J. Dairy Sci. 99:1–9
http://dx.doi.org/10.3168/jds.2015-10327

Physicochemical and sensory characteristics of fat-free goat milk yogurt added to stabilizers and skim milk powder fortification

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ABSTRACT

Goat milk yogurt has a less consistent coagulum compared with cow milk yogurt; furthermore, the presence of goat milk in foodstuffs imparts a characteristic flavor that can restrict its acceptance by consumers. This study aimed to assess and compare the physicochemical and sensory characteristics of fat-free goat milk yogurts with added stabilizers or bovine skim milk powder to improve the final product. Four treatment additions were evaluated: (1) a mixture of 0.1% (wt/vol) carrageenan and 0.1% (wt/vol) pectin (treatment CR); (2) 0.5% (wt/vol) pectin (treatment PE); (3) 4.65% (wt/vol) bovine skim milk powder (treatment BM); and (4) control (no stabilizer; treatment CT). The physicochemical parameters were investigated at on d 1 and 5 of storage. The BM treatment presented higher pH and titratable acidity values, resulting in a buffering capacity effect. The total crude protein (CP) and solids-not-fat (SNF) contents were also higher in BM compared with the other evaluated treatments because of the addition of bovine skim milk powder. We detected a reduction in pH values for all treatments. Lower SNF contents were present in the CR and CT treatments, which might be related to a syneresis process during storage; moreover, an increase in total CP was observed for all treatments due to the proteolytic action of the starter culture. Sensory attributes, including appearance (color, consistency, and presence of lumps), texture (consistency, viscosity, and presence of lumps), flavor (bitter, sweet, and characteristic of commercial plain nonfat yogurt), and overall impression were evaluated by quantitative descriptive analysis. The addition of 0.5% (wt/vol) of pectin (PE treatment) strengthened the curd; however, the visual and oral presence of lumps and a higher bitterness score were noted by trained panelists, which resulted in the lowest overall impression score for the PE treatment. In several sensory attributes, the CR treatment was considered similar to the control; the mixture of 0.1% (wt/vol) carrageenan and 0.1% (wt/vol) pectin was not as effective as expected. Goat milk yogurt containing added bovine skim milk powder (BM) had improved consistency, viscosity, and flavor due to its higher SNF and total CP contents, which are particularly important for the desirable texture of plain nonfat yogurt. In addition, the BM yogurt was considered to have characteristics most similar to that of available commercial brands and achieved the best score for overall impression.
Key words: skim milk powder, carrageenan, pectin, quantitative descriptive analysis, principal component analysis

INTRODUCTION

The economic contribution and nutritional value of goat milk can be observed in developing countries, particularly in the Mediterranean region, the Middle East, Eastern Europe, and South America (Ribeiro and Ribeiro, 2010). In Brazil, there is increasing demand for new dairy products with high added value in sophisticated market niches, which has stimulated goat milk production and trade (Fonseca et al., 2013).

Goat milk is highly digestible and can be consumed by people with cow milk allergies and gastrointestinal disorders; therefore, it can be used as a healthy substitute for cow milk products (Haenlein, 2004; Mituniewicz-Malek et al., 2014). Because of its chemical composition, goat milk has only a low level of, or lacks, αs_1-casein, which affects formation of an almost semiliquid coagulum (Seelee et al., 2009); moreover, the intense flavor of goat milk restricts acceptance of its derivatives by consumers (Gomes et al., 2013). Therefore, consistency and texture can be improved by adding dried milk solids and stabilizers (Wang et al., 2012; Mituniewicz-Malek et al., 2014). More research and technology are required for characterization of dairy products made with goat milk (Sant'Ana et al., 2013).

The production of reduced-fat products is a priority for the food industry; however, fat in food has a

Received August 28, 2015.
Accepted January 24, 2016.
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great effect on appearance, flavor, and texture, and it influences customer acceptance of dairy products (Tomaschunas et al., 2012). Fat-free and low-fat yogurts are soft, have a low solids content, and exhibit whey separation unless they are heavily stabilized (Trachoo and Mistry, 1998).

