Effect of Hull on the Physico-Chemical Properties of Soyflour

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ABSTRACT

This study investigated the effects of hull on the physico-chemical properties of flour obtained from processed soybean seed. Dehulled and undehulled soybeans at moisture levels ranging from 8.1% to 22.1% were boiled and oven dried. Similarly dehulled and undehulled soybeans at 12% moisture content (MC) were subjected to Thermal Processing (TP) methods of Roasting (ROA), Extrusion (EXT), Boiling and Sun Drying (BSD) and Boiling and Oven Drying (BOD) and used to prepare soy flour samples. The samples were milled in an attrition mill and the flours obtained were subjected to particle size, proximate composition and organoleptic evaluations. The results showed that between moisture content of 8.1% to 22.1%; 8.2% and 19.8% for dehulled and undehulled respectively, protein increased from 27.71% to 40.02% and 20.86% to 37.46%, acceptability increased from 4.6 to 5.4; 3.0 to 4.6 and yield reduced from 8.3% to 2.5%; 4.3% to 2.0% respectively. Though protein was increasing with MC, there is no significant difference ($p>0.05$) in protein retention between MC difference of 10.2%-22.1%, and 10.2%-19.8% but becoming significant at MC of 9.4% and 9.2%. TP treatment test for dehulled samples, showed a protein content of 36.69%, 38.47%, 34.83% and 35.55%, flour yields of 24.60%, 7.30%, 16.70% and 26.40%, and acceptability of 6.8, 6.9, 5.0, and 6.0 while for undehulled; protein content of 33.70%, 34.34%, 32.7% and 32.77%, flour yields of 17.0%, 5.00%, 14.06% and 12.25% and acceptability of 6.4, 6.8, 4.8 and 6.0 for BOD, EXT, ROA and BSD respectively. These results have not indicated any considerable reduction in the nutritive composition of the fibrous food but differences in acceptability which were all above the threshold.

Keywords: Moisture content, thermal treatment, yield, acceptability, protein, Nigeria

1. INTRODUCTION

The importance of soy flour and other grain legumes in the dietary need of the developing countries as well as the need for studies on the processing techniques with a view to effectively utilize, obtain the necessary nutrients and increased acceptability of soy products were highlighted in previous reports (Famurewa and Raji, 2005; Raji and Famurewa 2005; Shimelis *et al*., 2006). Dehulling is necessary in the processing of some seeds such as locust bean (*Ceratonia siliqua)* (Oloso, 1988; Audu *et al.*, 2004) and African Mesquite (*Prosopis africana*) (Raji and Akaaimo, 2005). However there are a number of other seeds subjected to dehulling during processing basically to improve the appearance and quality of the final products. These legumes, which include soybean, are one of these products. Unlike the seeds stated above, removal of the hulls in legumes is not necessarily a requirement before consumption but for the reasons stated. While efforts have been made on the development of appropriate dehulling methods and techniques (Raji and Akaaimo, 2005), there is a need to investigate the effect of these processes on the quality of the final products.

Flour refining and changes in dietary habits resulted in a decrease in the consumption of dietary fibre by fifty percent during the past two centuries. Epidemiological studies relate low fibre intake to many diseases particularly those of the gastrointestinal tract (Birdsall, 1985). Burkitt (1982) claimed that the large amount of fibres consumed by African natives protects them from suffering from many diseases common to western man such as cardiovascular disease, colon cancer, diverticulae, appendicitis, hemorrhoids and varicose vein of the legs. A diet consisting of a low-fat whole grain staple food such as whole grain bread would provide protective effects against colon cancer. Because bran reduced the number of tumors induced by chemical carcinogens in animal models (Bingham, 1990), it was concluded that it protects humans from colon cancer. A hypothesis for this effect is that fiber decreases intestinal contact with carcinogens.

Diets high in fiber such as whole cereal grains, legumes, and vegetables are usually the custom in populations with very low incidence of cardiovascular disease (Brown and Karmally, 1985; Anderson 1990). Studies indicate that high-fiber diets decrease blood pressure in normal as well as hypertensive subjects (Birdsall, 1985). For elevated blood serum lipids, dietary recommendations included increasing carbohydrate consumption to make up sixty five percent of total daily calories, emphasizing complex carbohydrate from nature (Gotto *et al*., 1984) because they influence the absorption of fat-soluble substances from the digestive tract and the reabsorption of bile acids neutesteroils (Hodges, 1985).

