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The Rheological and Sensory Properties of Some Soya Yoghurts

Pariyaporn Itsaranuwat and [1]R. K. Robinson,
Faculty of Technology, Department of Biotechnology, Mahasarakham University, Mahasarakham 44001, Thailand; [1]School of Food Biosciences, University of Reading, England

Abstract: Soya milk with 70 g/l total solids, heat-treated at 85°C for 30 min and fermented with a yoghurt culture (*Streptococcus thermophilus and Lactobacillus delbrueckii subsp. bulgaricus*) at 42°C for 12 h gave a product with a pH and viscosity comparable to a commercial dairy yoghurt (bovine milk). As the levels of total solids in the soya milks were raised to 100 g/l, so the viscosity of the yoghurts increased, but lowering the temperature of heat treatment had the opposite effect. The scores awarded by a taste panel for selected sensory properties of a natural soya yoghurt and a toffee-flavoured variant were significantly below the scores for comparable dairy yoghurts.

Key words:- stirred soya yoghurt, viscosity, sensory properties

Introduction

Soya beans and soya bean products have been important as dietary items in Oriental countries, such as China, Japan, Taiwan, Hong Kong, Korea, The Philippines and Thailand, for centuries (Liu, 2000), and China has been a major producer of soya beans since 11th. Century B.C. (Snyder, 1993). Moreover, soya beans are nutritious and, on a dry weight basis, the soya bean consists of 20% lipid, 40% protein, 35% carbohydrate and 5% ash (Snyder, 1993). In particular, soya protein contains all the essential amino acids (EAAs), except for methionine that is limiting amino acid of most leguminous plants (Liu, 2000).

The main problems limiting the widespread consumption of soya beans and soya bean products are: (a) their 'beany' flavour; and (b) the presence of indigestible components, e.g. oligosaccharides, which can cause flatulence (Mital and Steinkraus, 1975). Numerous processes have been studied with the aim of removing the undesirable 'beany' flavour from materials like soya milk (Wilkens *et al.*, 1967), and fermentation using the bacteria employed to make traditional yoghurt, *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*, has been examined as one possible option (Lee *et al.*, 1990; Chumchuere and Robinson, 1999).

However, there is a lack of detailed information in the literature about the rheological and sensory properties of a yoghurt produced by fermentation of soya milk with *Str. thermophilus* and *Lb. delbrueckii* subsp. *bulgaricus*, and hence the aims of this study were: (i) to determine the affect of different levels of total solids and heat treatments on the viscosity of stirred soya yoghurts; and (ii) compare the sensory properties of a soya yoghurt with a selected commercial yoghurt made with bovine milk.

Materials and Methods

In order to standardise the procedures, it was decided to reconstitute spray-dried soya milk powder (PROVESOL PS60) obtained from Soya International Ltd., Altrincham, Cheshire (UK) to provide the base milk for yoghurt-making. The proximate composition of the milk powder was: 60% protein, 1.5% lipids, 8% ash, 24% carbohydrates, 0.2% fibre and 6% moisture.

Production of Yoghurt: Batches of soya milk (70 g/l total solids; protein 42 g/l) were prepared by adding tap water to the powder to give the final concentration required, and blending with a Silverson High-speed Mixer (Silverson Ltd., Chesham, Bucks). Although the levels of calcium may fluctuate in tap water, some preliminary experiments suggested that the source of the water was not important (data not shown). Afterwards, aliquots of the milk (300 ml) were distributed into duplicate Duran bottles (500 ml) and heated at 65, 75 or 85°C for 30 min in a water-bath; the bottles were stored at 4°C before use.

Yoghurt cultures (*Str. thermophilus* and *Lb. delbrueckii* subsp. *bulgaricus* - Joghurt V2, Danisco Ltd., Swindon, UK) were grown at 42°C in sterile, reconstituted skim-milk (100 ml, 100 g/l total solids) to pH 4.5 prior to storage at 4°C. Aliquots of these cultures were aseptically transferred to the bottles of soya milk at a rate of 20 ml/l, and the bottles were incubated at 42°C for 12 h to give a final pH of approximately 4.4. After cooling to ~ 20°C in running tap water, the bottles were stored at 4°C.

The second stage was to examine the effect of total solids on viscosity. The concentrations of soya milk solids were varied from 70 (protein 42 g/l), 80 (protein 48 g/l), 90 (protein 54 g/l) to 100 g/l total solids (protein 60 g/l). Amounts of each milk (300 ml) were distributed into duplicate Duran bottles (500 ml) and heated at 85°C for 30 min in a water-bath; the samples were then handled as described for the first part of the study.

As the basic soya yoghurt (70 g/l) had a protein content of 42 g/l, a commercial stirred yoghurt (bovine protein

47 g/l) was used to provide a reference viscosity.

