Research Article
Physicochemical and Sensory Properties of Boiled *Prosopis africana* Seed Endosperm Macerated in Various Ethanol-water Mixtures

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Abstract: The processing of boiled *Prosopis africana* endosperm for better utilization using ethanol-water mixtures was explored. *Prosopis africana* seeds were boiled for 5 h to softness and the endosperm fraction separated from the kernel (cotyledon) and the hull. The endosperm was divided into five equal parts which were individually macerated in absolute (Abs) ethanol, 80, 60 and 40% ethanol in water prior to sun-drying (32±2°C, 3 days). The fifth sample, which served as control, was left untreated with ethanol. The samples were ground using a hand milling machine and analyzed for the proximate composition, water and oil absorption capacities, foaming capacity and foam stability, bulk density, emulsion activity and stability, colour preference, texture preference and overall acceptability. The results revealed that treatment of the endosperm significantly affected the moisture, protein, fat, ash and carbohydrate contents; water and oil absorption capacities, foaming capacity and foam stability; and the sensory properties. The moisture and protein contents, oil absorption capacity, foam stability, appearance, texture and overall acceptability of endosperm treated with 40% ethanol in water differed significantly (p<0.05) from that treated with absolute ethanol. There was also significant (p<0.05) differences in moisture, protein and carbohydrate contents, oil absorption capacity and foam stability of the 40% ethanol in water treated endosperm and the control. Slightly above 40% ethanol in water (50-60%) should be used to macerate *Prosopis africana* endosperm to reduce the cost of using absolute ethanol.

Keywords: Endosperm, ethanol, physicochemical, properties, *Prosopis africana*, sensory, water

INTRODUCTION

Prosopis africana is one of the lesser known leguminous seed crops used as food condiment in Nigeria. It thrives well in the savannah region of Nigeria, although there is no record of yield of annual production (Odibo *et al*., 1992). The use of this plant product indigenous to Africa may be limited to empirical culinary application even though it may have potential as important industrial functional ingredients. In some parts of Nigeria, the seed is locally processed into bean cake ('okpiye'), a local condiment of wild fermentation, used for flavoring foods (Achi, 1992; Odibo *et al*., 1992)

The pod of mesquite (*Prosopis spp*) consists of three separable components: exo- and mesocarp (pulp), endocarp and the seed (Pasiecnik *et al*., 2001; Vautier and Sancande, 2007). The seeds, which are stony and brown in color and oval or egg-shaped, are separated from one another within the mesocarp by a fibrous endocarp segment. They are made up of three parts; an episperm, being the thin brown seed coat, the endosperm which adheres to the seed coat and the cotyledon (Pasiecnik *et al*., 2001; Vautier and Sancande, 2007). Recent studies have shown that the functional properties of mesquite gum are as good as or better than those of gum Arabic and can be used as food additive in its place (Adikwu *et al*., 2001). According to Gall *et al*. (2005), mesquite is a good gum source. The seed gum is contained in a well-developed endosperm located between cotyledon and seed coat and comprised largely of storage carbohydrate, galactomannan. The ground endosperm of mesquite seed consists mainly of galactomannan type polysaccharide similar to those of locust bean and guar gums. According to Achi and Okolo (2004), the endocarp capsule, a water soluble high molecular weight polysaccharide gum, is a constituent of considerable economic interest. It constitutes 31.5% by weight of the whole seed; and proximately contains 21.5% crude fiber, 2.4 fats, 1.04% protein and 60.2% carbohydrate. Functionally, it has high Water Absorption Capacity (WAC) of 10 g/g, Oil Absorption Capacity of (OAC) of 6.5 g/g and high emulsion activity and stability of 78.4% and 80.3%,

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respectively. The endocarp cannot constitute 31.5% by weight of whole seed since it is a fibrous segment separating seeds from one another within a mesocarp (Pasiecnik *et al*., 2001; Vautier and Sancande, 2007). The endosperm must have, therefore, been mistaken by Achi and Okolo (2004) as the endocarp.

Despite its potential for its functional properties, the endosperm fraction is thrown away or fed to animals after separating the kernel (cotyledon) from the boiled, softened seed for 'okpiye' production. The boiled wet endosperm case-hardens and toughens on drying and consequently resists grinding. If ground at all, black gritty particles unacceptable in food formulations is obtained. To reduce case-hardening, the boiled wet endosperm is macerated in ethanol prior to drying. The use of absolute ethanol has proved successful (Obiegbuna, 2011), though not economical. To reduce cost, there is the need to investigate the effect of various alcohol-water mixtures. This study explored the better way of processing boiled *Prosopis africana* endosperm for better utilization using ethanol-water mixtures and the effect of the treatment on the physicochemical and sensory properties of the endosperm.

