

## COMPARATIVE STUDY OF THE EFFECT OF VARIOUS PRE-TREATMENTS ON THE SHELF-LIFE OF UNDEFATTED SOYBEAN FLOUR

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### Abstract

Soybean is a high protein yielding plant that normally serves as a substitute for the supply of protein needed by the body at a much cheaper rate. This research work study the shelf life of soybean full fat flour processed from soybeans soaked in three (3) different solutions (sodium carbonate, Sodium chloride and Sodium bicarbonate), and the samples soaked in water which served as the control for the experiment. The soybeans were separately processed in the following stages; draining, steam blanching (100<sup>o</sup>C) for 45minutes, dehulling, drying in a cabinet dryer and milled. The flour produced from the milled samples was packaged and their quality parameters determined over the 16weeks of storage at 4-week interval. The study result showed that sodium bicarbonate treated samples gave the best dehulling properties. Water (control) had the highest hydration property of 1.79. Soybeans soaked in sodium carbonate had the highest protein (35%) and fat (30%) contents after shelf life period, while sodium bi-carbonate treated samples had the least free fatty acid content (0.13) after storage. After the storage period, all the treated samples had higher contents of crude fibre but the control had the highest moisture content of 14% when compared with others that had 12%, 8% and 6%. Based on the study, it could be deduced that 5% w/v sodium bicarbonate solution should be used in soaking soybeans in order to obtain soy bean full fat flour that would be shelf stable.

**Key words:** Soy beans, full fat flour, soaking, chemical treatment, water, processing

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### Introduction

Soy beans (*glycine max*) belong to the plant family *leguminosae*, a group of plant with high nutritional value. Soybeans are one of the most nutritious and versatile plant foods of human due to its high protein values. Whole soybeans are transformed into many different varieties of food to create versatility and provide taste with easily digestible products (Wang, 1987) and have been used to fortify cereal based weaning foods (Akapo *et al.*, 1995; Njoku and Faller, 2001). Soybeans are an annual leguminous plant that is high in protein. It is the best source of plant protein known with a value of about 40%. It is highly recommended, along with its excellent source of calories, as supplement for meals all over the world (Nieuwenhuis and Nieuwelink, 2002). The principal protein content of soybeans is glycine, which is the simplest form of amino acid. It is highly demanded at periods of rapid growth especially by children and adolescents.

Soybeans is rich in fat (about 20%), which makes it next to coconut oil that is low in fatty acid contents. Apart from protein and fat, it

contains about 28% carbohydrate (Nieuwenhuis and Nieuwelink, 2002). A large proportion of the carbohydrate content consists of indigestible fibres as in most legumes. It is rich in vitamins and minerals, mostly vitamin B1, fat soluble vitamins A and E, iron and calcium (Nieuwenhuis and Nieuwelink, 2002) and rich supply of folate (Arcot *et al*; 2002).

Soybeans have an undesirable flavour and bitterness; they contain the toxic protein haemagglutinin and anti-trypsin (Wang, 1987). These substances must be inactivated to make the beans palatable and digestible both for human and animal consumption. These soybeans could be processed into various products such as soymilk, soy sauce, tofu (soybean curd), yoghurt, soybean sprout, tempeh (soy steak), soy flour (Wang, 1987; Fukushima, 1981). However, efforts have been made at breeding and producing improved soybean cultivars for specific characteristics such as high yield, desired seed quality, resistance to insect and diseases, early maturity and improved nutritional attributes (Giami, 2002).

Soaking (steeping), a unit operation can be defined as the immersion of seeds (legumes, cereals, grains etc) into any fluid. This operation helps to soften the seed bran, which helps in dehulling and aids further processing. Soaking and cooking of beans are separate functions that may or may not be performed simultaneously. In some situations, the beans are soaked to facilitate quicker cooking. Also, soaking prior to cooking reduces the concentration of toxic factors and flatulence inducing sugars (stachyose and raffinose) and gives a softer final texture to the cooked beans (Taiwo *et al*, 1994). Soybeans full fat flour is produced from the un-extracted dehulled beans containing about 18 to 20% oil. Enzyme active soy flour has a usage as oxidizing agent on flour and extends the shelf life of the dough (Stanley *et al*, 1979).

