ELSEVIER

Food Chemistry **54** (1995) 55–59

0308-8146/95/$9.50

A comparative study of some functional properties of *Afzelia africana* and *Glycine max* flours

Jane C. Onweluzo, Kris C. Onuoha & Zak A. Obanu

Department of Food Science and Technology, University of Nigeria, Nsukka, Nigeria

(Received 12 January 1994; revised version received and accepted 24 June 1994)

Seed flour made from a lesser known indigenous legume — *Afzelia africana* — was studied alongside *Glycine max* flour. *Glycine max* flour had a higher ($P < 0.05$) crude protein content (42%) while *A. africana* flour had higher fat (32%). Both flours showed comparable water absorption, oil absorption, bulk densities and least gelation concentrations but *G. max* flour had higher foam capacity and stability than *A. africana* flour. The legume flours showed appreciable emulsification abilities but *G. max* flour suspension exhibited significantly ($P < 0.05$) higher emulsion stability, emulsion capacity and emulsion viscosity. *Afzelia africana* showed better emulsion properties at acid pH than at natural and alkaline pH while *G. max* flour showed a pH-dependent emulsion property that is similar to its protein solubility profile.

INTRODUCTION

The importance of legume seeds as food and functional ingredients has stimulated much attention to their utilisation (Del Valle *et al.*, 1983). Such attention, however, seems to have been limited to such legumes as soya bean, peanut and winged bean (Poulter, 1981). Some tropical legumes, e.g. *Afzelia africana*, are excluded from the list of under-exploited legumes (NAS, 1979).

Afzelia africana is a member of the sub-family Caesalpinaceae and family Leguminosae. It is a perennial that thrives along the Savannah and drier parts of the forest region (Keay *et al.*, 1964). *Afzelia africana* seeds are ellipsoid, 1·88–3·13 cm long and glossy black with a waxy orange cup-like structure at the base. Embedded in the seed coat are cream-coloured cotyledons.

Afzelia africana seed is a commonly used soup thickener. It is also used as a major soup ingredient just as melon seed (*Citrullus vulgaris*) is used. It is non-toxic (Keay *et al.*, 1964). *Afzelia africana* seed is referred to in Nigeria as 'akparata', 'kawa' and 'apa' by the Igbos, Hausas and Yorubas, respectively.

MATERIALS AND METHODS

Mature dry seeds of *A. africana* and *Glycine max* (yellow variety) were purchased from Nsukka local market (Enugu State, Nigeria). The seeds were certified to be true samples at the Botany department of University of Nigeria, Nsukka.

Preparation of the legume flours

Afzelia africana seeds were cracked, soaked in water at room temperature (27 ± 2°C) for 20 min and then dehulled manually. The dehulled cotyledons were dried in an air oven at 65°C for 48 h and pulverised in a hammer mill (Retsch GmbH, Germany). The seed flour was screened through a 300 μm pore sized sieve (H. Jurgens and Co., Bremen, Germany) and designated as Aaf (*A. africana* flour).

The soya bean seeds were cracked by passing through an attrition mill (Bentalls Co. Ltd, Essex, UK) set at a good clearance of 0·025 cm after the method of McWatters and Cherry (1977). The hulls were separated and the cotyledons were dried and pulverised in a hammer mill. The flour was screened through a 300 μm pore sized sieve and designated as Gmf (*G. max* flour).

Proximate analysis

The legume flours were analysed for proximate composition according to AOAC (1984) methods.

Protein solubility at different pH values

Protein solubility was determined as described by Sathe *et al.* (1982) with the following modifications:

(a) Suspensions (0·2%) of the flour in distilled water were adjusted to pH 2, 4, 6, 8 and 10 using 1M HCl and 1M NaOH.

(b) The suspensions were centrifuged at 10 000 × *g* for 10 min.
(c) Percent nitrogen in each supernatant was determined by the micro-Kjeldahl method (AOAC, 1984).
(d) Percent soluble protein was calculated as percent nitrogen × 5·71 on a wet weight basis.

Water and oil absorption capacity

Water absorption and oil absorption capacities were determined according to the method of Sosulski (1962). Centrifugation was done at 20 000 × *g* for 20 min using the Heraeus Christ Cryofuge (Germany).

Bulk density

The apparent bulk densities of the legume flours were determined by the methods of Wang and Kinsella (1976). The flour samples were packed in 25 ml graduated cylinders by gently tapping the cylinders on the bench top several times. The volume and weights of the packed samples were recorded. The procedure was repeated three times for each sample and the bulk density was computed as g/ml of the sample.

Least gelation concentration

Least gelation concentrations were determined according to the method of Sathe and Salunkhe (1981) but using concentrations of flour from 1 to 30%.