MATERIALS AND METHODS

Raw material procurement and processing: *Prosopis africana* seeds used in this work was purchased from a local market in Idah, Kogi State, Nigeria. The cleaned seeds were boiled for 5 h to softness. The endosperm fraction was separated from the kernel (cotyledon) and the hull, divided into five equal parts and individually treated (washed) with absolute (Abs) ethanol, 80, 60 and 40% ethanol in water. The fifth sample, which served as the control, was left untreated with ethanol. The samples were sun-dried (32±2°C) for three days prior to grinding using a hand milling machine.

Methods of analysis:
Proximate analysis: Proximate analysis of the ground endosperm samples was carried out using the AOAC (1984) methods 14.084, 14.089, 14.085, 14.086 and 14.087 for moisture, crude fat, ash, protein and crude fiber, respectively. Nitrogen to protein conversion factor of 6.25 was used. Carbohydrate was estimated by difference.

Functional properties determination: Water and oil absorption capacities were determined as described by

Okaka and Potter (1979). Foaming capacity and foam stability were determined using the method described by Ihekoronye (1986). Emulsion activity and emulsion stability were determined following the methods described by Yasumatsu *et al*. (1972).

Sensory evaluation: Twenty-member panel comprising ten male and ten female adults of above 16 years assessed the samples for the sensory properties of color, texture and overall acceptability. The evaluation took place in the sensory evaluation laboratory naturally illuminated by sun rays. The samples were served simultaneously to the assessors in flat colorless plates. The judges were asked to score the samples based on preference on a 9-point hedonic scale where 1 represented extremely disliked, 5 neither liked nor disliked and 9 extremely liked.

Statistical analysis: Data were subjected to Analysis of Variance (ANOVA) and significant means discriminated by Tukey's LSD test (Miller and Freund, 1987).

RESULTS AND DISCUSSION

Proximate composition: The effect of treating *P. africana* endosperm with various percentages of ethanol in water on the proximate composition of the ground endosperm is shown in Table 1. Except the crude fiber, other parameters constituting the proximate composition were significantly (p<0.05) affected by the treatment. Whereas carbohydrate content was higher in the endosperm treated with higher percentage of ethanol in water, the moisture, crude protein, ash and crude fat contents were lower in the endosperm. Among the ethanol treated endosperm, only the moisture and crude protein contents of the 40% ethanol treated endosperm differed significantly (p<0.05) from that treated with absolute ethanol. In the same way, treatment with 40% ethanol led to significant (p<0.05) increase in carbohydrate and significant (p<0.05) decrease in moisture, crude protein and ash contents when compared to the control (sample not treated with ethanol). Hence, since the difference in the compositions of the 60% ethanol and absolute ethanol treated endosperm samples were insignificant (p>0.05), the former (or even 50% ethanol) can be applied so as to reduce the cost of processing. The decrease in moisture content of the endosperm treated with increasing level of ethanol in ethanol-water mixture

Table 1: Proximate composition (dry weight basis) of dried *Prosopis africana* endosperm treated with various percentages of ethanol in water

Parameter (%)	Level of ethanol in water				
	Absolute	80%	60%	40%	Untreated
Moisture*	12.80±1.32[a]	13.23±1.46[a]	14.00±1.09[ab]	16.02±1.56[b]	22.08±0.96[c]
Crud protein	1.90±0.33[a]	2.16±0.64[ab]	2.37±0.52[ab]	2.51±0.78[b]	4.50±0.67[c]
Crude fat	2.11±0.61[a]	2.35±0.72[ab]	2.42±0.85[ab]	2.51±0.66[ab]	2.80±0.58[b]
Ash	2.30±0.41[a]	2.27±0.55[a]	2.35±0.63[a]	2.30±0.36[a]	6.40±0.88[b]
Crude fiber	20.20±1.03[a]	19.88±1.12[a]	21.95±1.20[a]	21.00±1.05[a]	20.00±1.22[a]
Carbohydrate	74.29±1.54[a]	73.33±1.96[a]	70.91±2.01[a]	71.68±1.95[a]	66.30±1.88[b]

*Remains in wet weight basis; values with the same superscript within a row were not significantly different (p>0.05)

Table 2: Functional properties of dried *Prosopis africana* endosperm treated with various percentages of ethanol in water

