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FUNCTIONAL PROPERTY CHANGES IN HEAT PROCESSED SOYABEAN *(Glycine max)* MEAL

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ABSTRACT.

The functional characteristics of soyabean subjected to roasting (solely or combined with blanching as a pre-treatment) were evaluated. The process reduced nitrogen solubility drastically within a pH range of 2-10, except at pH4. Foaming capacity was reduced by roasting and foams obtained for samples subjected to the highest roasting temperature without defatting had better stability than raw soyabean meal. Gelation capacity and emulsifying activity were also reduced but about one-third of the heat processed samples had better emulsion stability. Water absorption capacity of soyabean meal was increased by 5.10 – 45.2% due to the heat treatments while changes in fat absorption were inconsistent. The effect of roasting on the water adsorption properties of the product were minimal. The results confirmed the suitability of roasted soyabean meal for use in food systems requiring high water holding capacity.

KEYWords. Functional properties, Soyabean, heat treatment, roasting process, blanching.

INTRODUCTION

Soyabean (*Glycine max*) is an important source of inexpensive protein in many developing countries. In Nigeria, the bean is mainly used as a food supplement and has been found to be suitable for the supplementation of several staple foods because of its unique nutritional properties. There are however, certain problems associated with the bean such as the inherent antinutritional factors, beany flavour and hard-to-cook characteristic which limit its utilization. Recent studies in this area have been geared towards increasing the utilization of the bean through the development of acceptable products. Badenhop and Hackler (1971) reported that roasting enhanced the sensory quality of soyabean. This processing technique also reduced the levels of some antinutritional factors in maize (Ayatse *et al.*, 1983), peanut and soyabean, (Aminigo *et al.*, 1993) and was more effective in reducing trypsin inhibitor activity than autoclaving. (Aletor and Ojo, 1989). Roasting therefore has potential to improve the acceptability of soyabean.

However the technique can denature proteins and thereby alter the functionality of soyabean proteins. Since functional properties also affect the utilisation of proteins in food systems (Vani and Zayas, 1995), an understanding of these is necessary for the enhanced utilisation of the beans. Roasting reduced the nitrogen solubility, gelation capacity, fat and water absorption of maize meal (Aminigo and Oguntunde, 2000) and reduced oil retention in sunflower meal. (Madhusudhan and Srinivas, 1987). Similarly micronization, a short-time and high-temperature dry treatment reduced nitrogen solubility of several cereals and legumes. (Zeng *et al.*, 1998).

Information on the functional properties of soyabean as affected by the roasting process is scanty in the literature. Considering the immense benefits derived from this kind of heat treatment in terms of the sensory and nutritional properties of the bean, it is important to study its effect on functionality. The present study investigated the functional properties of soyabean subjected to various roasting conditions.

METHODOLOGY

Soyabean variety TGX 996 – 25E was obtained from the International Institute of Tropical Agriculture, Ibadan, Nigeria.

Heat Treatments

The Soyabean seed was divided into two portions and one part was blanched for 30min in

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boiling water. Two hundred grams each of blanched and raw bean seed was roasted in a forced convection oven (size two Hotbox Oven, Gallenkamp, UK) at 130, 140 and 150°C for 20, 40 and 60 min. Roasting was performed in triplicate for each processing condition and the triplicate samples were combined and ground into meals with a Christy type 8 laboratory mill. Samples were defatted with hexane using a Tecator Soxtec system HT2 (Tecator, Sweden) Defatted and full-fat samples were packaged in polythene bags and kept at 4°C until analysis.

