Impact of cooking time on the nutritional profile of sesame milk

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The effect of cooking time on nutritional characteristics of sesame milk was determined. Sesame milk was cooked at the temperature of 100°C for various duration (0, 15, 30 and 45 min), to produce samples marked as A, B, C and D. The sesame milk products were subjected to physico-chemical and sensory analyses using standard analytical methods. The moisture, protein, crude fat and energy contents decreased significantly (p≤0.05) with increase of cooking time from 89.30 to 87.32%, 2.5 to 2.3%, 5.5 to 4.0% and 54.81 to 49.55 kcal/g respectively; while ash, fiber and carbohydrate contents increased significantly (p≤0.05). Total solids and pH varied from 7.95 to 10.90 and 6.57 to 6.83%, respectively. Calcium was highest (273.44 mg/100 g) followed by phosphorus (196.2 mg/100 g), magnesium (173.5 mg/100 g) and potassium (95.58 mg/100 g) in milk cooked for 45 min when compared with lower values observed at 0, 15 and 30 min. The vitamins (thiamine and riboflavin) significantly reduced in sesame milk after boiling for 45 min. This accounted for a post-boiling decrease of about 76.2 and 64.0% in vitamins B1 and B2, respectively. Duration of cooking was observed to affect the phytate and oxalate concentrations significantly (p≤0.05) in sesame milk with a maximum reduction observed after 45 min. Mean sensory scores for colour and flavour ranged from 6.75 to 7.29 and 7.28 to 7.52, respectively. Sesame milk cooked at 100°C for 30 min (sample C) gave the highest acceptability score of 8.06, followed by samples B, A and D in that order. It was evident that there were varying degrees of changes that occurred in each of the chemical composition of the sesame milk with respect to the different periods of cooking. Processing at 100°C for 30 min gave the product with appreciable nutritional and sensory qualities with tolerable concentration of anti nutrients, and is therefore, recommended for sesame milk processors.

Key words: Chemical composition, cooking, sensory analysis, sesame milk.

INTRODUCTION

Oil seeds are agricultural species which contain substantial quantities of fixed oils with appreciable quantities of protein and mineral elements. Oil seeds are the second most valuable commodity in the world trade (USDA, 2005). In some developing countries where the supply of animal protein is inadequate to meet the rapid
population growth, there is increase in research to utilize some of the protein-rich oil seeds in bridging the gap on demand. In Nigeria, there is a wide varieties of oil crops in various parts of the country ranging from largely known and highly utilized ones like soya bean, palm kernel and groundnut, to underutilized ones like walnut, locust bean, African oil bean and sesame seed.

Sesame seed (Sesamum indicum L., synonymous with Sesamum orientale L.), also known as sesamum, gingersly, sim sim, benniseed and til is probably the most ancient oilseed known and used by humans as a food source (Gharbia-Abau et al., 2000). It has been cultivated for centuries. Sesame seed contains about 25% crude proteins and 50% fat (Makinde and Akinoso, 2013). Much attention has been directed towards exploring the utilization sesame seed for new food uses seed due to its nutritional (Morris, 2002), functional (Oshodi et al., 1999) and health properties (Kapadia et al., 2002). Sesame protein has high biological value and it is cheaper as compared to animal protein sources e.g., meat and fish in the tropics. Sesame is also a good source of minerals especially calcium, potassium, magnesium, iron, zinc and copper and vitamins; thiamine, riboflavin and niacin (Biswas et al., 2001) with appreciable content of lignans, which in turn contains sesamin and sesamol. In addition, sesame are known to contain anti nutritional factors (majorly phytate and oxalate); but it is devoid of anti tryptic compounds.

The nutritional potentials of sesame can be explored to solve the protein gap problem among the low-income earners in Nigeria. Sesame seeds can be utilized in imitated dairy products, which could be used for infant and adults with lactose intolerance as well as for vegetarian or others who like to consume dairy products free of cholesterol. Additionally, the production of sesame-based dairy products can overcome the problems that limit consumption of soy-based dairy products such as flavour and flatulence.

Cooking is a common practise of food processing to prevent spoilage and enhance the keeping quality. The cooking process also gives the characteristics associated with edible food, which are generated through an intricate series of physical and chemical changes that occur when foods are heated.