The study however hopes to look at the effectiveness of the three soaking media; Sodium carbonate, sodium bicarbonate and sodium chlorides as processing methods for the production of full fat soybean flour and the shelf stability of the full fat flour, since the commonest fluid being used worldwide is water.

## Materials and Methods

### Materials

The soybeans were sourced from a local market in Ilorin, Kwara State. The soybean seeds were manually picked to remove extraneous substances such as stones, and other foreign constituents.

### Preparation of the Soybeans full fat flour

The soybean seeds were soaked in the sample solutions (sodium carbonate, sodium bicarbonate, sodium chloride and water) at room temperature of  $27\pm 2^{\circ}\text{C}$ . They were later washed with water, steam blanched at  $100^{\circ}\text{C}$  and dehulled manually.

The soybean full-fat flour was prepared from the dehulled seeds by grinding into a powder in a 60-mesh micropulverizer grinder (US, Filter Corporation, N.Y). Full Fat soybean flour was stored in sealed plastic bags (thickness  $85\mu\text{m}$ ). The bags were stored at room temperature of  $27\pm 2^{\circ}\text{C}$ . At every 4-week interval, lipids were

extracted using the soxhlet extraction method. Free fatty acid and peroxide value were also determined by procedures of AOAC (2005). The samples were designated as follows:

Sample T1 – Soybeans soaked in water (Control); Sample T2 – Soybeans soaked in 5% w/v sodium bicarbonate solution; Sample T3 – Soybeans soaked in 5% w/v sodium carbonate solution; Sample T4 – Soybeans soaked in 5% w/v sodium chloride solution.

The samples which were stored in air tight containers for about four months were at 4-week interval, analysed for:

### Hydration Studies

Equal weight of soybean seeds (20g) were soaked in  $100\text{cm}^3$  water containing sodium carbonate, sodium hydrogen carbonate, sodium chloride and ordinary water for 12 hours at room temperature ( $27\pm 2^{\circ}\text{C}$ ). The water absorption percentage and hydration ration was determined by weighing the seeds after soaking. Weight of the swelled seeds was recorded at 2-hour interval for 12 hours. Hydration ratio was computed by dividing the hydrated weight of the sample by the initial weight.

### Dehulling Studies

Using the fingers to apply pressure on the textural scale (hedonic scale) rating of I for hulls intact up to 7 for extremely easy removal of the hulls, a panel (10 members) who did not know the identity of the samples judged the ease of removal of the hulls of the soybeans in the following treatments. The seeds were soaked in % (w/v) sodium carbonate, sodium bicarbonate, Sodium chloride and ordinary water. The evaluation was done four times and reproducible results obtained.

### Proximate Analysis

The moisture, fat, free-fatty acid, protein, ash, carbohydrate and crude fibre contents of the samples were determined using standard methods of AOAC, 2005. They were done at intervals of four weeks alongside the free fatty acids.

### Peroxide Value Determination

The experiment which was carried out in subdivided light had 1g of the soybean crude oil measured into a boiling tube. 1g of

powdered potassium iodide and 20cm<sup>3</sup> solvent mixtures (2 volume glacial acetic acid and 1 volume chloroform) were added and made to boil for 30minutes. After 30minutes of boiling, the contents were quickly poured into a flask containing 20cm<sup>3</sup> potassium iodide solutions (5%). The tube was then washed out twice with water and the content titrated with 0.002 molar sodium thiosulphate using starch as indicator.

A blank was also titrated with a mixture of 1gm powdered potassium iodide and 20cm<sup>2</sup> solvent mixture (2 volume glacial acetic acid and 1 volume chloroform) against 0.002 molar sodium thiosulphate using starch as indicator. Peroxide value per 1000gm of oil was calculated thus:

$$\frac{(S - B) (N) (1000)}{\text{Weight of sample}}$$

Where:

B = Titration of blank

S = Titration of sample

N = Normality of Sodium thiosulphate

## Results and Discussion

Soybean full-fat flour contains high fat content rich in unsaturated fatty acids, which include linoleic, linolenic and oleic acid with linolenic fatty acid as the most predominant acid in soybean seeds.

