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Research Article

Effect of Cooking Temperature on Some Quality Characteristics of Soy Milk

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Abstract: The effect of different processing temperatures on some quality characteristics of soymilk was determined. Soybean was processed at varying temperatures (80, 90 and 110°C), to produce soymilk samples A, B and D, with product processed using the normal boiling temperature of 100°C (sample C) as standard. The soymilk products were subjected to physiochemical, microbiological and sensory analyses using standard analytical methods. The moisture and crude fat contents decreased significantly ($p<0.05$) with increase in temperature from 92.05 to 89.78% and 2.26 to 2.04% respectively; while the converse was true of crude protein, crude fibre, ash and carbohydrate contents, which all increased significantly ($p<0.05$). Total solids and pH increased from 7.95 to 10.90 and 6.50 to 6.58 respectively. The Total Viable Count (TVC) ranged from 1.4×10^3-2.3×10^3 CFU/mL, while yeast and mould count ranged from 0.3×10^2 to 1.2×10^2 CFU/mL, with the lowest values coming from the products processed at 110°C, thus making sample D microbiologically safer than the others. Mean sensory scores for colour and flavour ranged from 5.90 to 7.00 and 5.87 to 8.33, respectively. Though all the soy milk products were acceptable, milk processed at 100°C (sample C) had the highest acceptability score (8.33) followed by samples B (6.60), A (5.89) and D (5.87) in that order. Processing at 100°C gave the best product in terms of all the attributes measured and is therefore, recommended for soy milk processors.

Keywords: Flavour, processing, sensory analysis, soybean, soymilk, total viable counts, varying temperatures

INTRODUCTION

Soy milk, sometimes called soy drink or soy-beverage, is a white emulsion which resembles cow milk (conventional milk) in both appearance and consistency (Williams and Akiko, 2000). It is made from soybean (*Glycine max* L) seed and is described as a stable emulsion of oil, water and protein (Wikipedia, 2008). It is an inexpensive source of protein and calories for human consumption which compares favourably with diary milk and can be used as a vital and cheaper substitute for cow milk for solving malnutrition problems in developing countries like Nigeria (Iwe, 2003).

Soy milk contains as much as 3.50% protein (about the same as cow milk), 2.00% fat, 0.50% ash and 2.90% carbohydrate (Riaz, 2006). It has therefore been advocated that cow milk production should be substituted with soy milk production, especially where the former is difficult and expensive. It has lower fat content than cow milk and contains no cholesterol (Rehman *et al*., 2007). This is regarded as one of its positive health benefits. The absence of lactose in soymilk also positions it as a solution to lactose intolerance for some consumers of dairy milk, especially infants with such biochemical challenge. It promotes growth in children who are allergic to cow milk and has been used in solving protein deficiency problems all over the world (Onuorah *et al*., 2007).

Nigeria is yet to maximize the potential of soy milk as a replacement for cow milk as a cheap source of high quality proteins. In 2004 for instance, the country spent over N38, 744, 485, 425 on importation of cow milk and milk products, excluding yoghurt (FDS, 2004). It is therefore obvious that encouraging the production and consumption of soy milk portends high economic gains for the country. More people will have access to cheap but good quality protein needed by the body for good health.

Many techniques have been developed for the production of good quality bland tasting, sweet or flavoured soy milk (Liu, 1997; Williams and Akiko, 2000; Onuorah *et al*., 2007; Wikipedia, 2008). However, the successful utilization of soy milk has been greatly hampered by several constraints (Torres-Peneranda, 1998). One of the outstanding limiting problems has been the presence of highly objectionable beany flavour (Liu, 2000). Improvement in the flavor of soymilk will therefore go a long way in improving its acceptability and consumption. A lot of study has been done in the bid to remove the beany flavor in soy milk

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Table 1: Physico-chemical properties of soy milk samples

Parameters	A	B	C	D	LSD
Moisture (%)	92.05±0.02^a	91.07±0.10^b	90.20±0.07^c	89.78±0.06^d	0.23
Ash (%)	0.53±0.01^b	0.54±0.01^b	0.56±0.01^a	0.58±0.01^a	0.03
Protein (%)	3.40±0.05^b	3.43±0.02^b	3.45 ±0.01^a	3.50±0.02^a	0.06
Fat (%)	2.26±0.03^a	2.17±0.05^b	2.11±0.03^c	2.04±0.06^d	0.05
Crude fibre (%)	0.45±0.01^b	0.49±0.01^b	1.54 ±0.01^a	1.58±0.06^a	0.07
Carbohydrate (%)	1.31±0.06^c	2.11±0.04^b	2.20±0.04^b	2.41±0.06^a	0.18
Total solid (%)	7.95±0.02^d	8.20±0.03^c	9.80±0.04^b	10.90±0.17^a	0.15
pH	6.50±0.15^c	6.54±0.02^b	6.57±0.01^a	6.58±0.01^a	0.03

Values are means±standard deviation of duplicate determinations; means with different superscripts within the same row are significantly different ($p \leq 0.05$); key: A = Cooking at 80°C; B = Cooking at 90°C; C = Cooking at 100°C (Standard); D = Cooking at 110°C

using flavourings and enzymes (Rehman *et al*., 2007; Sheue-Lei, 2007; Laswai *et al*., 2009).