However, cooking time is a key property of food processing which in most cases is not adhered to. Heat applied during cooking has no instant effect on the food being cooked; it takes time for heat to make the desired effect that is required of it on food generally (Orhevba, 2011). Cooking had some adverse effects on foods such as denaturation of protein, coagulation of lipids, breaking down of starch, leaching of mineral elements, development of melanoids and cooked flavour, and destruction of essential amino acids and vitamins.

As a result, time is indeed a very important factor to be considered when processing food and indeed sesame milk to obtain its optimum benefit for man. Hence, the effect of cooking time on the nutritional parameters of sesame milk is of great importance to analyse.

MATERIALS AND METHODS

Source of material

The white variety of sesame seeds used for the preparation of the sesame milk were collected from National Cereal Research Institute (NCRI), Badegi, Nigeria and transported to the laboratory in an airtight polythene bag and stored under cool dry storage (4°C) condition until needed.

Preparation of sesame milk

The sesame seeds were cleaned to remove extraneous materials. The sesame seeds were dehulled by soaking in water (1: 5 w/v) for 4 h at 29 ± 2°C according to the method reported by Mohamed et al. (2007). The ruptured seed coats were then removed by rubbing with palms and washed with water. Dehulled sesame seed and tap water were weighed (1:4) to give the desired sesame seed percentage.

Sesame seed was transferred to the blender vessel and a small portion of the weighed water was added to facilitate the progress of mixing/grinding process. The blender was operated at highest speed for 10 min. After finishing the grinding process, the remaining quantity of water was added and mixed thoroughly. The resulted sesame dispersion was homogenized (in portions of 300 g) for 5 min using laboratory homogenizer.

The homogenized sesame milk base was squeezed through cheesecloth to separate coarse particles. The resulted milky solution was weighed and readjusted to its original weight (before filtration) by adding tap water.

The cooking of the extracted sesame milk

Sesame milk was cooked according to the method described by Orhevba (2011). A sample (500 mL) of the extracted sesame milk was boiled in a beaker to determine the temperature at which sesame milk boils. With the use of a thermometer, the boiling point (bp) of the sesame milk was measured once it began to boil. It was discovered that sesame milk boils at 100°C at ambient atmospheric conditions. Sesame milk at its boiling point (100°C) was collected as the control (sample A).

At 15 min from the time the sesame milk began to boil, sample B was collected from the boiling sesame milk, cooled and preserved in a sterile plastic bottle. The boiling sesame milk was allowed to cook for another 15 min, bringing the time to 30 min and then another sample C was collected, cooled and kept in sterile plastic bottle. The last sample of the experiment, sample D was collected after another 15 min of cooking from 30 min; bringing the total time of cooking to 45 min. The samples A, B, C and D were subjected to chemical analyses.

Chemical analysis

Proximate composition

The samples were analysed for moisture, crude protein (N × 6.25), fat, fiber and ash following standard procedures (AOAC, 2005). Total carbohydrates were calculated by difference. The sample energy value was estimated (kcal/g) by multiplying the percentages of crude protein, crude lipid and carbohydrate with the recommended factors (2.44, 8.37 and 3.57, respectively) as proposed by...
**Determination of mineral content**

Analysis of potassium content of the samples was carried out using flame photometry, while phosphorus was determined by the phosphovanado-molybdate (yellow) method (AOAC, 2005). The other elemental contents (Ca, Mg, Fe, Se, Zn and Mn) were determined, after wet digestion of sample ash with an Atomic Absorption Spectrophotometer (AAS, Hitachi Z6100, Tokyo, Japan). All the determinations were carried out in triplicates.

**Determination of vitamin content**

Thiamine (vitamin B\(_1\)) and riboflavin (vitamin B\(_2\)) were determined by using spectrophotometric method AOAC (1990). Thiamine content was determined by weighing 0.5 g of the sample and adding 30 mL dichloroethane and 30 mL of 30% HCl (ratio:1:1). Then 50 mL ammonium hydroxide solution was added. The solution was then filtered using Whatman No1 filter paper. Then the absorbance was read on a spectrophotometer (Spectronic 20 model) at 415 nm. Riboflavin content was determined by weighing 1 g of the sample and adding 50 mL of 50% methanol and 50 mL of 17% sodium carbonate. This is the extraction. Then, the absorbance was read on a spectrophotometer at a wavelength of 415 nm.