Functional Property Analysis

Nitrogen solubility was determined by the method of Vani and Zayas (1995). Emulsifying capacity and stability were determined using the

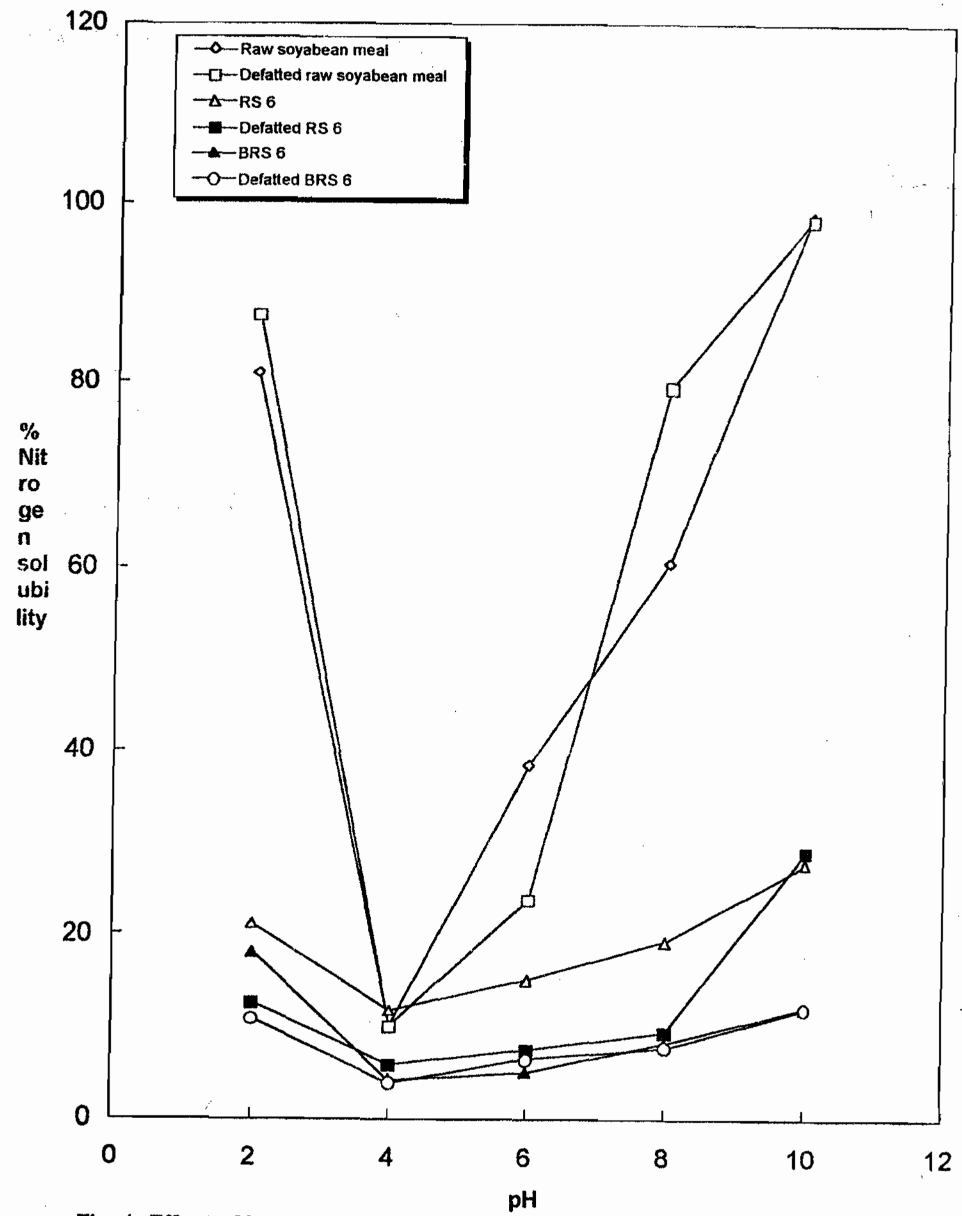

Fig. 1: Effect of heat treatment and pH value on the percent nitrogen solubility of soyabean meal

method of Yasumatsu *et al.* (1972). Foamability and gelation capacity were measured using the method of Sathe *et al.* (1982), and water absorption by the centrifuge method (Sosulski, 1962). Fat absorption was determined by the method of Sosulski *et al.* (1976), and water adsorption as described by Beuchat (1977) using saturated salt solutions to maintain relative humidities ranging from 11 – 97% (Rockland ,1960).

