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Functional properties of African yam bean (*Sphenostylis stenocarpa*) seed flour as affected by processing

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Full-fat flours processed from seeds of African yam bean (AYB) were evaluated for their functional properties. Foam and emulsion capacities were greatest between NaCl concentrations of 0·2 and 0·4 M. Steeping increased the emulsion capacity of AYB flour over roasting and malting. Roasting at 120°C reduced emulsion capacity, foam capacity and stability. However, it increased the oil and water absorption capacities relative to other processes.

INTRODUCTION

African yam bean (AYB) is one of the neglected pulses of tropical origin that has attracted research interest in recent times due to its nutrient content (Evans & Boulter, 1974; Watson, 1977; Ezueh, 1984; Nwokolo, 1987; Apata & Ologhobo, 1990; Edam *et al.*, 1990).

The characteristic problem of hard-to-cook phenomena which had hindered the extensive use of AYB has been substantially reduced by precooking treatments (Njoku *et al.*, 1989). Studies aimed at providing alternative methods of utilizing AYB have been reported (Enwere *et al.*, 1990; Ofuya *et al.*, 1991). The bean has been processed into flour and paste which were used locally for *moin-moin* (cooked cowpea paste) and *akara* (fried bean balls).

Whilst the functional properties of flours made from more popular legumes, including soybean, cowpea and pigeon pea, have been extensively studied (Coffman & Gracia, 1977; Ahmed & Schmidt, 1979; Akobundu *et al.*, 1982; Narayana & Rao, 1982; Sathe *et al.*, 1982), there is paucity of information on the functionality of AYB flours. This has limited the application of AYB flours in some food formulations. It was therefore the objective of this study to investigate the functional properties of AYB flours as affected by processing.

MATERIALS AND METHODS

Sample preparation

Dry seeds of AYB purchased from a local market in Bende La, Abia State, Nigeria were carefully selected, cleaned and divided into three lots for flour production. Cultural agricultural practice in this area prohibits pre-processing treatment of AYB except sun-drying, and the sample is representative of AYB available in the area.

One portion was malted following soaking in tap water for 36 h with water changed every 6 h, including an hour's air-rest before resoaking. The seeds were then germinated by spreading them out thinly on a polyethylene sheet for 72 h, dehulled, oven-dried at 60°C and derooted. The second portion was roasted in an oven at 120°C for 5 h, after which the beans were cooled and dehulled. The third portion was soaked in tap water for 12 h, dehulled and oven-dried at 60°C; this represented the control sample. Each of the samples was then milled into flour that passed through a 180-μm sieve and stored in airtight containers until used.

Emulsion capacity

The emulsion capacity of the flours was determined according to the procedure of Narayana & Rao (1982) at room temperature and expressed as ml of oil emulsified per g of flour. Emulsion capacity was also determined as a function of NaCl concentration.

Foam capacity and stability

Foam capacity and stability were determined as described by Lawhon *et al.* (1972) using a PHYWE magnetic stirrer at 10 Ruhrer speed for 5 min. Foam capacity was expressed as volume (ml) of foam after mixing; the volume after standing for a specified time was regarded as the foam stability. The foam capacity of salt-soluble protein was also determined at a concentration between 0·05 and 1·0 M.

Water absorption capacity

This was determined by the method of Beuchat (1977) at room temperature. The values were expressed as ml of water absorbed per g of flour.

Oil absorption capacity

The method of Beuchat (1977) was followed using a 1 g flour sample and AVOP vegetable oil (density 0·89 g ml^{-1}). The determinations were carried out at room temperature and the values are expressed as ml of oil absorbed per g flour.

RESULTS AND DISCUSSION

Emulsion capacity

The flour from steeped AYB had a higher emulsion capacity than those from malted and roasted grains (Table 1) as malting, and roasting at 120°C reduced the emulsion capacity from 4·2 ml g^{-1} to 2·6 ml g^{-1} and 0·9 ml g^{-1}, respectively. The results represented the direct effect of protein modification associated with heat, during malting or roasting. The observed reduction in emulsion capacity which was attributed to protein denaturation is similar to the results of heat-processed wing-bean flour (Narayana & Rao, 1982). McWaters & Holmes (1979*a*) have identified the degree of heating (temperature and time) as the primary determinant in the reduction of emulsion capacity of heat-processed flours from soybean and peanut. It is therefore evident that neither malting nor roasting is desirable in processing AYB intended for spread formulations because of the high emulsion requirements of the product. The consistently higher emulsion capacity of flour from steeped AYB (Table 1) indicates that steeping would be a desirable processing method over malting and roasting for AYB flour intended for food spread.

The salt concentration influenced the emulsion capacity of the AYB flours. The emulsion capacity of the steeped and malted samples increased with increased concentration of NaCl up to 0·4 M (Table 1). Beyond this salt level, the emulsion capacity decreased considerably for both samples. A similar observation was reported on alfalfa leaf protein (Wang & Kinsella, 1976), soy and winged-bean flours (Narayana & Rao, 1982) and detoxified madhuca seed flour (Shamugasundaram & Venkataraman, 1989). This was due to the salting-in effect of NaCl. McWaters & Holmes (1979*b*) reported that the thickness of emulsion formed within this salt concentration range was both pH- and salt-concentration-dependent. The high emulsion capacity of these samples at low salt concentration is beneficial in food formulations since a low NaCl level in nutrition is desirable. Salt concentration had little or no effect on the emulsion capacity of the roasted sample because of the reduced nitrogen solubility associated with heat-treated protein.

