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Effect of Dry Milling Methods on the Functional and Nutritive Qualities of Soybean

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Abstract: The effect of dry milling methods was studies using hammer and attrition mill to process soybeans prepare by 3 different pre-milling methods. The functional properties, sensory properties and proximate analysis were carried out on the prepared samples. Results obtained show that sensory values for colour, flavour, taste and general acceptability for both hammer and attrition milled soy flour (milk) were not significantly different ($p<0.05$). The general acceptability values ranged from 2.9-3.9 and 2.9-3.7 for hammer and attrition milled soy flour, respectively. The proximate composition range values for both milling methods were also statistically similar ($p<0.05$). However, for functional properties foaming stability values for the 2 milling methods were different ($p<0.05$) with ranges between 58.3-116 and 62.5-120% for hammer and attrition mill, respectively Furthermore, gelation values were also different ($p<0.05$) and ranged between 18-20 and 16-18, respectively while each of the other functional properties examined were statistically similar ($p<0.05$). This study has shown that hammer milling method could be used for soy flour production if higher functional values for gelation characteristics is required and attrition should be favoured for higher foaming properties. If these properties are not priority it can be stated that there is no significant difference ($p<0.05$) between hammer and attrition milled soy flour.

Key words: Soybean, hammer, attrition milled, sensory properties

INTRODUCTION

Soybean is widely acceptable because of its major chemical component, which is, its protein. In fact in Nigeria today it has remain a very useful ingredient in the feed mill industries. The soybean protein has gained great commercial value because of its amino acid composition, which compliment that of cereal (Amogu, 1984). However, the use of protein in food depends on their functional properties. These are properties of proteins, which contribute some performance in aqueous dispersion to influence the structure, flavour and colour of food formulations. Kinsella (1979) defined functional properties as those physio-chemical properties of food proteins that determine the behaviour of food during processing, storage, preparation and consumption. These properties affect processing application, food quality and overall acceptance. Functionality as applied to food ingredients, is any property on which the utility of those foods depends.

According to Halling (1981) the term functionality refers to the functional demands made on food products with regards to their desired properties such as gelation, water/oil absorption and structure forming capacity. Vilence and Flavia (2006) also reviewed the relationship of protein structure to functionality and indicated that altering the chemistry of the food protein can improve functional properties such as water and oil absorption, emulsification, foaming and nitrogen solubility. Hua *et al.* (2005) also established that processing method affects the functional properties of protein food.

Thousands of tones of soy protein are used worldwide as a functional ingredient in the food and non-food industries in a variety of application. The main functional properties of soy protein are: hydrating capacity, solubility, colloidal stability, gelation, emulsification, foaming and adhesion/cohesion; in addition, it is applied as a fat substitutes, as well as in meat, fish, milk and cereal-based product and infant formulations (Vilene and Flavia, 2006; Flusa and Ria, 1995).

The proximate chemical composition of soybeans can vary depending on the growing conditions, but reasonable average figures are 40% protein, 20% lipid, 35% carbohydrate and 5% ash on a dry weight basis. The water content of stored mature Soybeans is usually about 12-14%, in order to ensure storage stability (Synder and Kwon, 1987). Olomu (1995) also stated the following chemical composition for full fat soybean: Drymatter; 90-94%, crude protein; 36-40%, fat contents; 18-19% and ash contents: 4.5-5.5%.

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Since effects of milling on chemical composition of materials were reported differently by researchers. A school of thought stated that it has no effect on milling while another stated that a noticeable effect could be observed depending on type of milling equipment (Makaujuola, 1984; Hasting and Higgs, 1980; Wennerstrum *et al.*, 2002; ERPT, 2001; Juliano, 1984). The essence of this research therefore, is to determine the effect of dry milling on the physio-chemical and functional properties of soybean, which will help food processing and other related industries in effective quality control management.

MATERIALS AND METHODS

Soybean seeds were purchased from (International Institute for Tropical Agriculture, Ibadan). The beans were cleaned, sorted and preliminary studies were carried out before flour processing.

