Sensory Evaluation of Flavored Soy Milk-Based Yogurt: A Comparison between Jordanian and Malaysian Consumers

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Abstract: Soy yogurt has gained significant popularity due to its nutritional health benefits. The objectives of this study were to develop flavored yogurt from soybean milk with reduced soy aftertaste by the addition of 30% (wt/wt) strawberry or orange jam in conjunction with a lactic acid fermentation. Soy milk-based yogurt products were assessed for microbial quality and for acceptability by a panel of Jordanian and Malaysian consumers. Sixty-one individuals, of whom 75.4% (n = 46) were Jordanian and 24.6% (n = 15) were Malaysian, evaluated the plain and flavored soy milk-based yogurt. The overall acceptability of orange and strawberry soy yogurt was rated significantly higher than plain soy yogurt. In general, the orange and strawberry soy yogurt received higher sensory ratings from Malaysian than Jordanian consumers. In addition, formulations with orange jam received higher scores than those flavored with strawberry. Shelf life tests showed that soy yogurt was acceptable for at least 8 d without perceptible spoilage. Therefore, the approach used yielded flavored products with better acceptability and improved sensory attributes, including decreased intensity of off flavor, with suitable shelf life at 4 °C.

Key words: Soy milk, sensory evaluation, flavored yogurt, shelf life, functional food.

1. Introduction

Beyond basic nutritional considerations, functional foods have been demonstrated to have physiological benefits or reduce the risk of chronic disease [1]. Consumer awareness and acceptance of functional foods and natural health products are increasing and consequently their global market continues to expand [2]. The international market for functional food is estimated to be approximately US$30 to US$60 billion, which represents 3% of the total food market [3]. In Canada, the number of firms involved in the production of these products was approximately 8.1% of the total food industry in 2007 [4]. The Soyfoods Association of North America reported that U.S. sales of soy foods reached $3.9 billion in 2003, continuing an 11-year trend of 15% average annual increases [5]. According to the United Soybean Board in 2006, 30% of Americans consume soy foods or beverages at least once a month or more and 82% view soy products as healthy [6].

Soy products are important sources of many nutrients including isoflavones, dietary fiber, oligosaccharides,
proteins, trace minerals and vitamins. Vitamin C, total phenolic content and total isoflavones per 100 g of soybean seed were: 34.8-88.7 mg, 0.68-1.39 mg gallic acid equivalent and 8.6-33.2 mg, respectively [7]. Soy protein is the most important among plant proteins because of its relatively high biological value, its cost advantage and content of essential amino acids [8]. For example, the content of aspartic acid, glutamic acid, glycine and alanine was reported to be 0.37-1.51, 0.64-2.82, 0.17-0.72 and 0.11-0.51 g/100 g of green soybean seed, respectively [9].

Soy milk, the aqueous extract of soybeans, has been perceived as a functional food, because it provides additional health benefits resulting from its hypolipidemic, anticholesterolemic, antiatherogenic properties and reduced allergenicity [10, 11]. The proximal composition of soy milk is: protein (3.0%-3.6%), sugar (2.9%-3.5%), fat (2.0%-2.5%), ash (0.5%), and it has a pH value of 6.8 to 7.0 [11, 12].

Soy yogurt, produced in a manner similar to milk fermentation by the addition of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* cultures to soy milk, has become popular because it appears to reduce cardiovascular disease, can contribute to weight loss, mitigate arthritic symptoms and improve brain function [11, 13, 14]. However, soy products have had limited consumer acceptance because of its undesirable or “beany” aftertaste due to the presence of hexanal and pentanal. These aldehydes are formed mainly by hydroperoxidation of polyunsaturated fatty acids catalyzed by lipoxygenase [15].

Oxidation of soy milk can occur during the initial soaking and grinding of soybeans by traditional methods, but commercial methods use steps that either prevent the formation of undesirable volatile compounds (inactivation of lipoxygenase by heating) or remove the residual off-flavors using deodorizing techniques [16, 17]. Fermentation using lactic acid bacteria can also reduce the beany flavor of soy milk [11]. However, addition of sweeteners such as jams and fruit purée to fermented soy milk may be a better alternative to reduce the aftertaste of soy milk. This aftertaste is an important factor restricting its regional popularity since consumers in Middle Eastern and Western countries are not familiar with this flavor. The production of a soy-flavored yogurt product is a simple but novel approach to increase the consumption of soy milk-based products. Therefore, the objectives of the current study were to develop flavored yogurt from soybean milk, and assess its microbial quality and acceptability to Jordanian and Malaysian consumers.