Statistical Analysis

Experimental data were analyzed by analysis of variance (ANOVA) and Duncan Multiple Range Test (SAS, 1982) was used to compare means of data.

RESULTS AND DISCUSSION

Nitrogen solubility profiles of the soyabean samples as a function of extraction pH are shown in Fig. 1. The nitrogen solubility of soyabean was reduced by blanching and roasting. The region of least solubility was pH 4 - 6 and changes in this property were drastic at all pH values with the exception of pH4. Pre-treatment prior to roasting further lowered nitrogen solubility appreciably. Defatting caused a pronounced reduction in

Table 1: Effect of heat treatment on the foamability[a] and foam stability of soyabean meal

	Volume after whipping (ml)	% Increase	Volume (ml) at room temperature (24°C) after time (hr)					
			0.5	1.0	1.5	2.0	3.0	4.0
Raw Soyabean meal	110± 0.50	10.0± 0.50[d]	108± 1.0	107± 1.0	106± 0.50	104± 0.50	102± 0.50	101± 0.50
RS 3	108± 0.50	8.00± 0.50[d]	103 ± 0.50	101± 1.0	101± 0.50	101± 0.50	100± 0.50	100± 0.50
RS 6	104± 0.50	4.00± 0.50[e]	103± 0.00	103± 0.00	103± 0.00	103± 0.00	103± 0.00	100± 0.00
RS 9	103± 0.50	3.00± 0.50[e]	103± 0.50	103± 0.50	103± 0.50	103± 0.50	103± 0.50	103± 0.50
Blanched Soyabean meal	101± 0.00	1.00± 0.00[e]	100± 0.00	100± 0.00	100± 0.00	100± 0.00	100± 0.00	100± 0.00
BRS 3	102± 0.00	2.00± 0.00[e]	102± 0.00	101± 0.00	101± 0.00	101± 0.00	101± 0.00	100± 0.00
BRS 6	104± 0.50	4.00± 0.50[e]	103± 0.50	103± 0.50	103± 0.50	103± 0.50	102± 0.50	102± 0.50
BRS 9	102± 0.50	2.00± 0.50[e]	102± 2.0	102± 1.00	102± 1.00	102± 0.50	102± 0.50	102± 0.50
Raw soyabean meal (defatted)	172± 2.0	72.0± 0 2.0[a]	172± 2.0	168± 1.00	166± 1.0	165± 0.50	165± 0.50	163± 0.50
RS 3 (defatted)	167 ± 0.50	67 .0± 0.50[b]	160 ± 0.50	152 ± 0.50	152± 0.50	140± 0.50	136± 0.50	121± 0.50
RS 6 (defatted0	167 ± 0.50	67.0± 0.00[b]	160± 1.0	154± 1.00	154± 1.0	142± 1.0	134± 0.50	124± 0.50
RS 9 (defatted)	166±1.0	66.0± 1.0[b]	161± 1.0	157± 1.00	155± 1.0	151± 1.0	136± 1.0	130± 1.00
BRS 3 (defatted)	165± 1.0	65.0±1.0[b]	160± 1.0	154± 1.00	150± 1.0	150± 1.0	148± 0.50	144± 0.50
BRS 6 (defatted)	165± 0.50	65.0± 0.50[b]	160± 0.50	156± 0.50	152± 0.50	146± 0.50	140± 0.50	134± 1.0
BRS 9 (defatted)	160± 0.00	60.0± 0.00[c]	154± 1.00	151± 1.0	148± 1.0	140± 1.0	136± 1.0	134± 1.0

[a] Values are means of 2 replicates. Where letters following means differ, the means (± standard deviation) differ significantly ($P < 0.05$).

Key to abbreviations:
RS = Roasted soyabean; BRS = Blanched and roasted soyabean.
Abbreviations are followed by figures indicating roasting conditions.

