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Effects of freezing on composition and fatty acid profiles of sheep milk and cheese

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Abstract

A study was conducted with sheep milk to determine the effects of freezing temperature and freezing time on milk composition, cheese yield and composition and fatty acid profile of milk and cheese. Bulk tank samples of sheep milk were collected for 4 consecutive weeks and stored at −15 or −25 °C for 1–6 months. Milk samples frozen at the two different temperatures were thawed monthly at 22 °C and milk was used for cheese making. Results showed freezing temperature and freezing time had no effect on concentration of milk total solids, protein, casein, non-protein N, true protein and lactose contents, however, milk fat percentage decreased ($P < 0.05$) progressively during the 6 months freezing period with less changes ($P < 0.05$) observed at −25 °C than at −15 °C. Freezing at either temperature for more than 2 months reduced ($P < 0.05$) actual cheese yield with lowest ($P < 0.05$) yield observed at 6 months of storage, however, 37% moisture adjusted cheese yield and cheese fat and protein percentages were not affected by freezing treatments. Fatty acid composition of thawed milk and fatty acid profile of cheeses were not affected by freezing temperature and freezing time. It was concluded that freezing sheep milk at −15 and −25 °C for up to 6 months had only minor effects on milk and cheese composition. Despite the fact that freezing reduced actual cheese yield, adjusted cheese yield was similar for all freezing treatments. Freezing had no effect on milk or cheese fatty acid concentrations. Under the conditions of this study, good quality cheese can be produced from ovine milk frozen at −15 and −25 °C for up to 6 months without influencing cheese yield or composition.

Keywords: Sheep milk; Freezing; Fatty acids; Cheese

1. Introduction

Raising sheep for milk production is a traditional industry in many countries, such as in the Mediterranean region (Bencini and Pulina, 1997). However, the dairy sheep industry in North America only began in the late 1980's and has been growing steadily in the past decade, driven primarily by the increasing cheese market, small investment, ease of operation and freedom from quota limitation (Haenlein, 2001; Wendoff, 2001). Sheep milk is mainly used for cheese making due to its high fat and total solid contents. It has been

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reported that as much as 70% of sheep milk is used for cheese making (Mann, 1988).

Due to seasonality and low production levels, and in order to provide a stable milk supply or to accumulate enough milk for processing, raw sheep milk may be frozen for several weeks or months (Wendoff, 2001). Freezing could have adverse effects on milk quality and stability properties such as fat separation, protein flocculation and development of off-flavor (Muir, 1984; Needs, 1992). These changes not only affect product shelve life, but also the yield and quality of dairy products such as cheese and yogurt (Wendoff, 2001).

Preservation of milk by freezing has been a research subject since mid 1930s (Muir, 1984), and most of the work has focused on developing methods by which concentrated and unconcentrated cow milk could be kept for an extended period of time without affecting milk stability and quality. Freezing can have adverse effects on milk fat by destroying milk fat globules which leads to fat separation (Muir, 1984). Furthermore, unsaturated fatty acids in frozen milk are readily oxidized and degraded causing an oxidized off-flavor (Fennema et al., 1973; Needs, 1992). Further changes in fatty acid profile of frozen and thawed milk can occur during cheese making (Ha et al., 1989; Shantha et al., 1992; Garcia-Lopez et al., 1994). Effects of frozen storage on milk fatty acids and on yield and quality of cheese made from thawed sheep milk have not been determined. Therefore, the objectives of this study were: (1) to investigate the effects of freezing on cheese yield and composition of ovine milk, (2) to examine the influence of freezing temperature and freezing time on fatty acid composition in milk and cheese and (3) to determine changes in fatty acid composition related to freezing treatments during the cheese making process.

2. Materials and methods

2.1. Milk collection and storage

Bulk tank milk samples were collected from a collaborating farm in Quebec for 4 consecutive weeks in February 2003. The milking ewes (average days in milk 25 ± 5.7) were crossbred East Friesian with Lacaune and were receiving 600 g of concentrate mix (per animal per day, as fed) consisting of corn, wheat bran and soybean meal, and 2.5 kg alfalfa hay (as fed). During the first 2 weeks of milk collection, ewes were separated from their lambs for 12 h during the evening, machine milked once daily in the morning and their lambs allowed to suckle for 12 h during the day. At the end of the first 2 weeks, lambs were weaned and ewes were machine milked twice daily during the last 2 weeks of milk collection. The animals were kept in barn during the sampling period. Each week, milk samples (30 l) were collected and transported to the laboratory within 2 h. Once in the laboratory, milk samples were thoroughly mixed and packaged in 12 freezer bags (2.5 kg milk each). The freezer bags were then randomly placed in two freezers set at −15 and −25 °C (each with six bags) and stored for 1–6 months. Sub-samples of fresh milk were retained for compositional analyses and cheese making. The frozen milk samples from each week were removed from freezers monthly and thawed quickly at 22 °C. Each time the thawed samples were used for compositional analyses and cheese making. Visual examination was also made for the thawed milk samples to exam the stability and homogeneity of milk.

2.2. Cheese making

A laboratory cheese making procedure (Marziali, 1985) was used to make cheddar-type cheese from fresh and thawed milk samples. Briefly, 2 kg milk was put into a square plastic container, followed by pasteurizing milk for 30 min at 65 °C. Pasteurized milk was cooled down to 30 °C and maintained at that temperature for 30 min in a water bath, followed by addition of 40 ml lactic acid culture (Agropur Coopérative Agro-Alimentaire, Granby, Que., Canada). After 1 h incubation, calf rennet (Agropur Coopérative Agro-Alimentaire, Granby, Que., Canada) was added to the milk at a rate of 200 μl/kg milk, and thoroughly mixed using a wire whisk. After 30 min, the formed coagulum was cut horizontally and vertically to facilitate the drainage of whey, the whey was drained every 30 min for 3 h and collected into flasks for compositional analyses.

Milk and whey pH (after coagulation and cutting) were measured every 30 min during the cheese making process. When pH dropped to 5.75, all whey was removed, and the curd was weighed and cut into approximately 2.5 cm cubes to which an amount of salt equivalent to 1.5% of the coagulum's weight was added and well mixed. The curd was then collected into a cir-