**Determination of anti nutrient**

The phytate content was determined by the method of Maga (1982). Two grams of each finely ground sample was soaked in 20 mL of 0.2 N HCl and filtered. After filtration, 0.5 mL of the filtrate was mixed with 1 mL ferric ammonium sulphate solution in a test tube, boiled for 30 min in a water bath, cooled in ice for 15 min and centrifuged at 3000 rpm for 15 min.

One millilitre of the supernatant was mixed with 1.5 mL of 2,2'-pyridine solution and the absorbance measured in a spectrophotometer at 519 nm. The concentration of phytic acid was obtained by extrapolation from a standard curve using standard phytic acid solution.

The titration method described by Day and Underwood (1986) was used to determine the oxalate content. To 1 g of the ground powder, 75 mL of 15 N H\(_2\)SO\(_4\) was added. The solution was carefully stirred intermittently with a magnetic stirrer for 1 h and filtered using Whatman No 1 filter paper. Filtrate (25 mL) was then collected and titrated against 0.1 N KMnO\(_4\) solution till a faint pink colour appeared that persisted for 30 s. The concentration of oxalate in each sample was obtained from the calculation:

\[
1 \text{ mL} \times 0.1 \text{ permanganate} = 0.006303 \text{ g oxalate}
\]
Table 1. Physico-chemical properties of sesame milk samples.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>89.30±0.02</td>
<td>88.50±0.10</td>
<td>88.10±0.07</td>
<td>87.32±0.07</td>
</tr>
<tr>
<td>Ash (%)</td>
<td>1.08±0.06</td>
<td>1.32±0.02</td>
<td>1.47±0.10</td>
<td>1.54±0.07</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>2.53±0.01</td>
<td>2.44±0.01</td>
<td>2.35±0.01</td>
<td>2.28±0.01</td>
</tr>
<tr>
<td>Fat (%)</td>
<td>5.50±0.02</td>
<td>4.62±0.05</td>
<td>4.19±0.02</td>
<td>3.95±0.01</td>
</tr>
<tr>
<td>Fibre (%)</td>
<td>0.86±0.03</td>
<td>1.10±0.05</td>
<td>1.41±0.03</td>
<td>1.85±0.06</td>
</tr>
<tr>
<td>Carbohydrate (%)</td>
<td>0.73±0.01</td>
<td>2.02±0.01</td>
<td>2.48±0.01</td>
<td>3.06±0.06</td>
</tr>
<tr>
<td>Energy (kcal/g)</td>
<td>54.81±1.14</td>
<td>51.83±0.98</td>
<td>49.66±0.72</td>
<td>49.55±1.12</td>
</tr>
<tr>
<td>Total solids (%)</td>
<td>7.95±0.06</td>
<td>8.41±0.04</td>
<td>9.20±0.04</td>
<td>10.90±0.06</td>
</tr>
<tr>
<td>pH</td>
<td>6.57±0.06</td>
<td>6.64±0.04</td>
<td>6.77±0.04</td>
<td>6.83±0.06</td>
</tr>
</tbody>
</table>

Values are means ± standard deviation of triplicate determinations; means with different superscripts within the same row are significantly different (p ≤ 0.05); key: A = Control (Cooking at 100°C for 0 min); B = Cooking at 100°C for 15 min; C = Cooking at 100°C for 30 min; D = Cooking at 100°C for 45 min.

Table 2. Mineral and vitamin compositions of sesame milk (Mg/100 g).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>262.05±1.12</td>
<td>267.27±1.80</td>
<td>270.20±2.07</td>
<td>273.44±1.11</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>189.78±1.06</td>
<td>192.05±1.02</td>
<td>194.07±2.10</td>
<td>196.20±0.97</td>
</tr>
<tr>
<td>Potassium</td>
<td>90.53±0.01</td>
<td>92.54±0.15</td>
<td>93.56±0.81</td>
<td>95.58±0.12</td>
</tr>
<tr>
<td>Magnesium</td>
<td>163.50±0.02</td>
<td>167.40±0.05</td>
<td>170.43±0.02</td>
<td>173.45±0.01</td>
</tr>
<tr>
<td>Iron</td>
<td>2.04±0.03</td>
<td>2.11±0.05</td>
<td>2.21±0.03</td>
<td>2.34±0.06</td>
</tr>
<tr>
<td>Selenium</td>
<td>0.45±0.01</td>
<td>0.49±0.01</td>
<td>1.54±0.01</td>
<td>1.58±0.02</td>
</tr>
<tr>
<td>Zinc</td>
<td>2.31±0.06</td>
<td>2.71±0.04</td>
<td>2.82±0.04</td>
<td>2.89±0.05</td>
</tr>
<tr>
<td>Manganese</td>
<td>1.22±0.02</td>
<td>1.28±0.03</td>
<td>1.32±0.04</td>
<td>1.36±0.04</td>
</tr>
<tr>
<td>Thiamine</td>
<td>0.42±0.01</td>
<td>0.37±0.01</td>
<td>0.34±0.02</td>
<td>0.30±0.02</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>0.25±0.04</td>
<td>0.22±0.03</td>
<td>0.19±0.01</td>
<td>0.16±0.05</td>
</tr>
</tbody>
</table>