Iwe (2003) reported that processing of soybeans using various forms of heat treatment improves texture, palatability as well as nutritional and sensory quality characteristics and that the degree of improvement depends on the temperature, moisture content and duration of heating. This improvement appears to be related to the destruction of trypsin inhibitors and other biologically active components (Yuan *et al*., 2008). Yau-Chun *et al*. (2011) used consecutive blanching and grinding with hot water to eliminate beany flavor in soy milk.

This study was aimed at assessing the quality of soy milk produced from processing of soy beans using different cooking temperatures.

MATERIALS AND METHODS

Source of materials: The soybeans (2010 harvest) used for the production of soy milk was purchased from North-Bank market, Makurdi, Benue State. Laboratory equipment and chemicals were accessed in the Department of Food Science and Technology, Federal University of Agriculture, Makurdi, Nigeria, where the study was carried out.

Preparation of soy milk: Extraction of soymilk was carried out by the simple traditional method of milk extraction as described by Fellows (1997). About 1.0 kg of cleaned and washed beans were soaked in 10% Sodium bicarbonate ($NaHCO_3$) for 10 h, after which they were ground into a pulp using an electric blender (Kenwood, Model A 907 D) with addition of 6.0 L of water. The resulting slurry was divided into four equal portions and cooked at different temperatures of 80, 90, 100 and 110°C in a water bath for 20 min. The cooked soy milk samples were then filtered off (separated from the mush or fibre) and cooked for another 10 min, with continuous shaking. They were then cooled to room temperature and packaged in low density polyethylene bags to give the different soy milk samples (A, B, C and D) which were stored in the refrigerator (4-8°C) for analysis within a maximum of 4 h.

Analysis of soy milk:

Proximate composition: Moisture, crude protein, crude fat, crude fibre and ash were determined using the method of AOAC (2005), while carbohydrate was determined by difference (Ihekoronye and Ngoddy, 1985). pH was determined by the method described by Akpapunam and Sefa-Dedeh (1995) using a digital pH meter (model: WPACD 60).

Total solids: This was determined gravimetrically using the method described by Bradley Jr (2003). A measured weight of each test sample was put in a previously weighed evaporating dish and evaporated to dryness over a steam bath. It was then dried in an oven at 105°C for an hour. It was cooled in desiccators and then reweighed by difference. The dry weight of the sample was obtained and expressed as a percentage of the sample weight.

Microbiological analysis: Total Viable count (TVB) and Total yeast and mould count were both estimated by the pour plate method of Frazier and Westhoff (2010), where serial dilutions of the samples were poured into plate count agar and incubated at 37±20° for 48 h after which the total viable colonies on the plate were counted. For yeast and moulds, malt extract agar was used and the plates were incubated at 25±37°C for 3-5 days.

Sensory evaluation: A 15 member panelist judges comprising of Students of the Department of Food Science and Technology and Department of Home Science and Management of the University of Agriculture Makurdi, were used to assess the following quality attributes such as colour, mouth feel, flavour and general acceptability using a 9 point hedonic scale was used (Iwe, 2002).

Statistical analysis: All determinations were carried out in triplicates. Values were subjected to Analysis of Variance (ANOVA) using GENESTAT 2005 edition. Least significant differences between means were determined by Tukey's Test.

RESULTS AND DISCUSSION

Physico-chemical properties: Table 1 presents the results of physico-chemical properties for the soy milk samples. Moisture and fat contents decreased significantly ($p<0.05$) with increase in processing temperature from 92.05% to 89.78% and 2.26% to

2.04% from samples A to D, respectively. This could be due to evaporation of water and volatilization of fat caused by heat during cooking of the slurry. Conversely, crude protein, crude fibre, ash, carbohydrate and total solids increased significantly ($p<0.05$) with increase in processing temperature. This could be due to concentration effect. As the content of water and fat reduced from the soy milk, the other components increased, thus improving the nutritional value of the soy milk.