Viscosity and pH Measurements: The apparent viscosity of the yoghurts was determined with a Brookfield Viscometer (Model LVF, Brookfield Engineering Labs, Soughton MA, USA) using a helipath adaptor and a T-bar spindle (T-E size) at 6 rpm. Prior to reading, duplicate samples that had been held overnight at 4°C were poured into the bowl of a Kenwood Kitchen Mixer and stirred at low speed (~ 30 rpm for 10 min) until the yoghurt was homogeneous. The bulk sample was allowed to reach room temperature (20°C), and then a sub-sample (100 ml) was placed into a beaker (250 ml) for analysis. The readings obtained with the Brookfield were converted into centipoise units (cps) using conversion factors provided by the manufacturer. The final pH was measured using a pH meter (Kent EIL 7070, Kent Industries, Chertsey, UK). The entire experiment was repeated twice, and all figures are overall means.

Sensory Analysis: A batch (2 l) of soya milk (70 g/l total solids, heat-treated at 85°C for 30 min) was prepared in a stainless steel can and, after cooling to 42°C, the milk was inoculated with a yoghurt culture and incubated for 12 h to a final pH of 4.5-4.6 prior to storage at 4°C. Next morning, the soya yoghurt was stirred gently by hand (3 - 5 min) until a smooth texture developed, and then sub-samples (about 50 g) were transferred to clear glasses labelled with random three-digit codes. Panelists were asked to assess the appearance, aroma, taste and overall acceptability of the soya yoghurt and a 'control' (see later), and a nine-point hedonic scale was used with '9' for "like extremely", down to '1' for "dislike extremely" (Lawless and Heymann, 1999). The sensory evaluations were conducted by 15 untrained panelists, some of whom were familiar with consuming soya foods, but some who were not.

In addition, a further batch was modified by the addition of toffee sauce (Regency Moubtar Co Ltd., Staffordshire, U.K.) at a rate of 150 g/l of soya yoghurt. This flavour was chosen as the colour tended to blend into the soya base without any problem. As 'controls' of similar appearance and viscosity to the soya yoghurts, commercial natural and toffee-flavoured yoghurts (bovine protein 47 g/l) were purchased from a local supermarket.

Each evaluation was repeated after three days with a fresh batch of product, and the assessments of the natural and toffee-flavoured soya yoghurts were carried out in different weeks. For each sample, the scores given by individual panelists were averaged to give mean scores for each attribute.

Statistical Analysis: Analysis of variance was performed using the statistical package SPSS 11.0 for Windows (SPSS Inc., Chicago, IL, USA). The mean panel scores for each attribute were compared for significant differences using the Duncan multiple range test.

Results and Discussion

The effect of heat treatment on the properties of the soya yoghurt is shown in Figure 1 and, even though the levels of acid production were similar - pH of approximately 4.4, the apparent viscosities were significantly different ($p<0.01$). In particular, the sample heated at 85°C had the highest value for viscosity, whereas the lowest value was obtained at 65°C. It was stated by Walstra (1997) and Tamime and Robinson (1999) that, if bovine milk is heated to a high temperature, the final gel is much firmer, and a similar phenomenon appears to arise with soya milk. Hence heating at 85°C for 30 min was decided upon as the best treatment, but whether or not a higher temperature, e.g. 90°C, would have modified the soya protein even more was not examined; it was assumed that excessive 'browning' of the soya milk > 90°C could have made the yoghurts unacceptable.

Fig. 2 shows the influence of total solids on viscosity and, as expected, the interaction between total solids and viscosity was significant ($p<0.01$). It can be seen clearly that the highest viscosity was observed in the sample prepared from soya milk with 100 g/l total solids - > 57,000 cps; in contrast, the lowest value was ~ 30,000 cps for yoghurt made from milk with 70 g/l total solids. In other words, the higher protein contents provided the soya yoghurts with stronger gels (Lee *et al.*, 1990). However, soya yoghurt with 70 g/l total solids had a similar viscosity to the commercial yoghurt - ~ 30,000 and 29,000 cps, respectively, and hence soya milk at 70 g/l total solids was considered as an appropriate base preparing yoghurts for sensory evaluation.

Table 1 summarises the sensory panel results for appearance, aroma, taste and overall acceptability of the natural soya yoghurt and the commercial 'control', and it was slightly surprising that the panelists could not detect any difference in aroma between the samples. This reaction suggested that the soya samples had a 'beany-flavour' - usually regarded as "unpleasant" - lower than the detection threshold, and it may be that this attribute was reduced or masked by the lactic acid fermentation (Buono *et al.*, 1990; Nsofor and Chukwu, 1992). In addition, heating or steaming has been reported to decrease the volatile compounds in soya products (Kwok *et al.*, 2000), and it may be that spray-drying the original milk and heating the reconstituted milk at 85°C for 30 min contributed to the loss of volatile 'beany-flavour' compounds. However, panelists reacted negatively to the taste of the soya yoghurt.