Constipation is a major problem which may lead to hemorrhoid diverticulae and even contribute to the development of varicose vein (Burkitt, 1982). Bran decreases intestinal transit time (Payler *et al*., 1985), it is one of the best fecal bulking agents identified (Cummings, 1982) and is even more effective in raw form because of the structural changes that occur in the latter, increasing the amount of bacterial degradation it undergoes in the intestine (Pomeranz, 1988).

It is however observed that the removal of bran and hulls from food materials during processing is becoming popular in the developing world (Audu *et al*., 2004). This is as a result of introduction of foreign food products which appear neater, smoother and more attractive. In Nigeria it is common to find corn pap to be heavily composed of fibre as the corn is not dehulled before processing. However the trend is changing as people are more interested in smooth pap. Corn is therefore dehulled before further processing. This is the same for other crops such as guinea corn, rice, millet and cowpea which are the staple cereals and grains forming part of the daily delicacies in Nigeria and most West African countries. The objective of the presented work was to investigate the effect of the hull (the fiber content) on the physicochemical qualities of soy flour since fiber inclusion is beneficial to human health. Soy products are becoming increasingly popular in most of these nations serving as a cheap source of supplement and alternative protein, in form of a number of processed products, in place of the expensive animal products that are the sources of protein in the daily diets (Tijani-Eniola and Akinnifesi, 1996; Raji and Famurewa, 2005). It is therefore important to study the effect of hull and fibre content on the nutritive quality of soy products.

2. MATERIALS AND METHODS

2.1 Source of Soybean Samples.

Soybean with mixed variety which is the most commonly used was obtained from the main market, Akure, Nigeria. The seeds were first cleaned in a soybean destoner developed by Isikaye (2002) to remove stones and other debris. The beans were then subjected to the following treatments using the methods of Famurewa and Raji (2005) and Raji and Famurewa (2005).

2.1.1 Pre-Treatment and Dehulling Operations (Moisture Content Variation Test)

Ten kilogrammes (10kg) of soybean seeds at initial moisture content of 12% were divided into two parts. One portion was soaked in water at room temperature (28°C) for 12 minutes, followed by manual method (i.e. hand rubbing within two palms) to remove the testa. The floating testa on the soaked water were removed by decanting until no testa were present. Boiling of dehulled seeds was done for 30 minutes (Edem, *et al.*, 2001) in ordinary water to inactivate the trypsin inhibitor. Each of the dehulled and undehulled portions was divided into ten portions labeled A to J. They were placed in an oven (Blue-M SW-17TA, Blue-M Electric, Illinois) set at 60°C. Sample A was oven dried for 1hr, B for 2hrs, C for 3hrs,…, I for 9hrs and J for 10 hrs. Each sample was weighed using a top loading compact digital weighing balance EK-H6000i (A and D Company Ltd, Japan) after its drying period and the weight recorded (Famurewa and Raji, 2005).

2.1.2 Thermal Pre-treatment and Dehulling Operations

Eight kilogrammes (8kg) of cleaned soybean seeds, which were at the initial moisture content of 12%, were divided into 2 portions. One portion was soaked in water for 5 minutes, dehulled, drained and dried back to 12% moisture content. The procedures for each of the treatment are as presented in 2.13-2.16.

2.1.3 Boiling and Sun Drying (BSD): Boiling of 1kg of each dehulled and undehulled samples was done for 30 minutes (Muller, 1988). The two samples were sun dried (under daily temperature range of 23-36^{o}C and relative humidity of 64-79% for four days to obtain a constant weight.

2.1.4 Boiling and Oven Drying (BOD): Each of the dehulled and undehulled samples were oven dried at a temperature of 60°C (Edem *et al*., 2001) to a constant weight.

2.1.5 Roasting (ROA): Roasting of 1kg of each of the dehulled and undehulled samples was done on temperature controlled hot plate set as 105°C for 50 minutes (this was achieved from preliminary trials), to a constant weight.

2.1.6 Extrusion (EXT): One kilogramme of each sample was poured into Insta Pro Model 600 extruder, rated to operate at 600 kg/hr. The extruder barrel crushes the soybeans and mechanically forces the bean material past a series of steam lock restrictions via a screw press.