Preparation of soy flour: Soybeans were prepared by three pre-milling methods stated below as adapted by Synder and Kwon (1987). Each of these three products were divided into 2 and milled by both attribution and hammer mill, respectively in order to obtained 6 samples A1 A2 B1 B2 C1 and C2 as defined below.

Sample A1: Whole soybean conditioned, tempered in water at 50°C and milted using hammer mill.

Sample A2: Whole soybean conditioned and tempered in water at 50°C and milled in attribution mill.

Sample B1: Whole soybean roasted on a bed of washed sand and milled using hammer mill.

Sample B2: Whole soybean roasted on a bed of washed sand and milled using attrition mill.

Sample C1: Whole soybean roasted in oven and milled using hammer mill.

Sample C2: Whole soybean roasted in oven and milled with attrition mill.

Conditioned processing method: the Soybean was conditioned at 50°C to about 23% moisture in tap water and tempered between 45-50°C for 1 h in a closed container to allow moisture equilibration. The conditioned soybeans were dried in oven at 100°C for 25 min. The beans were cooked, cracked and dehulled. The dehulled fruits were milled using hammer and attrition method, respectively to a particle size of 500 μm.

Sand roasted processing method: this was prepared by roasting soybeans on a bed of washed sand in frying pan at a temperature between 120-140°C for 10 min. The beans were cooled to room temperature. cracked. dehulled by winnowing and milled into flour using hammer mill and attrition mill, respectively to a particle size of 500 μm.

Oven roasted processing method: this was prepared by roasting soybeans in an oven at a temperature of 130°C for 15 min, The beans were cooled to room temperature, cracked, dehulled and milled into flour using both attrition and hammer mill, respectively to a particle size of 500 μm.

Preparation of soymilk from soy flour: Fifty gram of each sample of soy flour were weighed into containers. Three hundrad mililiter of distilled water was added for reconstitution. The solution was properly stirred and then left for 30 min after which it sieved using muslin cloth. The filtrate was pasteurized at 75°C for 5 min and 15g of sugar was added to each of the sample (Iwe and Agu, 1993).

Sensory evaluation: Panel of 8 untrained members determined the colour, taste and flavour of the milk sample. A 5-point descriptive hedonic scale was used. The evaluation was carried out in the laboratory at room temperature and the panelist were called one after the other to judge the sample by, smelling (flavour), observing (colour) and tasting (taste)/rinsing their mouth before proceeding to the other sample (Ihekoroye and Ngoddy, 1985).

Functional properties

Foaming capacity: The method described by Okezie and Bello (1988) was employed 1.0 g of sample was shaken with 50 mL distilled water for 2 min in 100 mL measuring cylinder. The mixture was homogenized for 5 min in a blender at high speed. The foam volume changes in the cylinder were observed and height of foaming recorded as a function of foaming capacity at intervals of 0, 1, 10, 30, 60, 90 and 120 min for each sample, replicate determinations were made and the mean value recorded.

$$\text{Height of Foaming, HF} = \text{Volume after whipping} - \text{Volume before whipping} \quad (1)$$

$$\text{Foaming Capacity, FC (\%)} = \frac{\text{Volume after whipping - Volume before whipping}}{\text{Volume before whipping}} \times 100 \quad (2)$$

Foam stability was determined by measuring the decrease in volume of foam as a function of time up to a period of 120 min.

$$\text{Foaming Stability, FS (\%)} = \frac{\text{Foam volume after time (t)}}{\text{Initial foam volume}} \times 100 \quad (3)$$

Gelation: The method of coftmann and Garcia (1976) as modified by Sathe and Salunkhe (1981) was used. Samples: 2, 4, 6. 8, 10, 12, 14, 16, 18 and 20% (w/v) were prepared in 5 mL distilled water. The test tubes containing this suspension were heated for 1 h in a boiling water bath followed by rapid cooling under running tap water. The least gelation concentration was determined as that of the sample that did not slip from the inverted test tube.