1 = 130°C, 20 min 2 = 130°C, 40 min 3 = 130°C, 60min

4 = 140°C, 20min 5 = 140°C, 40 min 6 = 140°C, 60 min

7 = 150°, 20 min 8 = 150°, 40 min 9 =150°C, 60 min

nitrogen solubility of the sample roasted at 140°C for 60 min at pH 4 –8 but had minimal effect on the control sample and the sample blanched prior to roasting. The region of least solubility obtained in this study corresponded with the isoelectric point of soyabean proteins (Quinn and Beuchat, 1975). The two samples roasted at 140^{0}C for 60min had lower nitrogen solubility than raw soyabean meal but generally had slightly higher solubility values than soy protein isolate extracted at similar pH range

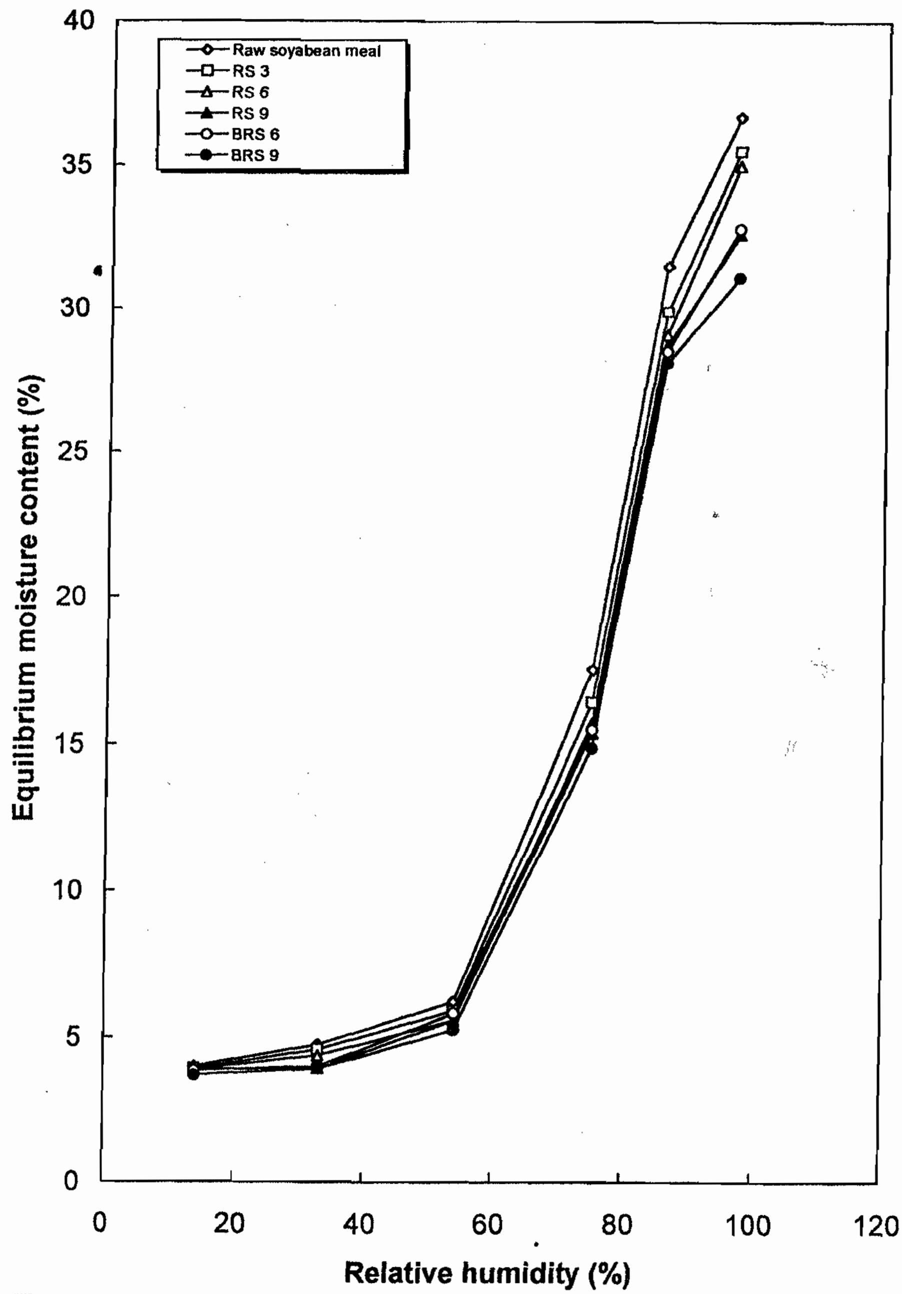

Fig. 2: Effect of heat treatment on the water sorption isotherm of soyabean

Table 2: Effect of heat treatment on fat absorption, water absorption, gelation capacity and emulsifying properties of soyabean meal.

Sample	Fat absorption capacity (%)	Water absorption capacity (%)	Gelation capacity (%)	Emulsifying properties	
				Emulsifying activity	Emulsifying stability
Soya bean meal	95.2± 076^{ef}	157± 0.561^{l}	16± 0.0^{e}	61.5± 0.53^{a}	92.4± 0.95^{bcd}
RS 1	100± 1.57^{bc}	214± 0.49^{b}	20± 0.0^{d}	47.3± 0.50^{b}	97.6± 0.0^{a}
RS 2	98.4± 1.03^{d}	204± 4.34^{cd}	22± 0.0^{c}	43.0± 0.70^{e}	56.5±1.15^{f}