2.2 Milling of Soy Samples

Each of the samples was milled to flour using an attrition mill driven by a 3.74kW electric motor. The plate mill has burrs of 300mm diameter, slope of 25° to the horizontal and a variable screw conveyor of 12mm pitch length. The milling was done at gap set of 1mm (Asiedu, 1989) through only one milling run.

2.3 Analyses of Samples

Three analyses, chemical and sieve analyses (particle size) as well as organoleptic evaluation, were carried out on each soy flour sample with 3 replications.

2.3.1 Sieve Analysis: A sample of 250g was weighed into a set of seven sieves (Endecotts, England) and operated for 5 minutes in a WQS Vibrator Rotap machine (Shanghai Precision & Scientific Instrument Co,.Ltd). The material retained on each sieve was weighed and the fineness modulus and particle size analyses were done. The sieves' numbers are according to the standard sieve numbers shown in ASAE Standard S319.3 (ASAE, 2003) i.e. the first seven micro-m sieves. Flour yield from each analysis was determined by adding together the quantity of material retained on the sieves that fall into flour size category (<212µm).

2.3.2 Chemical Analysis: This involved the determination of the proximate composition of each sample based on the standard of AOAC (1990). Average of 3 replications was used.

2.3.3 Organoleptic Evaluation: Each of the soy flour samples was used to produce soy/wheat bread (5%:95%) for sensory evaluation. The supplemented breads were evaluated in terms of appearance, colour, taste, aroma, crumb texture, crust texture and overall acceptability using 7 points Hedonic scale. Acceptability ranges from 1 (dislike very much) to 7 (like very much) while the value of 4, which is also taken as threshold, means 'Neither like nor Dislike'. 100% wheat flour bread was also presented as the control.

2.3.4 Statistical Analysis: Data were analysed using SPPS for Windows 10. The statistical significance of the observed difference among the means of triplicate readings of experimental results obtained were evaluated by analysis of variance (ANOVA) at 5% level of significance

3. RESULTS AND DISCUSSION

The results obtained on the influence of each of the parameters on retention of protein, flour yield and overall acceptability of the soy flour samples are presented in Tables 1 to 8 and Figures 1-4.

3.1 Flour yield and Particle Size at Different Moisture Levels

The results of sieve analysis of soybean flour samples, and the relationships with corresponding R^2 showing good fit, at varying moisture content for particle size and flour yield respectively are as presented in Figures 1 and 2. The absolute values of yield of the dehulled samples at the same moisture level are greater than those of the undehulled but vice versa for the particle size. This could be attributed to the fact that the undehulled samples are more fibrous because of the bran. Fibrous materials require more energy during milling than non fibrous materials (Ogundipe, 1989).

As observed from the results, flour yield of soybean during milling greatly depends on the moisture content of the seeds at the time of milling. This explains the high negative relation illustrated in Figure 2. From the analysis, assumption of linearity is often used but it was found that the best fit is a power relationship except for the particle size for undehulled (Figures 1 and 2). There are two possible reasons that could be responsible for these observations as reported by Famurewa and Raji (2005) and Raji and Famurewa (2005). Firstly, during dry milling, the serrations on the surfaces of the plates of burr mill get blinded when high moisture seeds are milled (Famurewa, 1997). When the serrations are blinded or gummed, shearing effect of the plates is reduced hence the large particle sizes and the reduction in the yield. Secondly, during milling, the part of the kinetic energy from the prime mover for disintegration of the seeds is converted into heat. The heat is more in dry milling than wet milling. As a result of the heat, gelatinization of starch takes place when high moisture seeds are milled leading to reduced flour yield.

3.2 Acceptability of Flour Produced with Moisture Variation.

The results obtained from organoleptic evaluation of the (5% soy/95% wheat) bread produced from undehulled and dehulled soybean flour at different moisture content are presented in Tables 1 and 2. The highest possible value which is ‘Like very much’ is 7 while the threshold is 4, that is ‘Neither like nor Dislike’. This shows that any value above 4 is above average and can be considered acceptable for all the parameters.