Values are means ± standard deviation of triplicate determinations; means with different superscripts within the same row are significantly different (p ≤ 0.05).

Table 3. Anti nutrient composition of sesame milk (Mg/100g).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxalate</td>
<td>45.26±1.02</td>
<td>37.23±0.47</td>
<td>30.47±1.07</td>
<td>28.15±0.05</td>
</tr>
<tr>
<td>Phytate</td>
<td>26.50±0.09</td>
<td>16.63±0.02</td>
<td>15.25±0.40</td>
<td>13.36±0.13</td>
</tr>
</tbody>
</table>

Values are means ± standard deviation of triplicate determinations; means with different superscripts within the same row are significantly different (p ≤ 0.05).

Phytate and oxalate in sesame milk was lowest and significantly different (p ≤ 0.05) from the samples cooked for 0, 15 and 30 min. Cooking for 45 min at 100°C is required to reach 50.42 and 62.20% inactivation of phytate and oxalate respectively in sesame milk.

Table 4 shows the mean sensory scores of sesame milk cooked at various time. The scores for colour increased significantly (p ≤ 0.05) from 6.73 in sample A to 7.12 and 7.29 in samples B and C respectively while sample D had least value. Similarly, the score for taste, flavour, mouth feel and overall acceptability increased significantly (p ≤ 0.05) from sample A to sample B and C, respectively, with a decrease in sample D only. Cooking at 100°C for 30 min (sample C) gave the highest acceptability score of 8.10, followed by samples B, A and D in that order.

DISCUSSION

The decrease in moisture content as cooking time increase was as a result of evaporation of water during...
cooking. However, the observed high moisture content of sesame milk could affect the stability and safety with respect to microbial growth; hence the products require cold storage. Results are within the range reported for soymilk cooked under the similar condition (Akintunde and Souley, 2009). Apparently, the differences observed in protein values as a result of different heating period could be related to the denaturation. Proteins form different 3-dimensional structures, by the folding and subsequent bonding of the amino acid strands. Generally, the bonds which link the folded amino acid strands together (mostly hydrogen bonds), are much weaker than the strong peptide bonds forming the strands. During cooking, the heat causes the proteins to vibrate more vigorously which results in the breakage of the weak hydrogen bonds holding the amino acid strands in place. Consequently, the protein unravels to re-take its initial form of amino acid strands. Similarly, cooking process could reduce protein content due to the fact that protein can be involved in the Maillard reactions together with reducing sugars. Among the proteins, lysine is the most implicated in this reaction and its diminution in time could be related to effect of heat treatment.

The significant decrease in fat content as sesame milk was cooked at its boiling temperature for 15 to 45 min as compared to sesame milk at its boiling point could be as a result of higher exposure times which introduce changes to lipids in such ways that affect their nutritional value. Some of these changes include lipid oxidation in the presence of oxygen and the removal of the film (rich in protein and fat) at the top of the milk during cooking. The remarkable reduction in the percentage fat agrees with the findings of Orhevba (2011). Significantly, higher ash, fiber and carbohydrate values observed with increase in cooking time may be attributed to concentration effects on sesame milk by loss of water. The significant (p≤0.05) increase in crude fiber with increase in cooking time is a positive nutritional development. Though crude fibre does not contribute nutrients to the body, it adds bulk to food thus facilitating bowel movements (peristalsis) and preventing many gastrointestinal diseases in man (Gordon, 1999). The increase in ash reflected in significant increase in mineral concentrations. The observed increase in carbohydrate content is in agreement with Yau-Chun et al. (2011) who also reported similar increase in soy milk produced by blanching and grinding of soybeans with hot water. Carbohydrates provide heat and energy for all forms of body activity. Deficiency of carbohydrate causes the body to divert proteins and body fat to produce needed energy, thus leading to depletion of body tissues (Gordon, 1999). The decrease in energy value observed with increase in cooking time could be attributed to decrease in fat content of the milk samples as fat contains about twice the food energy values of protein and carbohydrate.

