Effect of Milk Base Heat Treatment on Physicochemical, Physical, Textural and Sensory Attributes of Plain Set Yoghurt Made Employing Ultrafiltration

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Abstract

Effect of heat treatment (80°C/30 min and 85°C/30 min) of yoghurt milk base fortified with 5 fold ultrafiltered cow skim milk retentate on physicochemical, physical, textural and sensory properties of plain set yoghurt was investigated. Spontaneous whey syneresis was not observed in yoghurt made employing any of the milk base heat treatments. Whey protein denaturation, Water holding capacity and textural attributes of yoghurt were significanly (p<0.05) higher at 85°C/30 min compared to 80°C/30 min heat treatment to milk base. Body and texture and overall acceptability scores of yoghurt were significantly (p<0.05) higher at 85°C/30 min heat treatment compared to 80°C/30 min to milk base, while other sensory attributes did not show any difference. Hence, 85°C/30 min was observed to be better than 80°C/30 min heat treatment to yoghurt milk base for the production of good quality plain set yoghurt.

Key words: Heat treatment, Retentate, Spontaneous whey syneresis, Textural attributes, Ultrafiltration,

Introduction

Yoghurt is formed by slow fermentation of lactose to lactic acid (LA) by thermophillic yoghurt starter bacteria namely *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus*. According to a recent research conducted by Global Industry Analysts Inc., it was predicted that by year 2015, global yoghurt consumption will reach 20.6 million tons, equaling US$ 67 billion in sales (Anon, 2010); 27 billion higher sales than in 2009. Among different forms, set yoghurt is produced by packaging the yoghurt mix into individual containers before fermentation. Set yoghurt should have a curd with sufficient hardness to stand up to the impact caused by shaking during transportation and a glossy surface appearance without excessive whey.

The gel structure of set yoghurt is influenced by many factors among which the heat treatment is one of the most important processing parameters. Milk base for yoghurt making is subjected to a high temperature typically 85°C for 30 min or 90 to 95°C for 5 to 10 min in order to achieve several different objectives such as destruction of all pathogenic bacteria, inactivation of all the enzymes that may be present in milk including lipase, destruction of most of the spoilage causing bacteria including thermodurics and most importantly denaturation of whey proteins, β-lactoglobulin (*β*-Lg) and *α-lactalbumin (α-La),* thereby improving product consistency. However, other heat treatments such as high temperature short time or ultra high temperature treatments also have been reported (Savello and Dargan, 1997).

Lucey (2001) reported that excessive heat treatment (>80°C/30 min) leads to whey separation of yoghurt gels. Further, Brazuelo *et al.* (1995) mentioned that the possibility of the use of a milder heat treatment with ultrafiltered milk is an advantage over that of normal milk to obtain the same viscosity in yoghurt due to increase in protein content. Therfore, an attempt was made to optimize the heat treatment given to yoghurt milk base, in order to obtain a good quality plain set

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yoghurt made using milk fortified with 5 fold ultrafiltered cow skim milk retentate.

Materials and Methods

Raw cow skim milk and cream (50-55% fat) was obtained from Experimental Dairy of National Dairy Research Institute, Karnal, India. As the starter culture, commercial yoghurt (Nestle') containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* was used. Pilot ultrafiltration (UF) plant (Tech-Sep, France) with tubular module (channel diameter, 6 mm) having ZrO_2 membrane (membrane surface area, 1.68 m^2 and membrane molecular weight cut off, 50,000 Dalton) was used for UF of skim milk.

Skim milk was heated to 80°C, cooled to 55-60°C and transferred into the cleaned balance tank of UF plant and ultrafiltered to 5 fold. Skim milk was standardized to 13.9% total solids and 3.3% fat by adding calculated amount of 5 fold ultrafiltered cow skim milk retentate and cow milk cream, respectively. Resultant standardized milk was pre-heated to 65-70°C; homogenized in a two-stage homogenizer (M/s Goma Engineers, Mumbai) at 2000 and 500 psi at 1st and 2nd stages, respectively; divided into two lots and heat treated at 80°C/30 min and 85°C/30 min in thermostatically controlled water baths (NAVYUG, India) separately; cooled immediately in an ice water tub to 42-45°C; inoculated with 2% of yoghurt culture; mixed; filled in clean polystyrene cups; covered with lids and incubated at 42±1°C. Incubation was stopped after yoghurt reached slightly above 0.8% LA. Yoghurts were then immediately transferred to a refrigerator maintained at 4±1°C. Quality of yoghurt was evaluated in terms of sensory, physicochemical and physical parameters including textural attributes. Experiment was repeated 2 times.

Titratable acidity of yoghurt, fat content of skim milk and ultrafiltered cow skim milk retentates were determined as per the method given in BIS (1981), whereas, in cream as per the methods given in BIS (1977). Whey protein denaturation (WPD) was determined by the method given by Labropoulos *et al.* (1981). Siphon method described by Amatayakul *et al.* (2006) was used to determine the spontaneous whey syneresis. Water holding capacity (WHC) was measured by a centrifuge method according to Supavititpatana *et al.* (2009). Texture analysis was carried out according to the method given by Kumar and Mishra (2003), using a TA-XT2i Texture analyser (M/s Stable Micro Systems, UK). For the sensory evaluation, 100 point score card was used. SPSS Version 16 was used for data analysis.