From Tables 1 and 2, it is evident that all the parameters for the dehulled flour are above average while the bread from the undehulled flour are generally below average for all the parameters except for the aroma and appearance. The aroma for the undehulled is acceptable at all moisture levels (almost the same scores) though with a slightly lower acceptance compared to the dehulled samples while the appearance was attractive at all moisture contents from 15.5% and below. The acceptability levels for dehulled samples are on the positive side of the threshold (Hedonic scale 4). The undehulled samples were reduced in acceptability as moisture content decreased while acceptability is almost the same for all moisture content in the dehulled samples as can be observed in the statistical difference values in Table 2. However the levels of acceptability at low moisture contents are higher than those of high moisture contents for the dehulled samples. The reason for low acceptability of undehulled samples at low moisture content may be due to deeper yellowish colour of soy flour samples at low moisture content which is possibly due to more quantity of the bran that is reduced to flour size at lower moisture content thereby making the flour to lose its attractiveness. This is evident from the decreasing values for appearance at lower moisture contents.

In both samples (Tables 1 and 2), as the moisture content of the soybean used decreased the aroma increased in all the supplemented samples while crust and crumb textures have direct correlation with moisture content. The crumb and the crust texture were not acceptable to the consumers (they were below the threshold) although the level of acceptance was the same as the conventional wheat bread. Acceptability maintains a direct correlation with moisture content.

For undehulled there is no significant difference between the acceptability levels at moisture content between 15.5% and 11.4%. For the dehulled, between moisture content of 22.1% and 12.4% taste and appearance have no definite correlation with moisture content, but direct correlation exist below 12.4% while aroma has indirect correlation. The control sample has the least acceptability of all the samples (4.6). This shows that wheat-bread supplemented with soyflour is therefore a promising substitute for 100% wheat-flour bread.

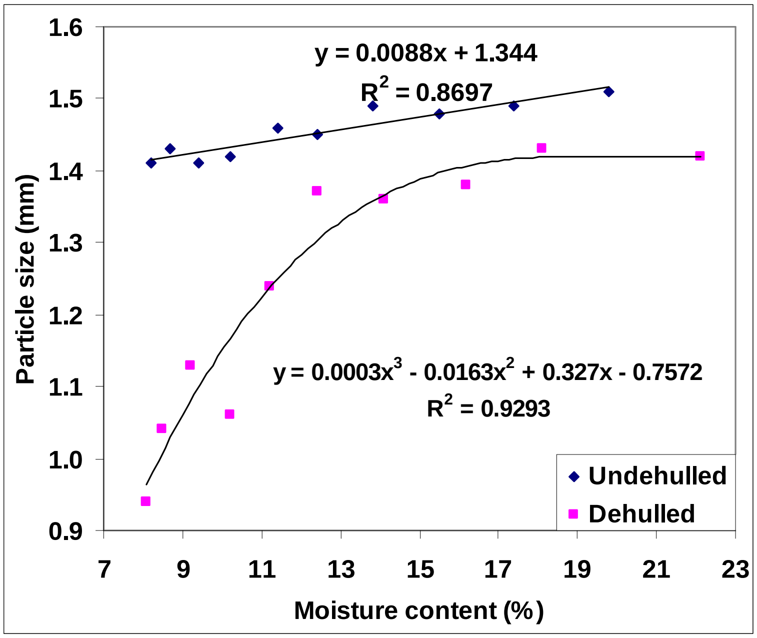

Figure 1. Particle size as affected by moisture content

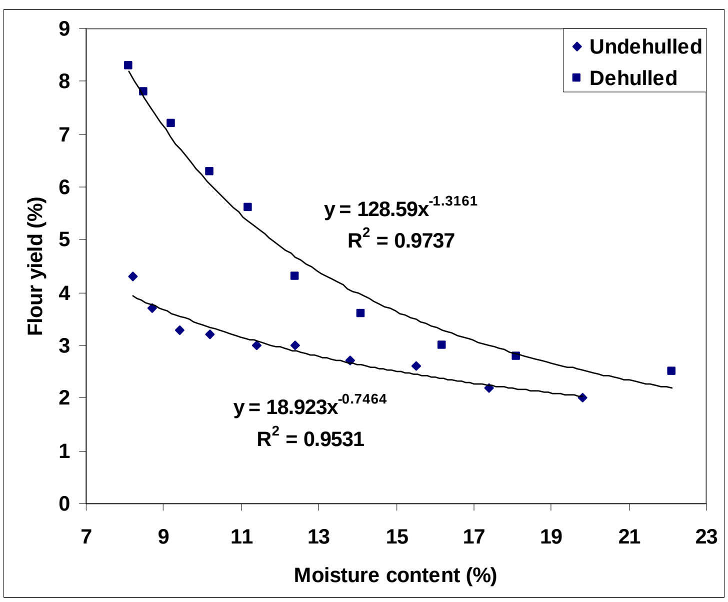

Figure 2. Flour yield as affected by moisture content

Table 1. Organoleptic evaluations of soy/wheat bread from undehulled seed at varying moisture content