Water/oil absorption: The method described by Okezie and Bello (1988) was used. 1g of sample was mixed with 5 mL distilled water or oil (refined soybean oil) for 3 min. The samples were then centrifuge at 5000×g for 30 sec and allowed to stand at room temperature for 30 min. The volume of the supernatant was noted in a 10 mL graduated cylinder, Density of water was assumed to be 1 g mL^{-1} and that of oil was determined.

$$\text{Water or oil absorption capacity, WA/OA}(g\,g^{-1}) = \frac{\text{Grams of water or oil absorbed}}{\text{Grams of sample}} \quad (4)$$

Emulsion capacity and stability: Emulsions were determined according to the method of Benchat (1977). The sample (1 g) was blended using a blender with 50ml of distilled water for 30 sec at high speed. Refined soybean oil was added in 5 mL portions gradually to decrease resistance to blending (subjectively). Emulsion stability point was taken to be the point of discontinuation of addition of oil. The amount of oil added up to this point was interpreted as the emulsifying capacity of the sample. The emulsion so prepared was then allowed to stand in a graduated cylinder and the volume of water separated at time interval of 10, 20 and 30 min was noted in each case as the emulsion stability.

Reconstitution index: Reconstitution index of the flour was determined by method of Banigo and Akpapunam (1987) 5 g of each sample was mixed with 50 mL of boiling water and the mixture was agitated for 90 sec. It was then poured into 50 mL graduated cylinder and volume of the mixture/sediment recorded after 10 min.

$$\text{The reconstitution index, R1}(mL\,g^{-1}) = \frac{\text{Volume of the sediment}}{\text{Weight of sample}} \quad (5)$$

Proximate analysis: Moisture content, ash content, crude protein, carbohydrate and crude fat were determined by the method of AOAC (1984).

Statistical analysis: Mean, standard deviation and analysis of variance were calculated on the data obtained. Least Significance Difference (LSD) among means were also calculated.

RESULTS AND DISCUSSION

Effect of milling methods on sensory qualities: The results in Table 1 indicated that there is no significant difference (p = 0.5) in the colour, taste, flavour and general acceptability of samples A1, A2, B1, B2, C1 and C2.

These show that milling does not have significant effect on the taste, flavour, colour and general acceptability of the samples and this is inconformity with the finding of Makanjuola, (1984).

Effect of milling on functional properties of soy flour

Foaming properties: The results in Table 2, show that the foaming characteristics of sample A1 and A2, B1 and B2 with C1 and C2 differ significantly at $p<0.05$. This is an indication that the milling method has significant effect on the foaming capacity and this has been attributed to the heat generated by high mechanical impact during the hammer milling of the samples which tend to lower the foaming capacity of the samples and this corresponds to the finding of Wermerstrum *et al.* (2000), Hutton and Cambell and Hasting and Higgs (1980) which indicated that much heat is generated in hammer mill than attrition mill.

Emulsion capacity, gelation, water/oil absorption and reconstitution index: The results in Table 3 shows that the gelation of samples A1 and A2, B1 and B2 with C1 and C2, respectively differ significantly. The observed differences in the gelation could be due to varied effect of processing on the proteins of the soy flour. Since protein concentration, incubation temperature and time as well as mechanical force are known to affect gelation of protein (Hutton, 1977; Synder and Kwon, 1987).

Table 1: Effect of milling on the sensory qualities of soy flour (milk)

Sample	Colour	Flavour	Taste	General acceptability
A1	$3.5_a\pm0.53$	$4.5_a\pm0.76$	$3.5_b\pm0.53$	$3.8_a\pm0.64$
A2	$3.6_a\pm0.52$	$4.5_a\pm0.53$	$3.5_b\pm0.53$	$3.7_a\pm0.71$
B1	$2.0_b\pm0.53$	$2.9_b\pm0.35$	$3.8_b\pm0.35$	$2.9_b\pm0.83$
B2	$2.0_b\pm0.53$	$2.8_b\pm0.46$	$3.7_b\pm0.46$	$2.9_b\pm0.64$
C1	$3.1_a\pm0.99$	$3.9_a\pm0.35$	$4.3_a\pm0.52$	$3.9_a\pm0.53$
C2	$3.1_a\pm0.83$	$3.8_a\pm0.46$	$4.2_a\pm0.71$	$3.8_a\pm0.46$

mean±STD, mean value in the same row with different letter are significantly different (p = 0.05)