Linolenic fatty acids are poly unsaturated fatty acids that lower plasma cholesterol. They are absorbed more efficiently from the gut than saturated fatty acids of the same chain length (Liu, 1997). Unsaturated fatty acids abound in the full fat soybean flour. Unsaturated fatty acids have been implicated in the nutritive treatment of Ischaemic heart diseases. Arachidonic acid for example, has been observed as precursors of prostaglandins. Linolenic acids for example, are precursors in the production of vitamin C, which has been found to be responsible for the somatic development of the brain cells.

As a result of the above, full fat soybean flour could supply these essential fatty acids that are deficient in defatted soybean flour as they are mostly lost by the extraction of the oil and hence, are missing in the food product made

from the defatted soya bean flour unless the products are enriched or fortified seriously.

Soybeans contain significant amount of bioactive compounds with antinutritional properties that can alter the body metabolism of consumers and exert a negative impact on the nutritional quality of the seed protein (Grant *et al.*, 1998). Also, trypsin inhibitor protein inhibits proteolytic activity of the enzymes, stimulate protein synthesis in the pancreas and enhance pancreatic enzymes secretion. Steam blanching was necessary to inactivate these inhibitors (Iwe, 2003; Anderson and Wolf, 1995). The blanching equally helps to inactivate the action of the lipase and lipoxidase present in the flour to reduce the rate of rancidity of full fat flour and consequent development of rancid flavour. Soaking operation reduces the water-soluble anti-nutritional constituents.

Full fat soybean flour deteriorates with time based on the ability of the packaging materials to prevent the products absorbing moisture. Soybean full fat flour deterioration could also be determined by lipid oxidation arising from the oxidative rancidity of the fat content of the flour.

### Hydration Analysis

Hydration ratio, which is simply a parameter to measure the swelling of a seed, was determined as the ratio of the weight of the swelled seed to that of the dry seed. Hydration ratio of seeds soaked in water (control) was 1.79 followed by sodium hydrogen carbonate (1.63), sodium carbonate (1.58) and sodium chloride (1.45).

**Table 1. Hydration of Soybean Seeds**

Medium	Weight before soaking (g)	Vol. of soaked solution (cm <sup>3</sup> )	Weight after soaking (g)	Hydration ratio
Water	20g	80.5±20.46	35.78±0.62	1.79±0.01
Na <sub>2</sub> CO <sub>3</sub>	20g	81.40±0.90	31.68±0.84	1.58±0.01
NaHCO <sub>3</sub>	20g	79.68±0.90	32.68±0.93	1.63±0.02
NaCl	20g	78.56±1.28	28.92±0.62	1.45±0.03

### Dehulling Studies

It was observed that the seed coats of soybeans soaked in the solution of sodium carbonate, sodium hydrogen carbonate, sodium chloride and ordinary water tenderize slowly. Seeds soaked in 5% (w/v) sodium bicarbonate gave

the best result. Normally, increased time of heating rendered the seed coat loose, but the chances of microbial growth on account of leaching of the nutrient into soaking water were higher.

#### *Shelf life study of the samples*

Table 2 shows that there was a gradual absorption of moisture from 6.50% at zero week to 16.2% after 16weeks of storage. The protein content decreased from 34% initially to 29.15%. The decrease could be due to the action of ketogenic amino acids which were broken down to glucose thereby increasing the carbohydrate content of the sample. High free fatty acid content was observed at zero week, which decreased over the period of storage likely due to high peroxidase action in the stored sample.

Table 3 shows the result of the shelf-life analysis carried out on sample T2. The ash content of this sample was relatively stable until the last four weeks of storage. Moisture content increased from 4% to 14.25%; protein and crude fibre contents decreased slightly over the 16weeks of storage. The slight changes observed could be due to deamination reaction leading to breakdown of amino acids of protein constituents. Fat content had a reduction of over 30%, while the reduction of free fatty acid values could be attributed to the action of peroxidase on the fat content of the sample.

