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Effect of Different Soaking Time and Boiling on the Proximate Composition and Functional Properties of Sprouted Sesame Seed Flour

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ABSTRACT

The effect of soaking time on the proximate composition and functional properties of sprouted sesame seed flour were investigated. Sesame seed samples were cleaned and pretreated by soaking in clean water for 8, 10, 12, 14 and 16 h. One batch was sprouted for 36 h and another portion was sprouted and then boiled (100°C for 20 min), dried, milled into flours and subjected to further analysis. The raw (unsprouted) sample was used as control. The proximate composition and the functional properties were determined for each of the samples and the result showed deviations in nutrient content from the raw seed flour. Moisture and protein content was increased by soaking and sprouting but reduced after boiling from a value of (4.99% and 47.64%) to (4.92% and 42.06%) respectively, for the 10 h soaked sample. Fat, crude fibre, ash and carbohydrate contents were reduced by soaking and sprouting while boiling of the sprouted seeds increased the fat and carbohydrate content. Soaking, sprouting and boiling significantly affected the functional properties of the flour ($p < 0.05$). Soaking and sprouting reduced the bulk density and dispersion of the samples from an initial value of (0.83% and 67.50%) for the unsprouted seed flour to a value of (0.71% and 59.00%) in 10 h soaked samples but increased slightly in most of the soaked sprouted-boiled samples. Thus, soaking of sesame seeds for 12 – 14 h before sprouting can be used to improve the proximate composition and functional properties of sesame seeds, hence, increase the utilization of the flour.

Keywords: Sesame seed, soaking, sprouting, proximate composition, functional properties.

Introduction

Sesame *(Sesamum indicum L.)* is one of the most important oilseed crops worldwide, and has been cultivated in Africa, Middle East, and Asia since ancient times for its edible oil and seeds used in traditional foods (Park *et al*., 2010). It is an erect tropical annual flowering plant in the family *pedaliaceae*. They are flat, tiny, oval seeds with a rich nutty flavour. Their colour ranges from creamy white to charcoal black. It is one of the oldest cultivated oilseed crops in the world (Langham, 1985). Due to its relatively low productivity, sesame ranks ninth among the top thirteen oilseed crops which make up 90% of the world production of edible oil (Kamal *et al.*, 1995). The widespread and long-standing tribute to sesame lies in its high oil content, nutritious protein, and savoury roasted flavour (Namiki, 1995).

Sesame has a high nutritive value with respect to high amount of proteins, lipids and important minerals and vitamins (Abu-Jdayil *et al*., 2002). Sesame contains approximately 20% protein (Namiki, 1995). Apart from the high protein content, sesame seeds have many other essential nutrients needed for the maintenance of human health (Namiki, 1995) such as manganese, copper

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and calcium; vitamin B_1 (thiamine) and vitamin E (tocopherol). In addition, they are particularly noted for imparting better functional properties to food system (Bernard–Don *et al*., 1991; Chang *et al.,* 2002).

Sesame seeds, much like other nuts, seeds and legumes can be milled into a fine powder or flour and used as a substitute with many baking recipes for those trying to avoid wheat. Hence, they have nutrient quality favourably comparable with other oilseeds and legumes. Processing methods, such as soaking, sprouting and cooking have been reported to improve the nutritional and functional properties of plant seeds (Jirapa *et al.,* 2001; Yagoub and Abdalla, 2007). This processing techniques can also reduce malnutrition by making micronutrients available for easy absorption; hence, increasing the utilization of sesame seeds.

Consumption of seed sprouts, which has been known for many centuries in oriental culture, has been growing in global popularity over the past 30 years (Robertson *et al.,* 2002). Bean sprouts, rich in dietary fibres, various nutrients, and bioactive components, are important vegetables consumed in Asian countries, and, nowadays, they have become more popular in the United States and European countries (Liu *et al.,* 2008). Although the most popular bean sprouts are cultivated from mung bean and soybean, sesame seeds are also a good source of bean sprouts (Liu *et al.,* 2011). Sesame sprouts have been consumed as vegetables in China for hundreds of years (Liu *et al.,* 2011).