Table 2: Foaming height (mL) and foaming stability (%)

Sample	0 min	1 min	10 min	30 min	60 min	90 min	120 min
A_1	(4.9) [100.0]	(5.7) [116.0]	(5.7) [116.0]	(5.7) [116.0]	(5.2) [106.0]	(5.2) [106.0]	(5.0) [101.0]
A_2	(5.0) [100.0]	(6.0) [120.0]	(6.0) [120.0]	(6.0) [120.0]	(5.5) [110.0]	(5.5) [110.0]	(5.0) [100.0]
B_1	(4.0) [100.0]	(3.8) [95.01]	(3.8) [95.01	(3.6) [90.0]	(2.4) [60.0]	(2.4) [60.0]	(2.4) [60.0]
B_2	(4.0) [100.0]	(4.0) [100.0]	(4.0) [100.0]	(3.0) [75.0]	(2.5) [62.5]	(2.5) [62.5]	(2.5) [62.5]
C_1	(4.8) [100.0]	(4.8) [100.0]	(3.9) [81.3]	(3.0) [62.5]	(3.0) [62.5]	(2.8) [58.5]	(2.8) [58.3]
C_2	(5.0) [100.0]	(5.0) [100.0]	(4.0) [80.0]	(3.0) [60.0]	(3.0) [60.0]	(3.0) [60.0]	(3.0) [60.0]

Replicate readings were determined and the mean taken, ** (foam height) (foam stability)

Table 3: Emulsion capacity, least gelation, water absorption, oil absorption

Sample	Least Gelation (LG) %	Water Absorption (WA) g g^{-1}	Oil Absorption (OA) g g^{-1}	Emulsion Capacity (EC) mL g^{-1}	Reconstitution Index (RI) mL g^{-1}
A1	18.00	2.80	2.62	3.20	1.20
A2	16.00	2.75	2.67	3.00	1.25
B1	20.00	2.00	2.90	2.70	1.80
B2	18.00	2.00	2.94	2.50	1.80
C1	18.00	2.15	2.53	3.30	2.00
C2	16.00	2.15	2.57	3.20	2.15

Table 4: The proximate composition of soy flour

Sample	Moisture Content (MC) %	Ash Content (AC)%	Crude Protein (CP) %	Crude Fat (CF) %	Carbohydrate (CH) %
Al	4.81	5.20	41.69	20.00	28.30
A2	4.80	5.30	41.59	20.00	28.31
BI	3.20	5.40	41.40	20.30	29.70
B2	3.21	5.38	41.20	20.30	29.91
C1	5.40	5.20	41.32	20.00	28.08
C2	5.38	5.25	41.35	20.00	28.02

Although, there were slight variation in values obtained for oil absorption of the 2 samples for the three processing method. However, it could be stated that water absorptions, oil absorptions and reconstitution index for the two milling method are not significantly difference ($p<0.05$). It is clear that milling has no effect on these properties.

Proximate composition: From the results presented in Table 4 samples B 1 and B2 had the least moisture content. This indicated that roasting on the bed of sand conduct greater heat than the oven. It is also clear that the proximate composition of the soy flour was not affected by milling methods. Although, the slight variation in the moisture content could be due to the storage condition and the treatment before and during processing (Makanjuola, 1984; Olomu, 1995).

CONCLUSION

The following conclusions could be drawn from this study:

- Pre-processing treatments have more effects on sensory qualities, proximate and functional properties of soy flour, rather than the milling methods employed.
- Hammer milled soy flour produced higher functional values for gelation than attrition milled soy flour.
- Attrition milled soy flour produced higher functional values for foaming characteristics than one milled with hammer.
- Sensory properties, proximate composition and functional properties for water absorption, oil absorption, emulsion capacity and reconstitution index for both hammer milled and attrition milled soy flour were not significantly different.
- Either Hammer or attrition milling method could be used for soy flour if foaming characteristic or gelation properties are not priority.

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