### 2. Materials and Methods

#### 2.1 Evaluation the Microbial Quality of Soy Milk

Soy milk was produced from soybean (obtained from a local processor) as follows: Soybeans were soaked overnight (8-10 h) at room temperature with water in a ratio of 1:3 followed by extrusion and pasteurization at 90 °C for 1 min. The microbiological quality of raw soy milk was assessed by measuring total plate count (TPC) and coliforms using the methods described by Youesf and Carlstrom [18]. Briefly, following soy milk pasteurization 1.0 mL or 0.1 mL samples were aseptically taken, serially diluted using 0.1% peptone water and plated on nutrient agar (Oxoid Ltd., Basingstoke, Hampshire, UK) or violet red bile agar (Oxoid Ltd.) to enumerate total bacterial and coliform numbers, respectively, and incubated at 37 °C for 48 h.

#### 2.2 Measurement of pH

The pH values of soy milk or yogurt samples were measured by immersing the electrode of a pH meter (Cyberscan 500, Eutech Instruments, Singapore) directly into the sample after aliquots had been removed for microbiological testing.

#### 2.3 Total Solid Determination

Soy milk total solids were measured by placing a 3 g soy milk sample in an oven at 100 °C for 4 h and then weighing the sample. Total solids were calculated as a
percent after dividing the remaining weight by the initial weight before drying.

2.4 Flavored Soy Yogurt Production

Plain and flavored soy yogurts were produced as follows: Soy milk was batch pasteurized at 90 °C for 15 min to inactivate pathogenic and spoilage organisms as well as to concentrate total solids to 11%. After pasteurization, soy milk was immediately cooled to 45 °C in a water bath and tempered at that temperature for 20 min. Then, 3% (wt/wt) of commercial yogurt starter culture (50:50 mixture, *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* (Chr. Hansen, Singapore Pte. Ltd.)) in direct vat set form was added to soy milk and stirred for 2 min followed by incubation at 43 °C for 4 h until the pH reached 5.2 ± 0.1. Fermented soy milk (yogurt) was cooled to 4 °C. Under aseptic conditions, strawberry or orange jam with pieces (Vitrac, Cairo, Egypt) was added to soy yogurt at a ratio of 30:70 (wt/wt) jam:soy yogurt and stirred with a sterile spatula for 5 min. Fruit yogurt was stored at 4 °C until sensory analysis was conducted.

2.5 Evaluation of Shelf Life

The shelf life of the flavored soy yogurt was assessed through determination of total plate count, coliform, yeast and mold, lactic acid bacteria and pH at day 1, 5 and 9. The total plate count and coliforms were determined as mentioned above. The lactic acid bacterial numbers were determined by surface plating 100 µL of flavored soy yogurt on deMan Rogosa Sharpe (MRS) (Oxoid Ltd.) and incubated anaerobically at 37 °C for 48 h. Yeast and mold were determined by plating 100 µL of flavored soy yogurt on potato dextrose agar (Oxoid Ltd.) and incubated aerobically at 25 °C for 7 d.

2.6 Assessment of the Consumer Acceptability of Flavored Soy Yogurt

A total of 61 consumers who were between 18 to 50 years of age and from various socioeconomic backgrounds were recruited from students and employees at Jordan University of Science and Technology (46 Jordanian and 15 Malaysian individuals). Jordanian panelists had not consumed soy milk or soy yogurt while Malaysian panelists had not consumed soy yogurt. The identity of samples was blinded to panelists. Each sample was coded with a randomly selected 3-digit number and a balanced order of sample presentation to panelists for tasting was used. Each consumer was provided with a tray containing three types of soy yogurt (one plain and two flavored) in sterilized 50 mL containers. To eliminate carryover flavor, consumers were also provided with water for cleansing the mouth between samples. The panelists were asked to record the intensity of their acceptance scores for color, flavor, aroma, taste, texture, consistency and overall impression based on a standard nine-point hedonic scale (9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely).

2.7 Statistical Analysis

All data reported were average values ± SD. Differences among treatments were analyzed by Student’s *t*-tests using JMP 10.0 software from SAS. Significant differences between treatments were concluded when *P* < 0.05.