Foaming properties

Foaming capacity and stability were determined by the method of Nath and Rao (1981) using 1 g flour suspended in distilled water at 27 ± 2°C. Each flour suspension was whipped in a National Waring blender for 5 min and poured immediately into a 250 ml measuring cylinder. The foam height and volume of liquid collected at the bottom of the cylinder were measured at 30-min intervals over a 180-min period. Percentage foam volume was calculated as described by Nath and Rao (1981).

Emulsification properties

Emulsion activity (EA) and emulsion stability (ES) were determined according to Yatsumatsu *et al.* (1972). Two grammes of samples were suspended in 100 ml distilled water at room temperature and rapidly blended for 5 min using the Silverson laboratory emulsifier (Silverson Machines Ltd, Model L2R, Waterside, UK). Refined soya bean oil (100 ml) was added gradually and blended rapidly for another 5 min. The emulsions prepared were centrifuged at 2000 × *g* for 5 min. The ratio of the height of the emulsified layer to the total height of the fluid was calculated and EA expressed as a percentage. ES was determined by the same method except that the emulsions were heated at 80°C for 30 min in a water bath and then cooled under running tap water for 15 min before centrifugation.

Emulsifying capacity (EC) was determined by the method of Beuchat (1977). A 2% dispersion of each flour blended for 5 min and refined soya bean oil was added to the mixture from a burette in 25 ml portions. Blending and viscosity measurements continued after each oil portion addition. Oil addition and blending were discontinued when there was a drop in viscosity from a maximum. The volume of oil added up to the point of maximum viscosity was recorded and the emulsifying capacity was calculated as ml of oil emulsified per gramme of flour sample.

In studying the effect of pH on emulsification properties, the flour dispersions were adjusted to the required pH unit with 1M HCl and 1M NaOH before emulsification.

Statistical analysis

Data were subjected to statistical analysis. Analysis of variance was done using the STATGRAPHICS programme of Olivetti M 246 PC. Least significant differences for mean composition tests was computed according to Tukey (1977).

RESULTS AND DISCUSSION

Proximate compositions

Table 1 shows that the proximate compositions of *A. africana* and *G. max*. *Afzelia africana* was higher in crude fat and total carbohydrate content while *G. max* was higher in crude protein and total ash.

Protein solubility

Glycine max and *A. africana* flours showed minimum protein solubility at pH 4 (Table 2). Protein solubility increased on either side of pH 4 for both flours. *Glycine*

Table 1. Proximate composition of *Afzelia africana* and *Glycine max* flours (%) (mean ± SD, *n* = 3)

Flour	Moisture	Crude fat	Crude protein (N × 5·71)	Total ash	Total carbohydrate (by difference)
A. africana	5·28 ±0·02	31·71 ±0·98	27·0 ±0·03	3·22 ±0·03	33·0 ±1·41
G. max	4·72 ±0·04	27·40 ±0·57	42·1 ±1·28	5·78 ±0·10	20·0 ±1·42

Table 2. Protein solubility (%) of *Afzelia africana* and *Glycine max* flours at different pH values (mean ± SD, *n* = 3)

	Normal pH	pH 2	pH 4	pH 6	pH 8	pH 10
A. africana	0·56 ±0·24	0·56 ±0·12	0·45 ±0·54	0·69 ±0·26	0·54 ±0·91	0·53 ±0·73
G. max	0·90 ±0·11	1·21 ±1·21	0·40 ±0·43	1·36 ±0·11	0·79 ±0·20	0·85 ±0·63

max showed higher protein solubility at all pH levels than *A. africana*.

Water and oil absorption capacities, bulk densities and least gelation concentration

The water-holding capacities of *A. africana* and *G. max* (Table 3) exhibited no significant differences. The water absorption capacity of *G. max* is in agreement with the values reported for soya bean flour by Nath and Rao (1981). Although *A. africana* flour contained less protein (Table 1) than *G. max* flour, their water absorption capacities were similar.

The comparable water absorption capacities of *A. africana* and *G. max* flours suggest the use of *A. africana* as a functional ingredient in products in which soya bean flour has found application.

Afzelia africana and *G. max* flours had low capacities to physically entrap oil (Table 3). Both flours showed comparable bulk densities (Table 3). Least gelation concentration values of *A. africana* and *G. max* did not differ significantly, despite the higher protein content of the latter. Gelation properties of *G. max* flour have been used to effect textural modification in products like soups and gravies. *Afzelia africana* flour found similar applications (Keay *et al.*, 1964)

Foaming properties

Glycine max showed a higher foaming capacity than *A. africana* (Fig. 1). *Afzelia africana*, unlike *G. max*, produced foams with many large, unstable air cells. This might be due to the low protein solubility in *A. africana*. Foam volume, over 180 min, decreased more in *A. africana* than in *G. max*, indicating poor foam stability.

