and other related food processing. The result showed that all the seeds flour contain variety of antinutritional factors including saponins (0.29-0.42%), phytate (0.11-0.52%), alkaloids (0.93-5.67%), tannins (0.45 - 4.87%mg/ml) and oxalate (2.25-7.19mg/g).There is therefore the need to pre-treat /process these seeds before their applications either domestically or industrially.

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