In spite of the apparent improvement in the nutritional composition with increase in cooking temperature, due diligence must be exercised in the use of heat in soy milk production. Yuan *et al.* (2008) reported that excessive heating results in the destruction or inactivation of cystine, lysine and many other amino acids such as arginine, tryptophan, histidine and serine, thus adversely affecting the nutritional value of soy protein. While cystine is particularly sensitive to heat, lysine does not only undergo destruction, but is rendered unavailable. This is because the amino group of the lysine so modified is no longer physiologically available, since the peptide bond containing the modified lysine is not susceptible to tryptic cleavage. The digestibility of soy protein by proteolytic enzymes therefore, becomes considerably reduced when the protein has been subjected to excessive heat treatment. Salunkhe *et al.* (1992) postulated that the maximum nutritive value of soy proteins is achieved by treatment with live steam for about 30 min or by autoclaving at 6.70 kg pressure for 15-20 min. This implies that cooking soy milk at 110°C for 30 min could cause some damage to the soy protein.

The significant ($p<0.05$) increase in crude fibre, with increase in processing temperature 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 carbohydrate content means increase in calories. This is in agreement with Yau-Chun *et al.* (2011) who also reported an increase in carbohydrate content of soy milk produced by blanching and grinding of soybeans with hot water. Carbohydrates provide heat and energy for all forms of body activity. Deficiency can cause the body to divert proteins and body fat to produce needed energy, thus leading to depletion of body tissues (Gordon, 1999).

The pH of the soy milk samples increased slightly but significantly ($p<0.05$) with increase in processing temperature from 6.50 in sample A to 6.58 in D. The fact that all the pH values are below neutral (7.0) is an indication that microbial growth will not be encouraged in the soy milk samples.

Table 2: Microbiological composition of soy milk samples (CFU/mL)

Parameter	A	B	C	D
Total Viable count (TVB)	2.3×10^3	2.1×10^3	1.8×10^3	1.4×10^3
Yeast and mould count	1.2×10^2	1.0×10^2	0.9×10^2	0.3×10^2

Key: A = Cooking at 80°C; B = Cooking at 90°C; C = Cooking at 100°C (standard); D = Cooking at 110°C

Table 3: Mean sensory scores of soy milk samples

Parameter	A	B	C	D	LSD
Colour	5.90^b	6.50^a	7.40^a	7.00^a	1.00
Mouth feel	5.65^b	6.32^b	7.64^a	7.10^a	0.90
Flavour	5.87^b	6.67^b	8.13^a	7.13^a	1.33
General acceptability	5.89^c	6.60^b	8.33^a	5.87^c	0.69

Means with different superscripts within the same row are significantly different ($p\leq0.05$); key: A = Cooking at 80°C; B = Cooking at 9°C; C = Cooking at 100°C (standard); D = Cooking at 110°C

Microbiological analysis: Microbial counts of the soy milk samples are presented in Table 2. Total viable counts decreased significantly ($p<0.05$) from 2.3×10^3CFU/mL in sample A to 1.4×10^3CFU/mL in D, while yeast and mould counts decreased from 1.2×10^2CFU/mL in A to 0.3×10^2CFU/mL in D with increase in processing temperature. This could be due to the destructive effect of heat. Yuan *et al.* (2008) also reported reduction in microbial load in soy milk produced by consecutive blanching and ultra-high temperature processing of soybeans. However, the total viable counts of the soy milk products were within the acceptable limits of 10^7 CFU/mL as given by ICMSF (1974).

Sensory properties: The mean sensory scores of soy milk processed at varying temperatures are shown in Table 3. The scores for colour, mouth feel, flavor and general acceptability increased significantly ($p<0.05$) from 5.90, 5.65, 5.87 and 5.89 respectively in sample A to 7.40, 7.64, 8.13 and 8.33 respectively in sample C, then decreased to 7.00, 7.10, 7.13 and 5.87 respectively in sample D.

The significant ($p<0.05$) increase in colour intensity (which caused a reduction in the colour score of sample D) could be due to Millard browning reactions, which usually occur between reducing sugars and amino groups in proteins and amino acids. These reactions are encouraged by increase in temperature, pH and concentration of reactants and are accompanied by destruction of some essential amino acids (Alais and Linden, 1991). This increase is in agreement with the report of Torres-Peneranda (1998) in sensory evaluation of soy milk made from lipoxigenase-free and normal soybeans.

The decrease in flavor scores of sample D could be due to derived off-flavours (development of new flavours and concentration of existing ones) as a result of cooking at higher temperatures. This concentration also made the soy milk heavier, thus increasing the mouth feel, which became objectionable to panelists.

Though all the soy milk products were acceptable, cooking at 100°C (sample C) gave the highest acceptability score of 8.33, followed by samples B, A and D in that order.

CONCLUSION

This study has shown that organoleptically acceptable and nutritious soy milk could be produced by cooking soaked and grounded soybeans at temperatures of between 80-110°C, without any apparent defects. However, though cooking at 110°C gave nutritionally richer and microbiologically safer products, cooking at 100°C gave soy milk that was most acceptable to consumers.

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