Sprouting has been used as a technique to minimize disadvantages of undesirable flavour and odour in soybean and its products (Agrahar-Murugkar *et al.,* 2013). Sprouting triggers a sequence of metabolic changes resulting in improvement of nutritional quality of legumes and reduction of the anti-nutritional factors such as trypsin inhibitor and phytic acid (Agrahar-Murugkar *et al.,* 2013). Therefore, the main objective of this study is to determine the soaking time that is best suited for the sprouting of sesame seeds to give good quality flour in terms of nutritive value and functional properties.

Materials and Methods

Sesame seeds were purchased from Sabo market, Ikorodu, Lagos State, Nigeria.

Preparation of sprouted and de-bittered sesame seed flour

Cleaned sesame seeds were transferred into big transparent plastic pails and covered with twice as much water as the quantity of the seeds and were soaked at different time intervals (8, 10, 12, 14 and 16 h). The seeds were sprouted at room temperature in a fairly lit environment for 36 h and rinsed every 4 h during sprouting. After sprouting, the seeds were divided into two portions. The first portions were properly rinsed, put in a cooking pot, covered with water and boiled to a temperature of 100^{o}C for 20 min in a covered container to remove bitterness. The water used in boiling the seeds was drained off and the seeds rinsed again with clean water. The sprouts were sun-dried and milled into flour. The second portions were properly rinsed, sun-dried and milled into flour.

Determination of proximate composition of pretreated sesame seed flour

Moisture, fat, crude protein, crude fibre and ash contents of the flours were determined by using AOAC (2000) method. The carbohydrate was calculated by difference between 100 and total sum of the percentage of moisture, protein, fat and ash.

Determination of functional properties of sesame seed flour

Bulk density

This was determined by the method of Wang and Kinsella (1967). A known amount of sample (10 g) was weighed into 50 ml graduated measuring cylinder. The sample was packed by gently tapping the cylinder on the bench top from a height of 5 cm. The volume of the sample was recorded

Bulk density = weight of sample/volume of sample after tapping (g/ml) ……..(1)

Dispersion

This was determined using the method described by Kulkarni *et al*. (1991). 10 g of flour was suspended in 100 ml measuring cylinder and distilled water was added to reach a volume of 100 ml. The setup was stirred vigorously and allowed to settle for three hours. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersion.

Water absorption capacity

Water absorption capacity was determined using Anderson *et al*. (1969). 5 g of flour was weighed into a centrifuge tube and 15 ml of water was added and mixed thoroughly. This was then allowed to stand for 30 min and centrifuged at 3000 rpm for 15 min.

The supernatant was decanted and the sample was reweighed. The amount of water retained in the sample was recorded as weight gained and then taken as water absorbed.

Water absorption capacity = weight of water absorbed in grams/ sample weight …….(2)

Swelling power and solubility index

This was determined by Takashi and Seib (1988) method. 1 g of the sesame flour was weighed into 50 ml centrifuge tube. Then 50 ml of distilled water was added and mixed gently. The slurry was heated in a water bath at 80°C for 40 min. On completion, the tubes containing the gel were centrifuged at 3000 rpm for 10 min using a centrifuge. The supernatant was decanted immediately after centrifuging. The weight of the sediment was taken and recorded. The moisture content of the sediment gel was thereafter determined to get the dry matter content of the gel.

Swelling power = weight of wet mass of sediments/ weight of dry matter in the gel ……(3)

% solubility = (weight of soluble / sample weight) x 100 ……………………………..(4)

Statistical analysis

Data were obtained in duplicates and subjected to Analysis of Variance (ANOVA) using SPSS version 16.0. Duncan Multiple Range Test was used to separate significant differences among treatment means.