We could deduce from table 4 that sample T3 maintained high protein content over the period of storage. The low carbohydrate and high protein content were similar with what was obtained for sample T1. It was equally noted that as protein content increases, carbohydrate content decreases and vice versa. It was also deduced that the rate of conversion of protein to carbohydrate during processing and storage

was reduced due to inactivation of the enzymes by heat treatment.

The steam blanching could have reduced the action of lipase and lipoxidase, thereby reducing the rate of rancidity of full fat flour. The constant weight of the ash content over the period of storage depicts that mineral contents were not lost throughout the shelf-life period.

It could be deduced from table 5 that the moisture content of sample T4 did not exceed the initial values even after the 16weeks of storage, which could be attributed to efficient storage. Minimal changes were observed for protein, crude fibre and fat contents. The low carbohydrate content of the sample could be due to the reduced action of ketogenic amino acids being converted to carbohydrate (glucose) during storage period. The chemical in the soaking liquid might have helped in reducing the peroxidase action on the fat content of the sample, which is evident in the low free fatty acid content of the sample.

#### *Peroxide Value Discussion*

The determination of both the free fatty acid (FFA) and peroxide value (PV) were to know the keeping qualities of the soyabean full fat flour. Peroxide values are the main initial products of auto-oxidation and expressed as milli-equivalents of oxygen per kilogram of fat. As reported by Nawar in 1996, PV was defined as the amount of oxygen that must be absorbed, or peroxide that must be formed, to produce noticeable oxidative rancidity (in terms of Oil). From the results, it was noticed that PV of sample T1 rose from 0.8 to 1.30meq/kg over the period of 16weeks of storage. Over same period of storage, T2 reduced from 0.75 to 0.6meq/kg; T3 (1.0 to 0.25meq/kg) and T4 increased slightly from 0.85 to 0.95meq/kg.

**Table 2. Shelf life Study of Sample T1**

Analysis	Zero week	4 <sup>th</sup> week	8 <sup>th</sup> week	12 <sup>th</sup> week	16 <sup>th</sup> week
Moisture (%)	6.50±0.01	6.60±0.01	14.04±0.02	14.20±0.01	16.20±0.01
Ash (%)	3.00±0.01	1.75±0.00	1.80±0.1	1.00±0.1	0.77±0.1
Protein (%)	34.00±0.01	33.25±0.01	33.20±0.1	30.85±0.2	29.15±0.2
Crude Fibre (%)	4.25±0.02	3.75±0.01	3.65±0.0	2.55±0.0	2.00±0.0
Fat (%)	20.00±0.00	19.10±0.2	19.00±0.0	18.00±0.14	0.09±0.1
Carbohydrate (%)	32.25±0.00	35.55±0.1	28.31±0.2	33.40±0.1	51.79±0.2
Free-fatty acid	0.40±0.01	0.30±0.1	0.21±0.1	0.14±0.1	0.08±0.0

Values are means of 4 determinations ± S.D.

**Table 3. Shelf Life Study of Sample T2**

Analysis	Zero week	4 <sup>th</sup> week	8 <sup>th</sup> week	12 <sup>th</sup> week	16 <sup>th</sup> week
Moisture (%)	4.00±0.2	8.00±0.2	8.00±0.0	12.00±0.3	14.25±0.1
Ash (%)	2.00±0.00	2.00±0.0	2.00±0.0	2.00±0.0	1.85±0.2
Protein (%)	35.00±0.0	35.00±0.0	34.35±0.1	34.00±0.1	33.95±0.1
Crude Fibre (%)	6.00±0.0	6.00±0.00	5.00±0.1	4.85±0.0	4.70±0.0
Fat (%)	30.00±0.0	28.00±0.00	24.00±0.0	22.00±0.0	20.00±0.0
Carbohydrate (%)	23.00±0.0	21.00±0.0	26.65±0.1	25.15±0.0	25.25±0.1
Free-fatty acid	0.13±0.0	0.12±0.0	0.11±0.00	0.10±0.0	0.08±0.1

Values are means of 4 determination ± SD.