Moisture content	**Acceptability**	**Taste**	**Appearance**	**Aroma**	**Crust texture**	**Crumb texture**
19.8	4.6[c]	3.7	3.6	4.5	3.2	2.7
17.4	4.1[c]	3.8	3.8	5.1	2.8	2.7
15.5	3.7[b]	3.8	4.1	5.1	2.7	2.7
13.8	3.6[b]	3.7	4.4.	5.1	2.5	2.7
12.4	3.6[b]	3.8	4.7	5.2	2.4.	2.6
11.4	3.6[b]	4.0	5.2	5.2	2.4	2.4
10.2	3.4[ab]	3.9	6.1	5.9	2.5	2.4
9.4	3.4[ab]	3.9	5.6	6.0	2.3	2.3
8.7	3.2[ab]	4.1	4.5	6.5	2.3	2.2
8.2	2.8[a]	4.5	4.0	6.8	2.0	1.9
100% wheat	3.0	4.0	4.3	4.4	2.8	2.7

Values are means of three replicates
Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

Table 2. Organoleptic evaluations of soy/wheat bread from dehulled seed at varying moisture content

Moisture content	**Acceptability**	**Taste**	**Appearance**	**Aroma**	**Crust texture**	**Crumb texture**
22.1	5.4[a]	4.7	5.8	4.3	3.2	2.7
18.9	5.2 [b]	4.8	5.8	4.9	2.8	2.7
16.2	5.3[b]	4.8	6.3	4.9	2.7	2.7
14.1	5.3[b]	4.5	6.3	5.0	2.5	2.7
12.4	5.1[ab]	4.9	6.4	5.0	2.4	2.6
11.2	5.4[b]	4.8	6.4	5.0	2.4	2.5
10.2	5.7[bc]	4.8	6.3	5.3	2.4	2.4
9.2	6.0[c]	4.7	6.1	5.5	2.3	2.3
8.5	5.6[bc]	4.5	5.8	5.6	2.3	2.2
8.1	5.8[c]	4.0	5.6	5.7	2.0	1.9
100% wheat	4.6[a]	3.9	6.0	4.8	3.8	2.7

Values are means of three replicates
Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

3.3 Proximate Composition of Soyflour with Varying Moisture Content

The results of proximate composition obtained from subjecting undehulled and dehulled soybean to moisture content variation are presented in Tables 3 and 4. Protein, fat, ash and fibre were decreasing with a decrease in moisture while carbohydrate increased. For the undehulled samples, significant differences between the values of protein occurred only at moisture contents below 10.2%. The result of the proximate composition of dehulled soybean flour sample obtained at different moisture content, presented in Table 4, follows the same pattern as that of undehulled samples presented in Table 3, only that the dehulled sample has higher protein, fat and carbohydrate content and less ash and fiber. There is significant difference between protein contents below 10.2% moisture content.

The rate of decrease of protein at lower moisture content is faster than at higher moisture content. It was observed that the dehulled samples have higher values than the undehulled at the same moisture level. This can be attributed to inclusion of bran in the undehulled samples which resulted in reduced percentage composition of endosperm. Protein is contained in the endosperm. The fibrous portion of soybean might have broken down to simpler non fibrous causing reduction in the bulk of fiber content of soy flour. Maillard reaction might have been responsible for reduction in protein, in the presence of heat, proteins (amino acids) would react with carbohydrate to form melanoidins (Baltes, 1982).

Table 3. Proximate composition of flour from undehulled soybean at different moisture content.