Results and Discussion

Proximate composition

The proximate composition of pre-soaked sprouted sesame flour and sprouted-boiled sesame flour are shown in Table 1. Soaking (8 – 16 h), sprouting (36 h) of pre-soaked seeds and boiling had significant ($p < 0.05$) effect on the chemical composition compared to the flour obtained from the raw sample (control). For the sprouted sesame seed flour, the moisture content, protein, and crude fibre content values were found to increase with an increase in soaking time while the reverse trend was observed in the fat, ash and carbohydrate content.

Boiling of the sprouted seed flour reduced the moisture, protein, crude fibre and ash content of the flour when compared to the sprouted sesame flour and the reverse trend was found in the fat and carbohydrate content. The changes observed are due to leaching of soluble component into soaking and cooking water and as a consequence of enzyme activities during sprouting (Yagoub and Abdalla, 2007).

The moisture content of the flour increased with an increase in soaking time and ranged from 4.80 – 5.74% and 4.75 – 5.51% for seeds sprouted and sprouted and boiled respectively. These values are comparable to the values reported for white sesame flours which ranged between 3.80 and 5.50%. Lower moisture content is an indication of longer shelf life. As reported by Sanni *et al*. (2006), the lower the initial moisture contents of a product to be stored, the better the storage stability of the product. The moisture content of a food is indicative of the dry matter in that food (Adebowale *et al*., 2012).

Table 1: Proximate composition of sprouted sesame flour

Soaking time (hours)	Treatment	Moisture (%)	Protein (%)	Fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
	UR	3.97^{a}	26.09^{a}	55.26^{k}	9.12^{d}	3.96^{k}	1.62^{d}
8	SP	4.80^{b}	45.64^{g}	36.86^{g}	9.24^{e}	2.33^{d}	0.97^{c}
	SPB	4.75^{b}	40.54^{b}	38.65^{j}	9.04^{c}	2.27^{h}	5.06^{f}
10	SP	4.99^{de}	47.64^{h}	35.06^{d}	9.34^{f}	2.33^{i}	0.66^{b}
	SPB	4.92^{c}	42.06^{c}	36.93^{h}	8.78^{a}	2.19^{g}	5.13^{f}
12	SP	5.03^{e}	48.70^{k}	34.40^{a}	9.35^{gh}	1.98^{f}	0.55^{ab}
	SPB	4.94^{cd}	43.69^{f}	35.85^{e}	8.72^{a}	1.86^{e}	4.95^{f}
14	SP	5.43^{f}	48.27^{j}	34.68^{b}	9.42^{gh}	1.73^{c}	0.49^{ab}
	SPB	5.38^{f}	43.07^{e}	36.71^{f}	8.77^{a}	1.54^{b}	4.54^{e}
16	SP	5.74^{h}	47.81^{i}	34.88^{c}	9.42^{gh}	1.85^{d}	0.31^{a}
	SPB	5.51^{g}	42.75^{d}	37.4^{i}	8.95^{b}	1.17^{a}	4.27^{e}

Values are means of two replicates
Mean values within a column with different superscripts are significantly different ($p < 0.05$) UR= Un-sprouted (Raw) sesame flour SP= Sprouted sesame flour
SPB= Sprouted and boiled sesame flour

The protein content of the flour was found to increase with increase in soaking time from an initial value of 26.09% to a value of (45.64 – 48.70%) for 8 to 12 h soak time respectively and decreased at a soak time of 14 and 16 h having a value of 48.27% and 47.81% respectively. Boiling of the seeds after sprouting decreased the protein content of the flour and ranged between 40.54% and 42.75% for 8 and 16 h soak time respectively. The value obtained for crude protein for the raw samples in this study was higher than the range stated in the literature (Godin and Spensley, 1971) which reports that sesame seed contains 45-55% oil, 19-25% protein and about 5% water. According to Chavan and Kadam (1989), the conversion of storage proteins of seeds into albumins and globulins during sprouting may improve the quality of seed proteins

The raw sample was significantly higher in fat compared with the sprouted samples. The fat content of the sprouted samples decreased with increase in soak time from 8 – 12 h and ranged from 36.86% – 34.40% respectively but increased slightly at a soak time of 14 – 16 h and range from 34.68% – 34.88% respectively. Boiling of the seeds after sprouting increased the fat content of the flour. The high fat content of the seeds gave the flour an oily and compacted/rough appearance instead of a smooth powdery appearance. The high fat content of the samples is as a result of the very high oil content of the seeds. The sharp drop in the percentage of fat after sprouting may be as a result of the breakdown of complex compounds into a more simple form during sprouting.