The pattern of foamability response to pH (Table 4) is similar to the protein solubility profile (Table 2). *Afzelia africana* and *G. max* flours showed minimum foamability at pH 4. Foams of both flours were more

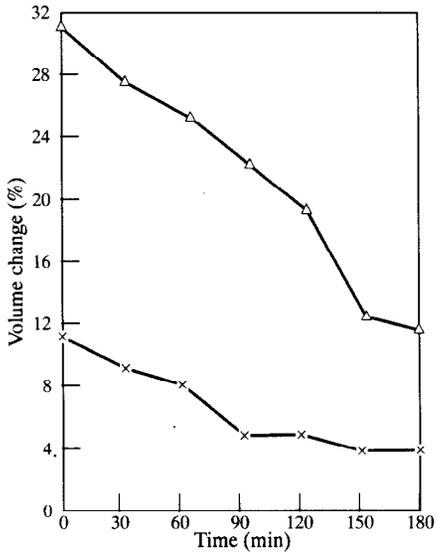

Fig. 1. Foaming capacities of *G. max* (Δ) and *A. africana* (X).

stable at the acid pH than at alkaline pH. Foam of *A. africana* flour suspension collapsed at pH 8 and 10 within 60 min. The better stability of the foams in the acid pH range may be attributed to the formation, in the acid pH range, of stable molecular layers in the air–water interface which impart to the foam stability and elasticity (Reichert, 1979). Since foam stability is governed by the ability of the film around entrapped air bubbles to remain intact, the poor foam stability at alkaline pH may indicate a negative correlation between alkalinity and surface activity.

Emulsification properties

Water dispersions of *A. africana* at its natural pH (6·8) at room temperature (27 ± 2°C) had a higher emulsion activity than an equal dispersion of *G. max* flour at its natural pH (6·5) and room temperature (Table 5). The results indicate that non-protein components in *A. africana* may have aided in the formation of an emulsion.

Table 3. Water absorption, oil absorption, bulk density and least gelation concentration of *Afzelia africana* and *Glycine max* (mean ± SD, *n* = 3)

Flour	Water absorption Capacity (g/g)	Oil absorption Capacity (g/g)	Bulk density (g/ml)	Least gelation concentration (% w/v)
A. africana	3·41 ±0·18	1·21 ±0·12	0·67 ±0·01	22·67 ±0·28
G. max	3·49 ±0·01	1·48 ±0·08	0·71 ±0·00	24·00 ±0·00

Table 4. Effect of pH on the foaming capacity and stability of 1% *Afzelia africana* and *Glycine max* flours (mean, $n = 3$)

Flour	pH	Original volume (ml)	Volume after whipping (ml)	Volume after times					
				30 min	60 min	90 min	120 min	150 min	180 min
A. africana	2	100	110	107	107	106	104	104	103
	4	100	104	104	104	104	103	103	103
	6	100	112	110	109	107	107	105	104
	8	100	108	105	103	103	102	100	100
	10	100	109	104	103	100	100	100	100
G. max	2	100	148	146	146	143	139	133	129
	4	100	114	113	111	110	110	108	108
	6	100	132	124	121	121	118	117	115
	8	100	125	121	119	117	110	110	108
	10	100	124	115	111	110	108	105	105

Table 5. Emulsion properties and effect of pH on the emulsion properties of *Afzelia africana* and *Glycine max* flours

Flour	Natural pH	pH 2	pH 4	pH 6	pH 8	pH 10
Emulsion activity (%)						
A. africana	56·19 ±0·95	53·70 ±0·93	53·67 ±0·96	54·29 ±0·58	53·30 ±0·96	51·11 ±0·55
G. max	52·83 ±1·26	52·67 ±0·58	47·00 ±1·00	53·97 ±0·55	53·03 ±1·39	52·67 ±0·58
Emulsion stability (%)						
A. africana	50·17 ±0·38	51·28 ±1·10	46·03 ±1·45	46·77 ±1·23	45·15 ±1·04	22·73 ±0·91
G. max	55·0 ±1·0	53·28 ±1·19	51·0 ±1·0	58·0 ±1·0	53·59 ±1·13	54·46 ±0·71
Emulsion capacity (EC) (ml/g) and emulsion apparent viscosity (η_A) (cp)						
A. afriana						
EC	175	150	175	175	150	75
(η_A)	572	1035	1178	579	502	228
G. max						
EC	225	200	150	175	250	250
(η_A)	1352	1622	301	1429	1445	313

Protein solubility was lowest at pH 4 (Table 2) but emulsion activity at this pH (53·7%) was relatively high and did not differ from the highest value at pH 6 (54·3%) where highest protein solubility was recorded. At pH 10, where there was high protein solubility (Table 2), emulsion activity value (51·1%) was lowest. Emulsion activity response of *G. max* flour to pH showed a pattern similar to its protein solubility. This might indicate the dependence of emulsification ability of *G. max* flour on dispersible protein.