Parameters	Level of ethanol in water				
	Absolute	80%	60%	40%	Untreated
Bulk density (g/cm^3)	0.74±0.03[a]	0.71±0.02[ab]	0.68±0.04[ab]	0.66±0.03[ab]	0.62±0.02[b]
Water absorption capacity (g/g)	3.08±0.32[a]	2.96±0.25[ab]	2.75±0.33[bc]	2.68±0.19[c]	2.60±0.22[c]
Oil absorption capacity (g/g)	2.60±0.74[a]	2.55±0.56[ab]	2.48±0.64[ab]	2.40±0.49[b]	2.20±0.82[c]
Foaming capacity (%)	1.96±0.14[a]	2.10±0.08[a]	2.52±0.11[ab]	2.89±0.22[ab]	3.45±0.15[b]
Foam stability (%)	3.92±0.10[a]	4.56±0.07[ab]	5.10±0.18[ab]	5.66±0.20[b]	7.69±0.16[c]
Emulsion activity (%)	ND	ND	ND	ND	ND
Emulsion stability (%)	ND	ND	ND	ND	ND

ND - not detected; Values with the same superscript within a row were not significantly different (p>0.05)

could be attributed to the solubilization of the mucilaginous substances. This may have likely reduced or prevented the case-hardening of the endosperm during drying thereby increasing the moisture loss. It is likely that some crude fat, ash and nitrogenous substances (protein and non-protein) may have leached into the ethanol-water mixtures thereby reducing their content or amount in the endosperm. The increase in the carbohydrate content could be due to the cumulative decrease in fat, protein and ash contents.

Functional properties:
Bulk density: The bulk density of the ground *Prosopis africana* endosperm (Table 2) increased on treatment with higher percentage of ethanol in water. The difference in the bulk density of the control and the 40% ethanol treated endosperm were insignificant (p>0.05). Also, the difference between the absolute ethanol and 40% ethanol treated endosperm did not show any significance (p>0.05). The higher bulk density of the ethanol treated endosperm samples than that of the control is an indication of smaller particle size resulting from the drier condition of the endosperm (Table 1). This is suggesting the effectiveness of ethanol in reducing the case-hardening and improving the drying and grinding conditions of the endosperm. Higher bulk density is desirable for greater ease of dispersibility of flour (Padmasshree *et al*., 1987) whereas low bulk density would be an advantage in the formulation of complementary foods (Akpata and Akubor, 1999).

Water and oil absorption capacities: Table 2 revealed that the Water Absorption Capacity (WAC) and Oil Absorption Capacity (OAC) of *P. africana* endosperm were significantly (p<0.05) affected by ethanol treatment. The WAC values ranged from 2.60 g/g for the control to 3.08 g/g for the absolute ethanol treated endosperm whereas the OAC ranged from 2.20 g/g for the control to 2.60 g/g for the absolute alcohol treatment. The higher WAC and OAC of ethanol treated samples may be as a result of finer particle size of the endosperm predicated by higher bulk density. More hydrophilic sites may have been exposed by increased surface area for water binding and hydrophobic sites for oil absorption. The WAC and OAC values (2.60-3.08 g/g and 2.20-2.60 g/g,

respectively) of the endosperm were; however, lower than the values reported by Achi and Okolo (2004). The WAC of the ground *P. africana* endosperm is higher than133.67% for buckwheat and 151.0% for refined wheat flours (Baljeet *et al*., 2010), 1.89-2.15 g/g for three varieties of cowpea in Ghana (Appiah *et al*., 2011), 2.04–2.44 g/g for raw and different heat-processed winged bean flour (Igene *et al*., 2005), 1.67 g/g for full-fat winged bean (Giami *et al*., 1992), 1.38 mL/g for pigeon pea (Oshodi and Ekperigia, 1989) and 1.8 mL/g for sunflower flour (Sosulski and Flemming, 1977) and thus could be useful for improving the WAC of these food products. Water absorption characteristic represents the ability of a product to associate with water under conditions such as dough and paste formations where water is limiting (Giami *et al*., 1992) and it enables bakers to add more water to dough and as such improve the handling qualities and maintain freshness of bread (Igene *et al*., 2005). In the same way, the OAC of the ground *P. africana* endosperm, being higher than that of buckwheat (181.37%) and refined wheat flour (169.97%) (Baljeet *et al*., 2010), processed African yam bean (1.42-1.69 mL/g) (Eke and Akobundu, 1993), raw and different heat processed winged bean flour (1.22-1.42 g/g) (Igene *et al*., 2005), soybean flour (1.2 mL/g) (Narayana and Rao, 1982) and three varieties of Cowpea in Ghana (1.95-2.31 g/g) (Appiah *et al*., 2011), can be used to improve the oil absorption property of these food products. According to Eke and Akobundu (1993), fats improve flavor and increase the mouth feel of food and, therefore, is a significant factor in food formulations.