The raw sample was slightly lower in crude fibre at a value of 9.12% compared to the sample sprouted after soaking for 8 – 16 h which ranged from 9.24 – 9.42% while the samples sprouted and boiled ranged from 9.04 – 8.95%. Crude fibre is an indication of the roughage/bulkiness of the sample. The higher the crude fibre content, the more bulky the variety of seed used (Yoshida, 1994). The ash content of the raw sample (3.96%) was higher than that of the pre-soaked sprouted and boiled (1.73 – 2.33%). Ash content could be used as an index of total mineral matter present in foods because ash is the inorganic residue remaining after the water and organic matter have been removed by heating in the presence of an oxidizing agent (Sanni *et al*., 2008).

Boiling of the sprouted seeds significantly increased the carbohydrate content of the flour at a soaking time of 8 – 10 h but decreased at a soaking time of 12 – 16 h. The carbohydrate content of the sprouted pre-soaked seeds was relatively lower than that of the raw seeds and decreased with an increase in soaking time from 8 – 16 h having values ranging from 0.97% – 0.31%, compared to a value of 1.62% for the raw seeds.

Functional properties of sesame flour

The result of functional properties of pre-soaked sprouted sesame flour and sprouted-boiled sesame flour are shown in Table 2. The result shows that flours from sprouted and boiled sesame seed at 8 h and 10 h have the highest bulk density of (0.87 g/ ml) and the 8 h soaked sample with the least value of (0.71 g/ml) for the sprouted sample. Boiling of the sprouted seeds increased the bulk density of the flour. The increase in bulk density with boiling was not significant ($p > 0.05$) between the various samples. Bulk density is a measure of heaviness of a flour sample, and is generally affected by particle size. It is also important for determining packaging requirement, material handling and application in wet processing in the food industry (Karuna *et al.,* 1996; Adebowale *et al*., 2008a; Ajanaku *et al*., 2012).

The raw (unsprouted) sample has the highest dispersion of 67.50% and the 10 and 12 h soaked sample with the least value of 59.00%. The dispersion decreased with an increase in soak time of 8 – 12 h and increased slightly at a soak time of 14 – 16 h at values of 65.50% – 59.00% and 60.00 – 61.00% respectively for the sprouted samples.

Table 2: Functional properties of sprouted sesame flour

Soaking time (h)	Treatment	Bulk density (g/ml)	Dispersibility (%)	Swelling power (%)	Solubility index (%)	Water absorbtion capacity (%)
	UR	0.8^{3bc}	67.50^{g}	9.52^{dc}	26.01^{g}	149^{g}
8	SP	0.71^{a}	65.50^{f}	9.66^{e}	26.38^{h}	163^{h}
	SPB	0.87^{c}	64.00^{e}	7.51^{ab}	28.00^{c}	137^{d}
10	SP	0.71^{a}	59.00^{a}	8.29^{bc}	11.38^{a}	170^{j}
	SPB	0.87^{c}	62.75^{d}	8.01^{bc}	14.60^{b}	140^{e}
12	SP	0.83^{bc}	59.00^{a}	8.13^{bc}	35.01^{j}	124^{c}
	SPB	0.77^{d}	62.50^{d}	7.78^{bc}	35.15^{k}	110^{b}
14	SP	0.80^{bc}	59.50^{ab}	7.29^{ab}	25.43^{f}	145^{f}
	SPB	0.80^{bc}	60.00^{bc}	7.67^{abc}	20.81^{d}	96^{a}
16	SP	0.83^{bc}	60.00^{abc}	6.69^{a}	25.73^{e}	162^{h}
	SPB	0.83^{bc}	61.00^{c}	8.65^{cd}	11.97^{c}	164^{i}

