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Effect of reduced fat content on the physicochemical and microbiological properties of buffalo milk yoghurt

Abdullah Akgun [a,*], Fehmi Yazici [b], Haci Ali Gulec [a]

[a] Trakya University, Engineering Faculty, Department of Food Engineering, Edirne, Turkey
[b] Ondokuz Mayis University, Engineering Faculty, Department of Food Engineering, Samsun, Turkey

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A B S T R A C T

The objective of this study was to investigate the effect of reduced fat content in buffalo milk on textural, chemical and microbiological characteristics of plain buffalo yoghurt during storage at 4 °C. Four yoghurt samples were manufactured with different fat ratios (1.5–6 g/100 g) and analysed on the first, 10th and 20th days of storage. Increasing the fat content of the yoghurt increased the L^* value, viscosity, and cohesiveness and decreased the a^* value, syneresis, hardness, and springiness. Fat reduction did not cause any significant changes in the adhesiveness, gumminess, titratable acidity, b^* value, and *Streptococcus thermophilus* population of buffalo yoghurt samples. Storage time had no significant effect on adhesiveness, springiness, and L^* value of buffalo yoghurts. A decrease in *S. thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus populations* during storage was detected. It was concluded that more acceptable buffalo yoghurt could be produced from milk with 3 g/100 g fat.

1. Introduction

Buffalo milk is naturally thick and creamy due to its high total solids and fat content and is thus suitable for making traditional milk products. Although buffalo milk is mainly used for the manufacture of mozzarella cheese and cream, yoghurt has recently become an excellent alternative for the utilization of buffalo milk (Cunha Neto, Oliveira, Hotta, & Sobral, 2005; Guimarães & e Silva, 2014). Buffalo milk has a significantly different composition than that of bovine milk. It is especially rich in a variety of nutritional constituents. Recent studies have indicated that buffalo milk contains more calcium, a better calcium/phosphorous ratio and a higher protein efficient ratio (PER) than bovine milk, which makes it a better nutritional supplement for infants. Another important feature of buffalo milk is that its proteins are more heat resistant than cow milk proteins. The superior features of buffalo milk can be seen in buffalo yoghurt directly because yoghurt generally has similar properties to the milk it is made from, especially in terms of nutritional profiles.

Compositional, textural and microbiological aspects of yoghurt are influenced by the gross composition of the milk (Kaminarides, Stamou, & Massouras, 2007). Breed, geographical location, and feeding regimen (Blasi et al., 2008) cause several differences in buffalo milk composition and the strong effect of the variation between species on the chemical composition of the milk impact both the processing steps in yoghurt production and the overall quality of the final product (Nguyen, Ong, Kentish, & Gras, 2014). In the literature, there have been various studies on the mineral contents and the physicochemical, rheological, microbiological, and sensory properties of buffalo yoghurts. However, there is still a great need to investigate the effects of regional variations in the gross composition of buffalo milk on the characteristic properties of buffalo yoghurt.

Some consumers prefer homemade buffalo yoghurt due to its more pleasant sensory properties, such as flavour, appearance and texture, compared to cow's yoghurt (Ahmed, Elahi, Salariya, & Rashid, 2014). However, other consumers have difficulty accepting buffalo yoghurt because of the original high fat content of the milk (Cunha Neto et al., 2005). Lately, there is also a great demand for low-fat yoghurt as a result of modern consumers' behaviour (Kaminarides et al., 2007). The standardization of buffalo yoghurt production on an industrial scale may improve its consumption.

The selection of a proper level of fat content in buffalo milk is also very important for the preparation of buffalo yoghurt with desired textural and organoleptic characteristics. In the literature, few studies have compared the quality characteristics of buffalo

* Corresponding author.
E-mail address: abdullahakgun@trakya.edu.tr (A. Akgun).

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yoghurts with different fat contents, though some have focused on the effects of fat on the physicochemical properties of set type yoghurts from other sources of milks (Pandya, Kanawjia, & Dave, 2004; Raju & Pal, 2009). Romeih, Abdel-Hamid, and Awad (2014) noted that milk fat has a crucial role in yoghurt quality, and therefore, fat reduction can cause some important defects in yoghurt, particularly weak body and poor texture (Domagala, Wszolek, Tamime, & Kupiec-Teahan, 2013) due to wheying off, or syneresis. It is clear that syneresis is not desirable in yoghurt and can negatively influence consumer acceptance of the product (Domagala, 2012).

The present research was undertaken to determine the effects of the reduced fat content of buffalo milk on the textural, microbiological and chemical properties of buffalo yoghurt during a storage period of 20 days at 4 °C. The regional differences of buffalo milk and its potential effects on buffalo yoghurt were also evaluated.

2. Materials and methods

2.1. Materials

Water buffalo milk was obtained from farmers in Kizilirmak Delta in Bafra, Turkey. Freeze dried (FD-DVS) starter cultures consisting of *Streptococcus thermophilus* and *Lactobacillus delbrueckii* subsp. *bulgaricus* (YC-X11 Yo-Flex®) were obtained from Peyma Chr.Hansen, Istanbul, Turkey.