MC	Protein	Fat	Fibre	Ash	CHO
%	%	%	%	%	%
19.8	37.46[c]	23.61	8.64	8.04	12.25
17.4	36.38[c]	23.08	8.12	7.92	14.80
15.5	35.43[bc]	22.56	7.49	7.66	16.86
13.8	34.63[bc]	21.72	7.19	7.48	18.98
12.4	34.02[bc]	20.54	6.87	7.36	21.21
11.4	33.42[bc]	19.62	6.63	7.41	22.72
10.2	32.51[bc]	18.24	6.72	7.57	24.92
9.4	29.77[b]	16.94	6.53	7.23	28.16
8.7	25.14[ab]	16.63	6.59	6.81	28.20
8.2	20.86[a]	16.06	6.44	6.35	30.2

Values are means of three replicates
Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

Table 4. Proximate composition of flour from dehulled soybean at different moisture content.

MC	Protein	Fat	Fibre	Ash	CHO
%	%	%	%	%	%
22.1	40.73[c]	26.30	7.87	7.34	17.76
18.9	40.04[c]	24.92	7.28	6.58	21.38
16.2	39.44[c]	23.51	6.42	6.54	24.09
14.1	37.72[bc]	23.45	6.22	6.32	24.29
12.4	36.53[bc]	22.98	6.00	5.97	26.52
11.2	35.76[bc]	22.14	5.78	5.80	28.52
10.2	34.64[bc]	22.25	5.63	5.62	31.86
9.2	31.12[b]	21.27	5.36	5.36	36.89
8.5	28.48[ab]	20.62	5.20	5.28	40.42
8.1	24.53[a]	19.90	5.03	5.04	44.50

Values are means of three replicates
Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

3.4 Flour Yield of Soyflour from Thermally Treated Dehulled and Undehulled Soybean.

The average particle size (APS) and yield for soyflour obtained from the soybean seeds subjected to thermal treatments are presented in Figures 3 and 4. The analysis of the undehulled samples showed that boiled and oven dried samples produced the highest flour yield of 17% with smallest APS of 0.90mm while extrusion method had the least yield of 5.0% with highest APS of 1.18mm (Figures 3 and 4). The yields of the boiled and oven dried (BOD) sample was significantly different ($p<0.05$) from others but there was no significant difference in the yields of roasted (ROA) and boiled and sun dried (BSD) sample. The dehulled samples on the other hand had the least yield (7.3%) from extrusion (EXT) samples with highest APS of 1.13mm though higher than undehulled. BSD sample yielded the highest flour (26.4%) with least APS of 0.74mm. There is no significant difference ($p>0.05$) in the yield of BOD and BSD. Generally the dehulled samples yielded higher than corresponding undehulled samples.

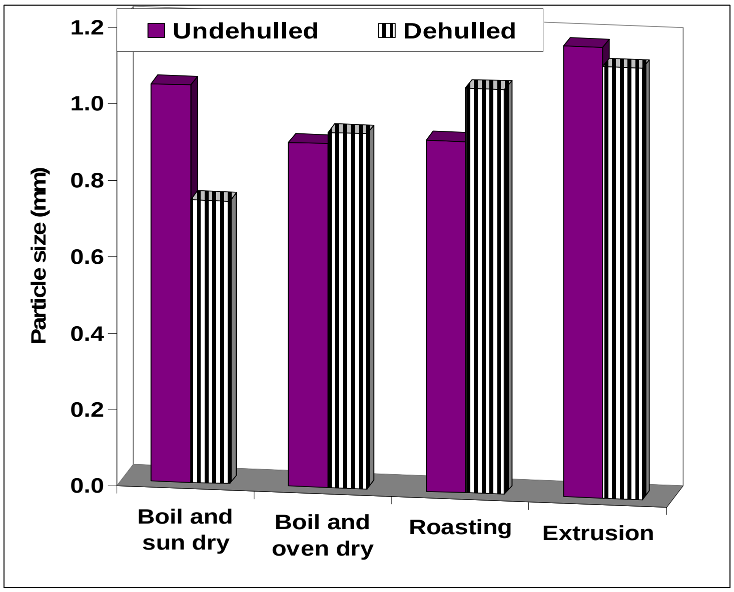

Figure 3. Average flour particle size after one pass milling for thermally treated soybeans.