Values are means of two replicates
Mean values within a column with different superscripts are significantly different ($p < 0.05$)
UR= Un-sprouted (Raw) sesame flour SP= Sprouted sesame flour
SPB= Sprouted and boiled sesame flour

Boiling of the seeds after sprouting decreased the dispersion for 8 – 14 h soak time and increased slightly at 16 h soak time. Dispersion is a measure of reconstitution of flour or flour blends in water (Adebowale *et al*., 2008). The higher the dispersiion, the better the flour reconstitutes in water (Kulkarni *et al*., 1991). Higher dispersion ability enhances the emulsifying and foaming capacities of proteins, which was observed during the making of bread, macaroni and cookies (Kinsella, 1979).

The swelling power increased at a soak time of 8 h from an initial value of 9.52 to a value of 9.66. The 8 h soaked sample has the highest swelling power of 9.66 and the 16 h soak time with the least value of 6.69. The swelling power decreased with an increase in soak time for the various samples except for the 14 and 16 h pre-soaked sprouted-boiled seed flour that increased in swelling power with boiling. Soaking and sprouting have a significant effect ($p < 0.05$) on the solubility index of the flour. The 12 h pre-soaked samples of both the sprouted and sprouted-boiled samples have the highest solubility index of 35.01% – 35.15% respectively when compared with that of the other samples. The solubility index of the flour obtained from the seeds soaked for 8 h was 26.38% and it reduced significantly to a value of 11.38% at 10 h soak time. The solubility index ranged between 35.01% – 25.13% for the 12 – 16 h soak time respectively. This shows that the solubility index of the samples reduces when the soak time exceeded 12 h. Boiling of the seeds after sprouting increased the solubility index of the samples soaked for 8 – 14 h but reduced at 16 h soak time. Moorthy and Ramanujam (1986) reported that the swelling power of flour samples is an indication of the extent of associative forces within the granule. Swelling power is also related to the water absorption index of the starch-based flour during heating (Loos *et al.,* 1981).

The water absorption capacity (WAC) of the pre-soaked sprouted sample increased significantly ($p < 0.05$) with an increase in soak time from an initial value of 149% for the raw sample to 163% and 170% for the 8 and 10 h soak time respectively. The value dropped considerably at 12 h soak time to 124% and increased at the 14 and 16 h soak time. The water absorption capacity for the sprouted-boiled samples reduced when compared to that of the sprouted ones. The varied WAC of the samples may be due to the change in protein structure with increase in soak time. WAC describes flour-water association ability under limited water supply. High WAC is also attributed to loose structure of starch polymers while low value indicates the compactness of the structure (Adebowale *et al*., 2005; Oladipupo and Nwokocha, 2011). It also refers to the ability of protein matrix, such as protein particles, protein gels or muscle to absorb and retain water against gravity. This water includes bound, hydrodynamic water, capillary water, and physically entrapped water. The physically entrapped water is however the largest fraction, it imparts juiciness and tenderness to various foods (Scheraga *et al*., 1962). Water absorption capacity is a desirable trait in foods such as custards, sausages and dough because these are supposed to imbibe water without dissolution of protein, thereby attaining body thickening and viscosity (Seena and Sridhar, 2005).

Conclusion

The chemical composition showed that soaking and spouting can be used to improve the nutritional composition of sesame seeds and hence the flour. Seeds soaked for 12 and 14 h gave the best result for both sprouted and sprouted-boiled samples in terms of protein content. The result for the functional properties showed that soaking and sprouting improved and modified the functional properties of the sesame flour. Sprouting improved the swelling power and water absorption capacity of the flour which are important parameters in food formulation. Therefore, sprouted and sprouted-boiled sesame seed flour could be a good substitute for flour from other seeds and legumes in some food formulation.

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