2.2. Preparation of yoghurt

The whole buffalo milk was skimmed by a centrifugal separator at 40 °C. The milk was standardized to 1.5, 3, 4.5, and 6 g/100 g fat ratios by addition of the removed cream to the raw milk using the Pearson Square Calculation. Each standardized milk was heated to 90 °C for 10 min and cooled to 45 °C rapidly. Cooled milk was inoculated with 2.5 g/100 g starter yoghurt cultures of *S. thermophilus* and *L. delbrueckii* subsp. *bulgaricus.* The mixtures were poured into 200 g polystyrene yoghurt cups. The subsequent incubation at 43 °C was stopped when the pH reached 4.80. After fermentation, yoghurt samples were cooled to room temperature (20 °C) and then covered cups were refrigerated at 4 °C. The yoghurt-making procedure was replicated 3 times for a total of 12 vats.

2.3. Physicochemical analyses

The pH of the milk and yoghurt samples were measured with a pH meter (Eutech CyberScan pH 100, Singapore). Total solids (TS), protein, fat, ash, and titratable acidity were determined according to the methods described by Bradley et al. (1992) and AOAC. (2000).

A texture analyser (TA-XT2, Stable Micro Systems, UK) was used to measure the Texture Profile Analysis (TPA) parameters such as hardness, adhesiveness, cohesiveness, springiness, and gumminess of set type buffalo yoghurt. The texture analyser was equipped with a 25 kg load cell and 25-mm diameter aluminium probe (SMSP/25) to measure TPA of set yoghurt samples. The yoghurt was penetrated with the probe at a depth of 20 mm. The speed of the probe was fixed at 1 mm/s during pre-test, compression and relaxation of samples. Set type buffalo yoghurt samples were analysed at 25 °C, with three repetitions performed.

Color measurement was performed by using a chroma meter (Konica Minolta CR-400 Series, Japan) to determine whiteness (L^*), red/greenness (a^*), and yellow/blueness (b^*) values of the buffalo yoghurt samples. Before measurements, the instrument was calibrated with its white reference tile. Three readings were taken from the surface of each yoghurt sample, and the average value was used.

Stirred yoghurt was made by standard stirring of the set yoghurt with a blender at 1902 g for 3 s to produce a more consistent body of yoghurt. Viscosity measurements were taken at 10 °C with a Brookfield viscometer (Model DV-1+; Brookfield Engineering Laboratories, Inc., MA, USA). The viscometer was operated at 10 rpm (spindle number 3). Each result was recorded in cP after 20 s of rotation. The average value of 3 measurements was taken.

For syneresis (whey separation), 5 g of yoghurt was centrifuged at 2208 g for 20 min at 4 °C and the separated whey was measured after 1 min. The syneresis rate was expressed as the volume of separated whey per 100 g of yoghurt (Wacher-Rodarte et al., 1993). The analyses were carried out in triplicate.

2.4. Microbiological analyses

Population of *S. thermophilus* were determined on M17 agar (Merck) at 37 °C for 48 h. *L. delbrueckii* subsp. *bulgaricus* population were enumerated in a Genbox Jar with anaerobic indicator (bioMérieux, France) by using MRS (Merck) at pH 5.2 (adjusted with acetic acid) and 45 °C for 72 h (Gardini, Lanciotti, Guerzoni, & Torriani, 1999). Lipolytic bacteria population were determined on Tributyrin agar at 30 °C for 48 h (Hatzikamari, Litopoulou-Tzanetaki, & Tzanetakis, 1999). Yeast and moulds were enumerated by using Chloramphenicol Yeast Extract Glucose agar (Merck) at 25 °C for 4 d (Harrigan, 1998). Coliform bacteria were counted by using Violet Red Bile agar (Merck) at 37 °C for 24–48 h (Al-Kadamany et al., 2002). *Escherichia coli* were counted by using Eosin Methylene Blue agar (Merck) at 35 °C for 24 h (Vanderzant & Splitstoesser, 1992). The enumerations of the microorganisms were performed in triplicate.

2.5. Statistical analysis

Statistical analysis of data for effects of the factors listed below on pH, titratable acidity, viscosity, syneresis, color, texture profile and microbiological parameters were performed by one-way and two-factor randomized complete block design using SPSS 13.0 statistical software. The factors are types (A, B, C, D for 1.5 g/100 g, 3 g/100 g, 4.5 g/100 g and 6 g/100 g fat, respectively) of buffalo yoghurts and storage time (1, 10, and 20 days). The mean differences were analysed using Tukey's multiple-range test at the 5% significance levels.

3. Results and discussion

The gross compositions of buffalo milks supplied from different sources are shown in Table 1. While the fat, crude protein and total solids content of the milk samples varied due to regional differences, the pH values, titratable acidity and ash content of the milk samples are similar. Han, Lee, Zhang, and Guo (2012) reported that seasonal variation in the chemical composition of buffalo milk was important to fat, crude protein and total solids content. They also concluded that genetics may play an important role in the variation of gross composition of the buffalo milk. Both regional and seasonal differences affect the gross composition of the buffalo milk, as well as process type and parameters of yoghurt production. The buffalo milk used in this study had a relatively higher crude protein to total solids ratio compared to milk from other sources. This ratio was 32% for the milk supplied from Turkey, while it varied in the range of 20–29% for the other sources. The relatively low fat content of the milk used in this study is the main cause of this result. As seen from Table 1, the total solids content of the milk used in this study is lower than that of the other sources. This is likely due to the lactation stage of the buffaloes. Zicarelli (2004) reported that the fat content of buffalo milk may be low, in the level of 5–6 g/100 g, at