RS 3	98.7± 0.41^{cd}	201± 1.51^{de}	22± 0.0^{c}	41.5± 0.35^{f}	24.8± 0.0^{h}
RS 4	98.3±0.58^{d}	207± 1.36^{c}	20± 0.0^{d}	41.4± 0.35^{f}	93.5± 0.35^{bc}
RS 5	98.6± 0.94^{d}	199± 1.10^{ef}	22± 0.0^{c}	35.4± 0.30^{i}	52.6± 0.25^{g}
RS 6	96.4± 0.78^{e}	195± 1.27^{f}	22± 0.0^{c}	25.5± 0.25^{k}	26.7± 0.75^{h}
RS 7	92.8± 0.42^{gh}	200± 0.42^{de}	20± 0.0^{d}	38.7±1.05^{h}	91.0± 0.65^{cd}
RS 8	91.1± 0.54^{hi}	181± 1.52^{hi}	22± 0.0^{c}	35.1± 0.45^{i}	50.1± 3.3^{g}
RS 9	85.3± 0.46^{k}	174± 3.43^{j}	22± 0.0^{c}	22.4± 0.25^{l}	57.0± 0.0^{f}
Blanched soyabean meal	90.5± 0.33^{ij}	228± 1.84^{a}	20± 0.0^{d}	44.2± 0.45^{cd}	86.1± 3.4^{e}
BRS 1	91.0± 0.51^{hi}	195± 1.32^{f}	20± 0.0^{d}	47.1± 0.25^{b}	94.3± 0.61^{b}
BRS 2	91.4± 0.41^{hi}	184± 1.69^{h}	20± 0.0^{d}	44.7± 0.25^{c}	94.0± 0.05^{b}
BRS 3	92.0± 0.65^{hi}	180± 3.30^{hi}	21± 1.0^{c}	42.7± 0.25^{ef}	93.8± 0.65^{b}
BRS 4	100± 0.66^{bc}	196± 1.60^{f}	20±1.0^{d}	44.8± 0.41^{c}	93.5± 0.78^{bc}
BRS 5	107± 0.98^{a}	189± 1.05^{g}	22± 0.0^{c}	42.6± 0.25^{de}	92.4± 0.40^{bcd}
BRS 6	102± 0.74^{b}	203± 1.15^{cd}	23±1.0^{b}	40.7± 0.55^{fg}	90.1±1.25^{d}
BRS 7	92.1± 0.43^{hi}	190± 0.09^{g}	20± 0.0^{d}	42.4± 0.31^{e}	87.0± 0.73^{e}
BRS 8	94.0± 0.85^{fg}	198± 1.35^{ef}	23±1.0^{b}	39.6±1.05^{gh}	87.0± 0.95^{e}
BRS 9	89.0± 0.54^{j}	165± 0.62^{k}	25±1.0^{a}	27.6±1.05^{j}	84.1± 0.60^{e}