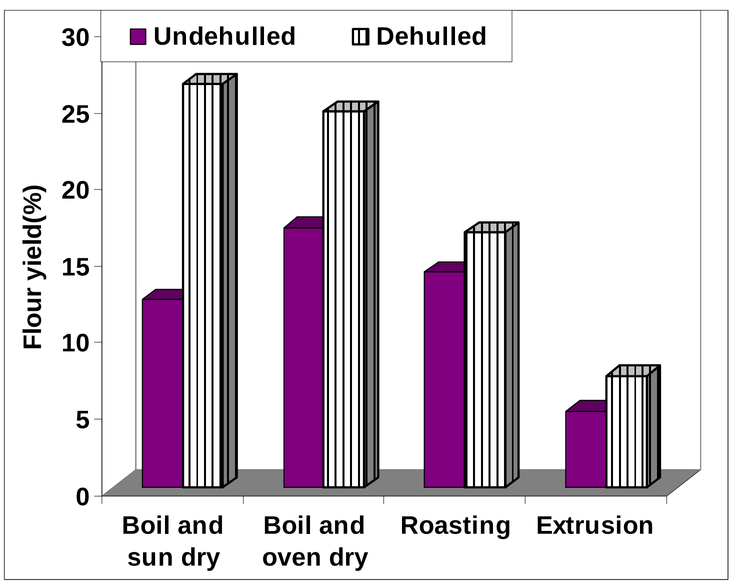

Figure 4. Flour yield of thermally treated soybeans

The fibrous nature of the bran of the undehulled samples is possibly responsible for their low yield, compared to dehulled samples that contain no bran. During extrusion, high heat and pressure is generated in the barrel of the extruder. Gelatinization of starch takes place in the presence of water, heat and pressure. Gelatinization of the starchy constituent of soy bean during extrusion is the possible reason for low yield in extruded sample.

3.5 Organoleptic Characteristics of Soyflour from Thermally Treated Soybean

The results of organoleptic evaluation of bread produced from soy flours used to supplement wheat bread (5% soy/95% wheat) obtained from thermally treated undehulled and dehulled soybean are presented in Tables 5 and 6, respectively. In all the sensory characteristics, the least accepted breads were those produced from the roasted beans and their values are significantly different from other samples. However all the tested samples were above the threshold values which imply that the breads produced were acceptable. There is no significant difference in the overall acceptability of control, BOD and BSD samples (Table 5) for the undehulled samples. In the dehulled samples, acceptability of the breads produced from the boiled and sun dried and control samples are not significantly different but both are significantly different from boiled oven dried and extruded samples.

Table 5. Organoleptic evaluation of soy\wheat bread from thermally treated undehulled soybean

Treatment	Acceptability	Taste	Appearance	Aroma	Crust texture	Crumb texture
Boil and sun dry	6.0^{b}	4.7	4.3	4.9	6.5	6.4
Boil and oven dry	6.4^{ab}	5.8	5.4	5.0	6.3	5.8
Roasting	4.8^{c}	5.5	4.0	4.8	5.8	5.3
Extrusion	6.8^{a}	6.5	6.0	5.2	6.6	5.6
Control	6.1^{b}	5.2	5.3	4.8	6.1	6.0

Values are means of three replicates
Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

Table 6. Organoleptic evaluation of soy\wheat bread from thermally treated dehulled soybean

Treatment	Acceptability	Taste	Appearance	Aroma	Crust texture	Crumb texture
Boil and sun dry	6.0^{b}	4.9	4.7	4.9	4.3	6.4
Boil and oven dry	6.8^{c}	5.0	5.8	5.7	5.4	5.8
Roasting	5.0^{a}	4.8	5.5	5.3	4.0	5.3
Extrusion	6.9^{c}	5.2	6.5	5.6	6.0	5.6
Control	6.2^{b}	4.8	5.2	6.0	5.3	6.0

Values are means of three replicates
Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

The most acceptable breads were obtained from the flour produced from extrusion method though not significantly different from that of boiled and oven dried method. The dehulled samples were more accepted than undehulled samples. The reason for this may be due to the presence of bran in the undehulled samples. The bran present will adversely affect the appearance, hence the overall acceptability as well. The possible reason for low acceptability of roasted samples is that roasting will reduce the fibrous nature of the seed coats therefore making more quantity of the coat reduced to flour size. The presence of appreciable quantity of bran in the bulk will change the colour, making it less attractive in appearance thereby causing reduced acceptability, this is in agreement with the reports of Ogundipe (1988).