3. Results and Discussion

The quality of soy milk is a crucial factor that controls the physical properties of soy yogurt gels including syneresis, which in turn, influence consumer acceptance. Syneresis is a common defect in yogurt which results from the spontaneous appearance of milk serum at the upper surface of yogurt [19]. Extended periods at poor refrigerated storage temperature (> 4 °C) can cause considerable serum separation. An important factor influencing the development of syneresis is the
total solids content, which was only 6.8% in the soy milk extracted in this study (Table 1). This value was less than that found by Osundahunsi et al. [20] where soy milk contained 10.4% total solids. Since it was anticipated that the low soy milk solids might be problematic, in preliminary experiments yogurt was produced without solids adjustment. It was found the yogurt had a soft texture and serum separation was notable on the surface, especially after 24 h of storage. Serum separation can occur if there is insufficient protein present to allow formation of a firm yogurt gel when protein denaturation takes place as the pH is reduced during fermentation. Therefore, to produce a flavored soy yogurt with acceptable texture that could withstand the shearing effects of stirring after the addition of jam, the total solids content of soy milk was increased to 11% by enhancing moisture loss during heating by increasing the pasteurization time to 15 min at 90 °C. The pH value of raw soy milk and soy milk after pasteurization was acceptable at 6.8 (Table 1). These results are similar to those of Osundahunsi et al. [20] who found that the pH of soy milk was 7.2. The results of the microbial quality assessment of soy milk also showed that soy milk prepared as described was acceptable. It was evident that pasteurization at 90 °C reduced the initial total plate count and coliforms to undetectable levels (Table 1).

Incubation temperature during fermentation is also considered an important processing parameter that affects the firmness of yogurt gels. In general, moderate temperature (43 °C) with short incubation is commonly used for yogurt production since it allows for faster maturation of yogurt, and thus is more economical for dairy plants. However, incubation time should not be less than 3 h to allow adequate production of aroma substances, and in these experiments such substances were considered important for their ability to mask the compounds responsible for beany flavor. The use of high incubation temperature and high starter culture inoculation level can result in an increased acidification rate which is considered responsible for acidic tastes [21]. Therefore, a combination of an intermediate to high commercial yogurt starter culture inoculation rate (3%, wt/wt) and incubation temperature (43 °C for 4 h to reach a pH 5.2) were used to produce yogurt with desired flavor and taste.

To predict the shelf life of the soy yogurt, a storage study at 4 °C ± 1 °C up to 8 d was conducted (Table 2). Coliforms were not detected in soy yogurt up to 8 d. However, total plate count and mold and yeast significantly increased ($P \leq 0.05$) to reach 6.1 and 5.9 log$_{10}$ CFU/mL, respectively, at day 8 while numbers of LAB were significantly reduced ($P \leq 0.05$) from 7.3 log$_{10}$ CFU/mL at day 1 to 5.5 log$_{10}$ CFU/mL at day 8 (Table 2). Molds and yeast are the primary contaminants in yogurt responsible for spoilage. The yogurt acidity and slight oxygen reduction during fermentation provide a suitable environment for growth of yeasts and molds [22]. On the basis of the microbiological results obtained the shelf life of these products should be at least 8 d, since it is unlikely that there would be visible evidence of spoilage as long as the total plate and yeast and mold counts do not exceed 7.0 log$_{10}$ CFU/g. Beyond these levels, changes in flavor, texture, taste and discoloration tend to become apparent.

<table>
<thead>
<tr>
<th>Table 1 Microbiological analysis and characteristics of soy milk.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Ground beans</td>
</tr>
<tr>
<td>Raw soy milk</td>
</tr>
<tr>
<td>Pasteurized soy milk</td>
</tr>
</tbody>
</table>

ND: not detected (the minimum detectable level was ≤ 1 CFU/mL);
NT: not tested.
Table 2  Microbiological and chemical evaluation of plain soy yogurt.