Values are means of 3 replicates. Where letters following means within a column differ, means differ significantly ($P < 0.05$)

Key to abbreviations: Same as for Table 1.

(Ahmedna *et al*., 1999). Protein solubility affects functional properties such as emulsification, foamability and gelation (Kinsella, 1976) which are important in a variety of food products.

The foaming capacity of soyabean meal was reduced significantly by the two types of heat treatment, individually and combined (Table 1). The foaming capacities of defatted samples did not vary widely but were markedly higher than values for the full-fat samples. The effect of roasting on nitrogen solubility was thus similar to that on foaming capacity. Defatting greatly enhanced the foamability of roasted soyabean meal due to increased concentration of proteins which are responsible for foam production. In the case of the full fat samples foam stability was slightly lower for raw soyabean meal, and samples roasted at 150^{0}C for 60min had the most stable foams. On the other hand, defatted raw soyabean meal had a higher foaming capacity and better foam stability than the defatted heat treated samples.

Gelation capacity was significantly reduced by the heat treatments (Table 2). The concentrations of roasted soyabean meal required to form gels varied slightly and ranged from 22 – 25% in contrast to 16% for the control sample. Variations in the emulsifying properties of soyabean due to the heat treatments were more pronounced than in gelation capacity. The gelation capacity of raw soyabean meal obtained in this study was higher than that for winged bean flour (Sathe et al., 1982). The fairly high concentration of soyabean meal required to form firm gels is due to its low starch content as gels are formed by interactions of starch – starch or starch – protein. (Singh and Singh, 1991).

Emulsifying activity declined with increase in roasting temperature but about one-third of the roasted samples had higher emulsifying stability than the control sample. Blanched and roasted samples had slightly higher emulsifying activity and stability than the corresponding samples roasted without pre-treatment. The lowering of emulsifying activity by the heat treatments may be attributed to a reduction in nitrogen solubility. The implication is that supplementation of food products that require high foamability, emulsion and gelation capacities with roasted soyabean meal in appreciable quantities will affect functional properties adversely.

The fat and water absorption capacities of heat – processed samples are presented in Table 2. Changes in water absorption capacity were more pronounced than in fat absorption capacity. The heat treatments increased water absorption by 5.10-45.2% but the trend was inconsistent for fat absorption. For samples subjected to roasting alone, fat and water absorption generally increased initially and then decreased. The fat and water absorption capacities obtained for raw soyabean meal were higher than the values of 84% and 130% reported for soyabean flour (Lin et al., 1974). Increase in fat and water absorption may be due to the dissociation of proteins resulting in an unmasking of non-polar residues from within the protein molecule. (Abbey and Ibeh, 1987; Narayana and Narasinga Rao, 1982).

The sorption isotherms for raw and roasted soyabean samples are presented in Fig. 2. The equilibrium moisture content (EMC) of the control sample at 25°C ranged from 6 to 37%. Heat treatment reduced the water adsorption properties of soyabean meal minimally and sorption isotherms for roasted samples were generally similar to that for the control sample.

Roasting, a traditional cooking method in Nigeria, has varying effects on the functional properties of soyabean meal. The processing conditions employed in this study caused reductions in nitrogen solubility, gelation capacity, emulsification and foamability while changes in fat absorption capacity and sorption isotherms of soyabean meal were inconsistent and minimal, respectively. Water absorption capacity was significantly increased by roasting indicating that roasted soyabean would be a suitable ingredient in food systems that require high water holding capacity.

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