Table 1: Scores out of 9.0 for some sensory properties of natural soya yoghurt fermented with a traditional yoghurt culture; the scores for a commercial stirred yoghurt (bovine milk) are included for comparison

Sample	Appearance	Aroma	Taste	Overall
Commercial	7.20	6.27	5.53 a	6.40 a
Yoghurt	6.20	6.20	4.00 b	5.00 b

Means in the same column followed by a different letter are significantly different ($p<0.01$).

Table 2: Scores out of 9.0 for some sensory properties of toffee-flavoured soya yoghurt fermented with a traditional yoghurt culture; the scores for a commercial stirred yoghurt (bovine milk) are included for comparison

Sample	Appearance	Aroma	Taste	Overall
Commercial	7.93 a	7.53 a	7.13 a	7.27 a
Yoghurt	6.60 b	6.27 a	5.33 b	5.93 b

Means in the same column followed by a different letter are significantly different ($p<0.01$).

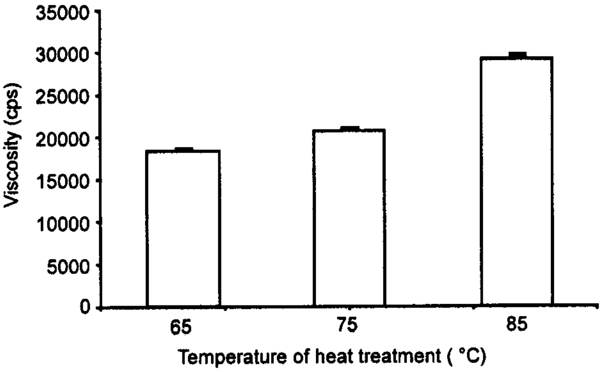

Fig. 1: Viscosities of soya yoghurt made from milk heated to temperatures of 65, 75 or 85°C for 30 min. The different letters represent significant difference between means ($p<0.01$) of viscosity. cps = Centipoises.

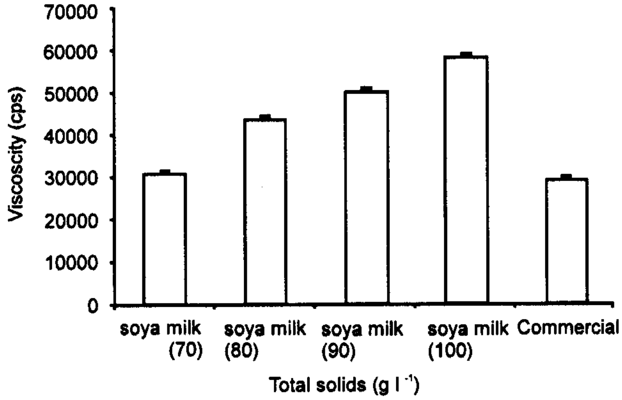

Fig. 2: Viscosities of soya yoghurts with levels of total solids between 70, 80, 90 and 100 g l^{-1} total solids and commercial yoghurt. The different letters represent significant difference between means ($p<0.01$) of viscosities. cps = Centipoises

In order to overcome the taste problem, a number of researchers have attempted to improve the palatability of soya products by the addition of flavourings, such as strawberry, chocolate or vanilla (Wang *et al.*, 2001). In this study. toffee sauce was employed in an attempt to improve the quality of the products, because the natural colour of toffee sauce - light-brown tone - seemed appropriate for use with soya milk. Nevertheless, the results obtained from the sensory test showed that the soya yoghurt was perceived as substantially different from the commercial 'control' (Table 2), even though the score for the flavoured soya yoghurt was higher than for its natural counterpart (Table 1). Similarly, it was a quite positive sign that the toffee-flavoured soya yoghurt achieved a score for overall acceptability higher than 5, i.e. above the "Neither like nor dislike" category.

Conclusion

It can be seen that the fermentation of soya milk with a yoghurt culture produced a fermented milk - whether natural or toffee-flavoured - that was only marginal in terms of sensory acceptability, and neither sample could compete with a commercial yoghurt based on bovine milk. Whether the use of other cultures or flavouring agents would have improved the situation is an open question, but further attention to the sensory side might be worthwhile.

It would have been of interest also to have segregated the panelists on the basis of their familiarity with soya products, for it may be that higher scores for acceptability would have been generated by tasters who normally consume soya foods. Unfortunately, the number of available panelists did not permit this division.

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