Table 1. Emulsion and foam capacities of processed AYB flour[a]

Molar concn of NaCl	Emulsion capacity (ml g^{-1})			Foam capacity (ml g^{-1})		
	Steeped	Malted	Roasted	Steeped	Malted	Roasted
0·00	4·2	2·6	0·9	6·0	6·0	1·0
0·05	—	—	—	6·5	6·0	2·0
0·10	—	—	—	6·8	6·3	2·0
0·20	4·4	2·8	0·9	7·5	7·3	2·5
0·40	4·4	3·1	0·9	7·5	7·2	2·5
0·60	3·8	2·4	0·8	5·8	5·9	1·5
0·80	3·8	2·4	0·9	5·2	5·0	1·3
1·00	3·6	2·1	0·8	5·0	4·5	1·1

[a] Mean of three determinations.

Foam properties

The results (Table 1) showed that the malted and steeped samples had a similar foam capacity, indicating that the proteins in both samples had similar surface activity. Foamability is related to the rate of decrease of the surface tension of the air–water interface caused by absorption of protein molecules (Sathe *et al.*, 1982).

Roasting was observed to reduce the foam capacity of the flour considerably, possibly because of protein denaturation. Reduced foam capacity caused by protein denaturation was reported for sunflower meal (Lin *et al.*, 1974). According to Graham & Philips (1976), flexible protein molecules which can rapidly reduce surface tension have a higher foam capacity than highly ordered protein molecules that are relatively difficult to surface-denature. Thereby, the low foam capacity of the heat-processed flour can be explained. Similar observations were made on winged bean flour (Narayana and Rao, 1982).

Addition of NaCl up to 0·2 M concentration, increased the foam capacity of the flours (Table 1). Beyond 0·4 M, NaCl considerably reduced the foam capacity. With the roasted sample, the foam capacity at 1·0 M NaCl was almost the same as in water.

In both the steeped and malted samples, the foam decreased markedly in volume after 60 min and thereafter decreased gradually (Table 2). The foam from the malted AYB flour was more stable than the steeped flour, retaining 40% of its original volume after 60 min whilst the steeped flour retained 33% of its initial volume. In the case of the roasted AYB flour, the foam disappeared completely after 60 min.

Foam stability is related to protein denaturation,

Table 2. Foam stability of processed AYB flours[a]

Time (min)	Steeped	Malted	Roasted
0	6·0 (100)	6·0 (100)[b]	1·0 (100)
30	3·5 (58·3)	4·0 (66·7)	0·1 (10)
60	2·0 (33·3)	2·4 (40)	0·0 (0)
90	1·0 (16·7)	2·0 (33·3)	—
120	0·5 (8·3)	1·5 (25)	—

[a] Mean of three determinations.

[b] Figures in parentheses are percentages of foam remaining.

Table 3. Absorption capacity of AYB flours[a]

Process	Water absorption capacity (ml g^{-1})	Oil absorption capacity (ml g^{-1})
Steeped	1·70	1·42
Malted	1·92	1·51
Roasted	2·00	1·69

[a] Mean of three determinations.

with native protein showing greater foam stability than denaturated protein (Yatsumatsu *et al.*, 1972). Foam stability is also related to the size of the foam bubbles, with smaller bubbles being more stable (Waniska & Kinsella, 1979).

Water and oil absorption

The water absorption capacities of malted, roasted and steeped AYB flours are presented in Table 3, with the roasted sample showing highest absorption. The higher water uptake by the malted sample compared with the steeped could be due to the presence of more protein or more hydrophilic polysaccharides in the malted sample. Narayana & Rao (1982) attributed the increased absorption capacity of heat-processed flours to heat-dissociation of the proteins, gelatinisation of carbohydrates in the flour and swelling of crude fibre. A similar observation of increased water absorption due to heat treatment was made by Abbey & Ibeh (1988). The water absorption capacities of the AYB flours are comparable to the 1·8 ml g^{-1} reported for sunflower (Sosulski & Fleming, 1977) but higher than 1·30 ml g^{-1} for soy flour (Lin *et al.*, 1974) and 1·38 ml g^{-1} for pigeon pea flour (Oshodi & Ekperigia, 1989).

Since fats improve flavour and increase the mouthfeel of foods, fat absorption is an important property in food formulations. The oil-absorption capacities of the AYB processed flours (Table 3) are higher than those reported for winged bean (1·4 ml g^{-1}) and soybean (1·2 ml g^{-1}) flours (Narayana & Rao, 1982). This indicated that AYB flours may contain more hydrophobic proteins than winged-bean and soybean flours. The increase in oil absorption of the roasted sample could be due to both the heat-dissociation of the proteins and denaturation, which were expected to unmask the nonpolar residues from the interior of the protein molecules (Kinsella, 1976). Both the oil and water absorption capacities of the flours were found to decrease with increasing NaCl concentration up to 1·0 M.

CONCLUSION

African yam bean (AYB) flours compare well with flours from other more common legumes such as soya bean, pigeon pea, winged bean and cowpea, in their functional properties. The method of processing the AYB seed affects its functional properties. Generally, malting of the seeds yields flour with similar functional properties to the flour obtained from the conventional method of soaking in water before dehulling. Although roasting improved the water and oil absorption properties of the flour, it considerably reduced the foam and emulsion properties. AYB seed could be processed into flour by either malting or roasting to increase its absorption capacity.

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