Extrusion cooking (cooked at very high pressure and temperature) on the other hand causes a special kind of forming, a formulated dough or mash with uniformity in characteristics, destruction of anti-nutrients and removal of off setting factors in soybean, therefore causing a high level of acceptability in all the sensory characteristics (Potter, 1987; Harper, 1992; Famurewa and Raji, 2005). The removal of the off-setting factors and destruction of anti-nutrients resulted in good taste and aroma while uniformity in characteristics led to the acceptable appearance, crust and crumb textures. It should also be noted that the thermally treated samples produced breads with very high level acceptability of crumb and crust textures. The thermal treatment make the seed brittle and easy to grind resulting in uniformity in milling with finer flour particle sizes (between 0.74 and 1.18mm, Figure 3) as compared to those obtained under moisture variation studies (greater than 1.20mm, Figure 1).

3.6 Proximate Composition of Thermally Treated Soybean Flour

As shown in Table 7 for the undehulled sample, roasting method has the highest fibre, fat and ash contents (11.83%, 22.69% and 9.73% respectively). There is no significant difference in the protein content of ROA, BOD and BSD samples. EXT samples however retained the highest protein content which is significantly different from roasting and sun drying methods. In Table 8, the fibre and ash contents are less than that of undehulled in Table 7. This is obvious because of the absence of bran in the dehulled sample. Also, fat and protein contents increased in the dehulled samples.

Table 7. Proximate analysis of bread from thermally treated undehulled soybean

Treatment	**Protein (%)**	**Ash (%)**	**Fat (%)**	**Fibre (%)**	**CHO (%)**
Boil and sun dry	32.37^{b}	10.24	19.38	8.62	28.99
Boil and oven dry	33.70^{ab}	10.49	20.41	8.23	26.67
Roasting	32.70^{b}	11.83	22.69	9.73	23.40
Extrusion	34.34^{a}	11.15	21.81	8.87	24.46

Values are means of three replicates

Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

Table 8. Proximate analysis of bread from thermally treated dehulled soybean

Treatment	**Protein (%)**	**Ash (%)**	**Fat (%)**	**Fibre (%)**	**CHO (%)**
Boil and sun dry	35.55^{ab}	8.83	20.57	7.46	27.62
Boil and oven dry	36.69^{ab}	9.09	22.04	7.43	25.05
Roasting	34.83^{b}	8.87	23.92	7.73	24.42
Extrusion	38.47^{a}	9.10	23.63	7.78	20.97

Values are means of three replicates

Values in a column denoted by different letters differ significantly from each other at $p < 0.05$

From the Tables 7 and 8, it can then be said that protein retention is a function of thermal treatment. Dehulled samples in all the treatments retained higher protein values than undehulled. Extrusion method proved to be the best of all the treatments while roasting gave the least in terms of proximate composition. The possible reason for the difference in retained protein in dehulled and undehulled samples is the absence of bran in the bulk of dehulled samples which will cause increase in concentration of protein in each sample. The result obtained with extrusion is in agreement with past work (Famurewa *et al.*, 2006). Extrusion cooking has been reported to results in considerable retention of nutrients like B complex, vitamins and certain minerals like calcium, iron and zinc, being a high temperature short time process, thereby yielding a better product. In contrast, roasting though a high temperature process, involves a longer high temperature time which leads to denaturation of protein and Millard reaction (Ogundipe, 1988) hence the low protein retention.

4. CONCLUSIONS

From the results presented, it can be concluded that in both dehulled and undehulled samples, flour yield was increasing as moisture content was reducing, showing that flour yield is not a function of hull present. Acceptability and proximate composition are however affected by the prescence of hull. Generally the dehulled samples gave higher yield and better nutritive composition except for ash and fibre which are obvious. However moisture removal, a function of the thermal treatment affected the quantity of hull present in the bulk which eventually affected the proximate composition and acceptability of the soy flour. This implies that soybean seed hull has inverse relation with acceptability and protein content of flour obtained from it when subjected to thermal pretreatment. The presence of hull has its advantage in higher fibre and ash contents for easier digestion and purging where necessary. This study has not indicated any considerable reduction in the nutritive composition of the fibrous food but a slight difference in acceptability which was not below the threshold. This does not show an absolute rejection but relatively a better acceptance of dehulled samples. The inclusion of some other nutrient to reduce the factors responsible for the reduced acceptance and improve the undehulled samples will bring the acceptance to the same level or better. This is an area for further studies.

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