<table>
<thead>
<tr>
<th>Time (day)</th>
<th>Coliforms (log_{10} CFU/g)</th>
<th>Total plate count (log_{10} CFU/g)</th>
<th>LAB (log_{10} CFU/g)</th>
<th>Yeast and mold (log_{10} CFU/g)</th>
<th>pH</th>
<th>Total solids (%)</th>
<th>Water activity</th>
<th>Ash (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>ND</td>
<td>7.04a</td>
<td>7.25a</td>
<td>1.77a</td>
<td>5.07a</td>
<td>11.22</td>
<td>0.996</td>
<td>0.34</td>
</tr>
<tr>
<td>4</td>
<td>ND</td>
<td>6.78b</td>
<td>6.25b</td>
<td>3.00b</td>
<td>4.89b</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
</tr>
<tr>
<td>8</td>
<td>ND</td>
<td>6.10b</td>
<td>5.49b</td>
<td>5.88a</td>
<td>5.01a</td>
<td>NT</td>
<td>NT</td>
<td>NT</td>
</tr>
</tbody>
</table>

Means from different sampling times in the same column with the same letters are not significantly different (P > 0.05);
ND: not detected (the minimum detectable level was 1 log_{10} CFU/g);
NT: not tested.

In other preliminary tests different concentrations of a number of different natural jams (apricot, orange and strawberry) were used to flavor and sweeten the plain soy yogurt. The results of these experiments showed that adding orange or strawberry jam at a concentration of 30% (wt/wt) was acceptable. Based on this information, orange and strawberry jams were selected to produce the flavored soy yogurts used for sensory evaluation trials.

Sensory data were collected from a group of 61 panelists affiliated with Jordan University of Science and Technology. Of these, 46 had a Jordanian background and were unfamiliar with soy milk, while 15 were from Malaysia and consumed soy milk regularly, at least once a week. To all consumers the overall acceptability, flavor, aroma and taste of orange and strawberry soy yogurt were rated significantly higher than plain yogurt (Fig. 1A). No significant differences were observed in color and texture between different types of soy yogurt. However, the consistency of orange soy yogurt was rated significantly higher than the other two yogurts (Fig. 1A). In other work, mango pulp improved the overall acceptability of soy milk-based yogurt containing 7.1% mango pulp, 14.7% soy milk and 78.2% buffalo milk [23]. Sakhale et al. [24] also found that mango pulp improved color, appearance, flavor, taste, mouth-feel and overall acceptability of a soy milk beverage. In the present work, it was observed that Jordanian consumers showed only slight differences in their sensory ratings of plain, orange and strawberry soy yogurt (Fig. 1B). In contrast, Malaysian consumers were able to differentiate (P < 0.05) the sensory properties of the different types of yogurt (Fig. 1C). This was likely due to the greater familiarity of the Malaysian panelists than those from Jordan with the flavor of soy-based foods.

In general the orange and strawberry soy yogurts were given higher sensory ratings by the Malaysian panelists than the Jordanian consumers; however, the Jordanian panelists ranked the acceptability of plain soy yogurt higher than Malaysian consumers (Fig. 2). Furthermore, the average score of all sensory properties showed that panelists preferred soy yogurt with orange jam which received the highest score (5/9, neither like nor dislike), followed by strawberry and finally plain soy yogurt (Fig. 3). Similar results were obtained by Alpaslan and Hayta [25] with salep, a traditional Turkish milk beverage, altered by mixing soy milk with cow’s milk at 0%, 25%, 50% and 75% (g/100 g total milk) and evaluated by a panel of consumers. The beverage containing 25% soy milk was scored the highest in terms of overall acceptability by sensory panelists, furthermore, 60% to 69% of the participants rated these beverages as acceptable and 53% to 61% agreed they would purchase the product. It seems that consumers are willing to accept soybean products, particularly if they recognized their nutritional and potential health benefits.

4. Conclusions

The limited acceptability of soy milk due to its undesirable (beany) flavour was overcome in the current work through fermentation and the addition of orange or strawberry jam. Therefore, it was possible to obtain products with better acceptability and improved sensory attributes including flavour by masking the
Fig. 1  Panelist scores for plain or flavored soy yogurt: (A) total consumers; (B) Jordanian consumers; (C) Malaysian consumers.
Fig. 2 Comparison between Jordanian and Malaysian panelist’s acceptance of plain or flavored soy yogurt.
Fig. 3 Overall scores of plain and flavoured soy yogurt by Jordanian and Malaysian panelists.

detection of compounds that contribute to undesirable aftertaste. Orange and strawberry jams can be used to enhance the desirability and appeal of soy yogurt which could contribute to improved levels of nutrition. This suggestion is supported by the approval in 1999 by the Food and Drug Admiration (FDA) [26] of a food-labelling health claim for soy proteins in food products with low saturated fat and cholesterol for the prevention of coronary heart disease by lowering blood cholesterol levels.

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References


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