In this study, we investigated the use of stabilizers, including carrageenan and pectin, and milk fortification. In dairy products, carrageenan interacts with casein at pH 6.7 in normal milk and at the isoelectric point (pH 4.6) of casein. Above the isoelectric point, polyvalent metallic ions in solution form bridges of protein negatively charged carboxylic groups and negative charges from carrageenan sulfate ester groups (Lin, 1977; Moirano, 1977; Glicksman, 1982; Whistler and Daniel, 1985; Syrbe et al., 1998). Pectin is a polysaccharide derived from plant cell walls; it forms gels with casein micelles and calcium after acidification by milk fermentation (Endress et al., 2005; Wang et al., 2012). Milk base fortification is one of the most important steps that enhances functional and nutritional properties and prevents textural defects such as poor gel firmness and syneresis in yogurts. The SNF content is traditionally increased to achieve a protein concentration between 40 and 50 g/kg (Karam et al., 2013). The rate of skim milk powder (**SMP**) addition to a yogurt mix ranges from 1 to 6%, but the recommended level is 3 to 4% (Tamime and Robinson, 2007). Thomopoulos et al. (1993) obtained low-fat milk yogurts with higher solids contents, which significantly increased apparent viscosity. Seelee et al. (2009) observed an improvement in viscosity and smoothness of goat milk yogurt after addition of concentrated whey protein to a final concentration of 3% (wt/vol).

In this study, we aimed to evaluate the physicochemical and sensory characteristics of fat-free goat milk yogurt with added stabilizers and SMP fortification.

MATERIALS AND METHODS

Yogurt Preparation

Eight liters of goat milk was provided by the Animal Science Department and plain fat-free yogurt was produced in the Dairy Laboratory facilities at "Luiz de Queiroz" College of Agriculture, Piracicaba, São Paulo, Brazil. After the cream fraction of the milk was removed, the remainder was divided equally into 4 beakers and treated as follows: (1) a mixture of 0.1% (wt/vol) carrageenan (Seakem GP 418, FMC Química do Brasil, Campinas, Brazil) and 0.1% (wt/vol) pectin (treatment **CR**); (2) 0.5% (wt/vol) pectin (low methoxyl, type 8002, CP Kelco do Brasil S.A., Limeira, Brazil; treatment **PE**); (3) 4.65% (wt/vol) bovine SMP (adjustment of solids to 14% ± 0.5; treatment **BM**); and (4) control (no stabilizer; treatment **CT**). The beakers were placed into a water bath at 80°C for 30 min with constant stirring. The samples were cooled to 42°C and inoculated with 3% reactivated starter culture (*Streptococcus salivarius* ssp. *thermophilus* and *Lactobacillus delbrueckii* ssp. *bulgaricus*; Chr. Hansen Ind. e Com, Valinhos, Brazil). Inoculated samples were maintained at 42°C for 3 h until the pH reached 4.6 and then the incubation was stopped. The resulting yogurts were cooled and then stored at 4°C.

Physicochemical Analysis

Specific gravity at 15°C (Brazil Ministry of Agriculture and Livestock, 1981), pH (method 981.12), titratable acidity (method 947.05), SNF (method 990.21), total CP (N × 6.38, Kjeldahl method; method 991.20), and ash (method 945.46) contents of raw goat milk were analyzed by the methods recommended by AOAC International (2003). Total fat content was determined according to Newlander and Atherton (1964). All measurements were done in triplicate on the day the samples were collected.

The yogurts were analyzed for SNF, total CP, titratable acidity, and pH according to AOAC International (2003). Yogurt samples were collected in triplicate on d 1 and 5 of storage.

Sensory Analysis

The sensory analysis was established by using quantitative descriptive analysis (**QDA**; Stone et al., 1974; Meilgaard et al., 2007). This technique is commonly used in the evaluation of processed food, such as dairy products (Gaze et al., 2015). The panelists were recruited from master's degree students and laboratory technicians from Agri-Food Industry, Food and Nutrition Department of "Luiz de Queiroz," College of Agriculture, Brazil, and they were selected based on regular consumption of yogurt and time availability. The sensory evaluation process was conducted in individual booths under controlled lighting and temperature. Booths included potable water, styrofoam trays where the samples were served monadically, pencil, evaluation forms, eraser, and paper napkin. In the selection stage, the panelists were asked to recognize basic tastes of the following compounds and level of concentration: (a) sweet [0.14% (wt/vol) sucrose], (b) acid [0.07% (wt/vol) citric acid], (c) salty [0.5% (wt/vol) sodium chloride], and (d) bitter [0.07% (wt/vol) caffeine] (Fisher and Yates, 1971). No assessors were excluded because all attained 100% accuracy. The flavor sensibility evaluation was carried out with 9 triangle