**Table 4. Shelf Life Study of Sample T3**

Analysis	Zero week	4 <sup>th</sup> week	8 <sup>th</sup> week	12 <sup>th</sup> week	16 <sup>th</sup> week
Moisture (%)	4.00±0.1	6.00±0.2	8.00±0.1	8.00±0.1	11.00±0.0
Ash (%)	2.00±0.00	2.00±0.1	2.00±0.0	2.00±0.2	1.90±0.1
Protein (%)	35.45±0.6	34.95±0.0	35.30±0.0	35.00±0.1	34.85±0.0
Crude Fibre (%)	6.50±0.1	7.55±0.0	7.00±0.0	6.50±0.0	6.50±0.0
Fat (%)	30.00±0.1	30.00±0.1	29.00±0.0	29.00±0.0	28.00±0.1
Carbohydrate (%)	22.05±0.0	19.50±0.1	18.70±0.1	19.50±0.0	17.75±0.0
Free-fatty acid	0.40±0.0	0.38±0.0	0.27±0.1	0.21±0.1	0.17±0.2

Values are means of 4 determination ± SD

**Table 5. Shelf Life Study of Sample T4**

Analysis	Zero week	4 <sup>th</sup> week	8 <sup>th</sup> week	12 <sup>th</sup> week	16 <sup>th</sup> week
Moisture (%)	8.00±0.1	10.00±0.2	6.00±0.2	8.00±0.1	7.50±0.3
Ash (%)	3.00±0.1	4.00±0.0	3.00±0.1	3.00±0.0	2.90±0.0
Protein (%)	34.57±0.6	35.00±0.0	34.13±0.0	34.00±0.1	34.00±0.1
Crude Fibre (%)	11.00±0.1	10.00±0.0	12.00±0.0	11.50±0.4	11.50±0.3
Fat (%)	26.00±0.0	28.00±0.0	29.00±0.1	29.00±0.1	29.50±0.1
Carbohydrate (%)	17.43±0.0	13.00±0.1	15.87±0.1	16.50±0.1	18.60±0.2
Free-fatty acid	0.11±0.1	0.11±0.1	0.14±0.0	0.06±0.0	0.06±0.1

Values are means of 4 determinations ± SD

**Table 6. Result of Peroxide Value (meq/kg)**

Sample	Zero week	4 <sup>th</sup> week	8 <sup>th</sup> week	12 <sup>th</sup> week	16 <sup>th</sup> week
T1	0.8±0.2	0.9±0.1	1.3±0.0	1.25±0.1	1.30±0.0
T2	0.75±0.2	0.8±0.0	0.7±0.0	0.5±0.1	0.6±0.0
T3	1.0±0.1	0.8±0.1	0.8±0.1	0.4±0.0	0.25±0.0
T4	0.85±0.1	0.8±0.0	0.8±0.0	0.9±0.1	0.95±0.0

Values are means of 4 determinations ± SD

The reduction experienced in the control sample (T1) and treated samples (T2 and T3) and the slight increase in the values of sample T4 could be due to inactivation of lipases made possible by the effect of heat during steam blanching. The result depicts the stability of soybean full fat flour. There was also a report by Wenli *et al* 2001 on peroxide formation in stored soybean full fat flour, but keeping quality has hardly been reported. From this study, it could be inferred that soybean full fat flour could be stored effectively for 16 weeks at

27±2<sup>0</sup>C without any adverse consequence on the proximate composition.

### Conclusion

In line with the literature report that soybean seeds have high fat content, the soybean flour was stored in a cool, dry place and away from light to prevent lipid oxidation of the flour and moisture gains. It was also observed that soaking in chemical solution helps to reduce the activities of peroxidase as shown with the values of FFA towards the end of the shelf life period.

We equally conclude that sodium bicarbonate (5% w/v) was most effective in dehulling the seeds and that the lesser the seeds were soaked in water, the better it reduces leaching of the nutrients as well as prevent lypolysis of the oil, which could negatively affect the flavour quality. Samples dehulled by sodium bicarbonate gave the best yield of full fat flour.

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