Glycine max flour showed higher emulsion stability than *A. africana* flour at all pH values (Table 5). This implied that a greater percentage of the original emulsion of *G. max* flour, than of *A. africana,* remained stable after heating and centrifugation. The higher dispersible protein in *G. max* apparently enhanced encapsulation of the fat droplets and the formation of a stable emulsion. *Afzelia africana* flour showed very poor stability (23%) at pH 10. At natural pH (6·5–6·8) (Table 5), *G. max* flour had a higher emulsion capacity (225 ml/g), with an emulsion viscosity of 1351 cp, than *A. africana* flour, with an emulsion capacity of 175 ml/g and emulsion viscosity of 572 cp. The higher fat content (Table 1) of *A. africana* flour may have reduced its capacity to emulsify more oil.

The response of *G. max* flour emulsion capacity to pH shows a similar pattern to its protein solubility (Table 2) except at pH 6 where in spite of the high soluble protein, there was a relatively low emulsion capacity (175 ml/g) and emulsion apparent viscosity (1429 cp). *Glycine max* flour showed high emulsion capacity (250 ml/g) at pH 10 but the emulsion apparent viscosity (313 cp) was very low and the flour showed a high protein solubility. Similarly, *A. africana* flour had high protein solubility at both pH 2 and 10 but its emulsion capacity (75 ml/g) and emulsion apparent viscosity (228 cp) at pH 10 were lower than at pH 2. In *G. max* flour dispersion, both the emulsion capacity (150 ml/g) and emulsion apparent viscosity (301 cp) at pH 4 were low. Thus, emulsion properties may not be attributed to dispersible proteins only. Other flour components, such as insoluble protein and carbohydrates, may influence emulsification (McWatters & Cherry, 1977). The formation of thick mayonnaise-like emulsions by *A.*

africana flour at acid pH values rather than at natural and alkaline pH values may suggest suitability as a functional ingredient in acid food systems.

REFERENCES

AOAC (1984). *Official Methods of Analysis* (14th edn). Association Official Analytical Chemists, Washington, DC, USA.

Beuchat, L. R. (1977). Functional and electrophoretic characteristics of succinylated peanut flour proteins. *J. Agric. Food Chem.*, **25**, 258–62.

Del Valle, F. R., Escobedo, M., Munzo, M. J., Ortega, R. & Bourges, H. (1983). Chemical and nutritional studies of mesquite beans (*Prosopis juliflora*). *J. Food Sci.*, **48**, 914–18.

Keay, R. W. J., Onochie, C. F. A. & Stanfield, D. P. (1964). *Nigerian Trees* (Vol. 2). National Press Ltd, Apapa Publ. Fed. Dept. Forest Research Ibadan, Nigeria.

McWatters, K. H. & Cherry, J. P. (1977). Emulsification, foaming and protein solubility properties of defatted soybean, peanut and field pea and pecan flours. *J. Food Sci.*, **42**(6) 1444–50.

NAS (1979). *Tropical Legumes: Resources for the Future.* Report of an Ad Hoc Committee on Technology Innovation, Board on Sciences and Technology for International Development, Commission on International Relations and National Research Council, National Academy of Sciences, Washington, DC, USA.

Nath, J. P. & Rao, M. S. N. (1981). Functional properties of guar proteins. *J. Food Sci.*, **46**, 1255–9.

Poulter, N. M. (1981). Properties of some protein fractions from bambara groundnut. *J. Sci. Food Agric.*, **32**, 44–50.

Reichert, S. H. (1979). Physical–chemical properties of whey protein foams. *J. Agric. Food Chem.*, **28**, 665–8.

Sathe, S. K. & Salunkhe, D. K. (1981) Functional properties of the Great Northern Bean (*Phaseolus vulgaris* L.). Proteins: emulsion, foaming, viscosity, and gelation properties. *J. Food Sci.*, **46**, 71–81.

Sathe, S. K., Deshpande, S. S. & Salunkhe, D. K. (1982). Functional properties of winged bean (*Psophocarpus tetragonolobus* (L) D. C.) proteins. *J. Food Sci.*, **47**, 503–9.

Sosulski, F. W. (1962). The centrifuge method for determining flour water absorption in hard red spring wheat. *Cereal Chem.*, **29**, 344–50.

Tukey, J. W. (1977). *Exploratory Data Analysis.*. Addison-Wesley, Reading, MA, USA.

Wang, J. C. & Kinsella, J. C. (1976). Functional properties of novel proteins: Alfalfa leaf protein. *J. Food Sci.*, **41**, 286–92.

Yatsumatsu, K., Sawada, K. & Moritaka, S. (1972). Whipping and emulsifying properties of soybean products. *J. Agric. Biol. Chem.*, **36**(5), 719–27.