Foaming properties: The Foaming Capacity (FC) and Foam Stability (FS) decreased with increasing ethanol in the macerating water-ethanol mixture (Table 2). The difference in the foaming properties of the control and the 40% ethanol treated endosperm were insignificant (p>0.05). The difference between the absolute ethanol and 40% ethanol treated endosperm did not also show any significance (p>0.05) in these properties. Yasumatsu *et al*. (1972) reported that foaming properties are dependent on the configuration of protein. Kinsella (1981) and Townsend and Nakai (1983) observed important contribution of protein solubility to the foaming behavior. Okezie and Bello (1988) noted the dependence of foaming capacity on

Table 3: Mean sensory scores on preference for dried *Prosopis africana* endosperm treated with various percentages of ethanol in water

Parameter	Level of ethanol in water					
	Absolute	80%	60%	40%	Untreated	LSD
Appearance	6.64±0.45[a]	5.88±0.83[ab]	5.40±0.64[ab]	4.75±0.77[bc]	3.41±0.94[c]	1.43
Texture	5.76±0.89[a]	5.25±0.65[ab]	4.66±1.02[ab]	4.07±0.85[bc]	3.02±0.61[c]	1.21
Overall acceptability	6.08±0.67[a]	5.50±0.34[ab]	4.76±0.91[ab]	4.22±0.57[bc]	2.92±0.73[c]	1.62

Values with the same superscript within a row were not significantly different (p>0.05)

protein concentration. The crude protein content of the *Prosopis africana* endosperm, which ranged from 1.90% in absolute ethanol treated sample to 4.50% in the control (Table 1), was low and would have been severely denatured by the long period of boiling (5 h). This has resulted to loss of solubility and consequently low foaming capacity and foam stabilities of 1.96-3.45 and 3.92-7.69%, respectively (Table 2).

Emulsion properties: Emulsion was neither formed in ethanol treated sample nor in the control (Table 2). The non-formation of emulsions in the ground endosperm contrasted the emulsion activity and stability of 78.4 and 80.3%, respectively, reported by Achi and Okolo (2004). Like foaming properties, emulsion properties are dependent on protein concentration and solubility (Sathe and Salunkhe, 1981). However, whereas FC is a function of total hydrophobicity, emulsion properties are dependent on the effective or surface hydrophobicity (Li-Chan *et al.*, 1984). The target of the use of the endosperm is the galactomannan, which is a hydrocolloid and the major carbohydrate of mesquite seed (Achi and Okolo, 2004; Gall *et al.*, 2005). According to Milani and Maleki (2012), the functionality of hydrocolloids as emulsifier and/ or stabilizers correlate to phenomena among which are prevention of aggregation of dispersed particles and retardation of coalescence of oil droplets. Chaplin (2012) also stated that polysaccharide hydrocolloids stabilize emulsion primarily by increasing the viscosity but may also act as emulsifier where their emulsification ability is mainly due to accompanying contaminating or intrinsic protein moieties. It is, therefore, likely that the protein content of 1.90-4.50% (Table 1) and its denatured state/ form could not provide the required impurities for emulsion formation. An emulsion must be formed before stabilization would take place. The possibility of the endosperm to form and/ or stabilize emulsion due to its content of the polysaccharide, galactomannan, can be verified in a food system of adequate and correct form of protein.

Sensory properties: The sensory attributes of appearance, texture and overall acceptability (Table 3) were significantly (p<0.05) affected by ethanol treatment. The values between the ethanol treated samples became significantly (p<0.05) different at 40% ethanol in water. There was no significant difference (p<0.05) between the 40% ethanol treated sample and the control. Though all the samples, irrespective of

treatment, were dark in appearance, the ones treated with higher levels of ethanol in water looked glossier. This could be attributed to higher reflectance of the samples resulting from finer particle sizes. The preference for the texture of ethanol treated samples could also be attributed to the finer particle sizes. The preferences for both texture and appearance seemed to have influenced the overall acceptability.

CONCLUSION

Treating boiled *Prosopis africana* endosperm with ethanol prior to drying effectively solubilized the mucilage that covers the endosperm. Consequently, case-hardening was reduced and drying improved. The higher the ethanol in the ethanol-water mixture, the drier the endosperm and the easier the ability to grind. This resulted to finer particle sized products of higher bulk density. The treatment of the endosperm with 40% ethanol in water gave the products that significantly (p<0.05) differed from that of absolute ethanol only in moisture and protein contents, oil absorption capacity, foam stability and sensory properties of appearance, texture and overall acceptability. Significant differences also existed between the 40% ethanol in water treated endosperm and the control in moisture, protein and carbohydrate contents, oil absorption capacity and foam stability. Hence, *Prosopis africana* endosperm should be treated with slightly above 40% ethanol in water (50-60%) so as to reduce the cost of using absolute alcohol.

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