The fact that all the pH values are below neutral (7.0) is an indication that microbial growth will not be easily encouraged in the sesame milk samples. The pH values of sesame milk samples were comparable to the pH of soymilk (6.60) as reported by Onweluzo and Owo (2005). Differences in total solids between the milk samples were comparable to the pH of soymilk samples as fat contains about twice the food energy values of protein and carbohydrate.

There was positive increase in the elemental concentrations from the control to sample D. Minerals are essential nutrients, without which the body cannot function correctly. Heating itself does not affect mineral levels but are usually leached if cooked in boiling water. Minerals tend to have higher heat stability and are less affected by cooking methods which involve heating foods for longer periods of time. However, the higher mineral concentrations observed as sesame milk was cooked at its boiling point for 0-30 min are the result of the decrease in anti-nutrients particularly phytate as the major elements such as phosphorus, calcium and potassium are parts of the molecular structure of phytic acid and phytin (Duhan et al., 2002).

The only factor that could account for the observed significant decrease in thiamine and riboflavin as the cooking time increased was the heat applied as these vitamins are thermo labile in nature. Milk boiling is a common processing practice around the globe to reduce the level of natural microbial pathogens found in milk, however, this practice has deleterious effect on the contents of B-vitamins (Asadullah et al., 2010). Due to their tendency to disperse in water, water-soluble vitamins in particular are immensely affected by cooking processes. Considering the effect of cooking on the reten-

### Table 4. Mean sensory scores of sesame milk.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colour</td>
<td>6.73±0.02</td>
<td>7.12±0.10</td>
<td>7.29±0.07</td>
<td>5.98±0.07</td>
</tr>
<tr>
<td>Flavour</td>
<td>7.28±0.06</td>
<td>7.35±0.02</td>
<td>7.52±0.10</td>
<td>6.82±0.02</td>
</tr>
<tr>
<td>Taste</td>
<td>7.41±1.12</td>
<td>7.57±0.07</td>
<td>7.68±1.01</td>
<td>6.56±0.06</td>
</tr>
<tr>
<td>Mouth feel</td>
<td>7.35±0.08</td>
<td>7.48±0.05</td>
<td>7.63±1.12</td>
<td>6.44±0.03</td>
</tr>
<tr>
<td>Overall acceptability</td>
<td>7.67±0.07</td>
<td>7.83±0.45</td>
<td>8.06±0.73</td>
<td>6.66±1.02</td>
</tr>
</tbody>
</table>

Values are means ± standard deviation of triplicate determinations; means with different superscripts within the same row are significantly different (p≤0.05).
tion of these water-soluble vitamins, it was observed that riboflavin is more stable than thiamine. Similar observation was reported by Fanelli et al. (1985). They further reported that such stability can only be ensured if light is excluded during processing and cooking of food as riboflavin undergoes photo degradation in the wavelength range of 400-550 nm.

The anti nutritional compositions of milk samples were reduced to innocuous level. The physical removal of sesame hull during initial dehulling was associated with decreased phytate and oxalate contents (Makinde and Akinoso, 2013) and much more is expected during the cooking of resultant sesame milk. In general, cooking time was reported to have pronounced effects on the anti-nutritional factors present in natural foods (Kaack, 1994).

Cooking has a substantial impact on the final sensorial characteristics of many different foods. The observed reduction in the colour score of sample D as compared to other milk samples could be due to Maillard browning reactions, which usually occur between reducing sugars and amino groups in proteins and amino acids. Such reactions were encouraged by increase in concentration of reactants (Alais and Linden, 1991). Similarly, the decrease in flavour score of sample D could be due to derived off-flavours due to concentration effects. The concentration also made the sesame milk thicker and heavier, thus adversely affecting the taste and the mouth feel. However, sesame milk cooked at 100°C for 30 min (sample C) gave the highest acceptability score.

Conclusions

Sesame milk offers array of nutrients which are essentials to normal body functions. In this study, cooking within the time limit (15-45 min) had a significant effect on sesame milk composition and sensory properties. Results indicated that the appropriate heat treatment for sesame milk processing was cooking at 100°C for 30 min.

Conflict of Interests

The author(s) did not declare any conflict of interests.

REFERENCES