Results and Discussion

Effect of milk base heat treatment on quality characteristics of plain set yoghurt is presented in Table 1. Spontaneous whey syneresis was not observed in yoghurts made employing any of the milk base heat treatments. Whey protein denaturation was observed to be significanly ($p<0.05$) higher in milk base heated to 85°C/30 min compared to 80°C/30 min. Labropoulos *et al.* (1981) studied the extent of WPD in whole milk giving various vat and indirect ultra high temperature (UHT) processing heat treatments. They showed that the WPD increased with both the time and temperature of heating. In current study, when temperature was increased by keeping time as a constant factor, extent of WPD was observed to be significantly ($p<0.05$) increased. However, the percentage of denaturation was observed to be lesser than the values (99% at 82°C for 30 min) reported by Labropoulos *et al.* (1981) for vat heat treatments.

Table 1: Effect of milk base heat treatment on quality characteristics of plain set yoghurt

Characteristic	Heat treatment	
	80°C/30 min	85°C/30 min
Physicochemical parameters		
WPD (%)	72.08±0.44[a]	73.78±0.49[b]
WHC (%)	60.56±0.18[a]	64.75±1.01[b]
Textural attributes		
Firmness (N)	1.86±0.03[a]	1.99±0.04[b]
Stickiness (N)	-0.41±0.02[a]	-0.43±0.01[b]
Work of Shear (WoS) (N.s)	54.41±0.41[a]	56.06±0.44[b]
Work of Adhesion (WoA) (N.s)	-2.18±0.03[a]	-2.41±0.09[b]
Sensory attributes		
Flavour	41.41±0.92[a]	41.47±0.92[a]
Body & texture	26.88±0.83[a]	27.94±0.60[b]
Acidity	8.72±0.68[a]	8.81±0.57[a]
Colour & appearance	8.91±0.69[a]	8.94±0.60[a]
Overall Acceptability	90.91±1.88[a]	92.25±1.56[b]

* Mean of 2 trials
[a,b] Mean±SD with different superscripts within each row differ significantly ($p<0.05$)

Kaytanli (1993) observed 90.2% WPD in milk heated at 80°C to 30 min for yoghurt making. Krasaekoopt *et al.* (2004) observed WPD in yoghurt premixes fortified with low heat skim milk powder to different milk solids levels (16, 18 and 20%) and subjected to UHT (143°C/6 s) and batch (85°C/30 min) heat treatments. They reported that the WPD in conventionally heated milk to be 78.6%, 85.9%, and 86.4% at 16%, 18%, and 20% milk solids levels, respectively, which was higher than that of UHT-treated milk (50.0%, 50.5%, and 60.7%, respectively).

Water holding capacity was observed to be significantly ($p<0.05$) higher in yoghurt made using milk base heat treated to 85°C/30 min compared to 80°C/30 min. It was reported that, there is a linear relationship between WPD and WHC (Augustin *et al.*, 1999). In the present study, yoghurt milk base heat treated to 85°C/30 min had significantly ($p<0.05$) higher WPD than 80°C/30 min heat treatment. Structure of the casein gel formed during fermentation is strongly influenced by the nature of the heat treatment of the yoghurt milk. Association of denatured β-Lg with the casein led to formation of filamentous appendages on the surface of the micelles. This complex protects the micelles from excessive fusion during fermentation and thus favours the formation of a fine meshed gel network having a firm structure enabling immobilization of more bulk phase water resulting in higher WHC.

All the textural attributes studied, namely, firmness, stickiness, WoS and WoA of yoghurt were influenced by the applied heat treatment, and the values were significantly ($p<0.05$) higher at 85°C/30 min compared to 80°C/30 min heat treatment to milk base. It is generally believed that the degree of denaturation of whey proteins due to heat treatment of milk base, is a major factor affecting yoghurt texture. Degree of denaturation was higher in milk base heat treated to 85°C/30 min resulted in the formation of more dense net work composed of casein micelles chains.

It was noted that body and texture and overall acceptability scores were significantly ($p<0.05$) higher at 85°C/30 min heat treatment compared to 80°C/30 min, while the other sensory attributes did not show any difference. Skriver *et al.* (1999) reported that the sensorial perception of in-mouth and in-cup viscosities of yoghurt were increased up to 4 and 8 times when the milk was heated at 85°C instead of 75°C. It is considered that insufficient heating will result in a weak bodied yoghurt.

Pearson's correlation coefficients were determined for selected parameters to check whether there is any correlation and to determine the strength of the correlation. It was observed that the heat treatment of yoghurt milk base had a significant ($p<0.05$) positive correlation with WPD (r=0.911). Whey protein denaturation was significantly ($p<0.05$) positively correlated with WHC (r=0.953) and firmness (r=0.853) of yoghurt. Further, WHC was also significantly ($p<0.05$) positively correlated with firmness (r=0.884).

Findings of the present study reveal that 85°C/30 min was superior than 80°C/30 min heat treatment to milk base fortified with 5 fold ultrafiltered skim milk retentate for the production of good quality plain set yoghurt.

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