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The suitability of milk from a spring-calved dairy herd during the transition from normal to very late lactation for the manufacture of low-moisture Mozzarella cheese

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Abstract

Bulk milk from a spring-calved dairy herd on a good plane of nutrition was collected and made into low-moisture Mozzarella cheese weekly over 10 weeks from 22 September (218 days in lactation, DIL) to 27 November (284 DIL). The 10 weeks were divided into three lactation periods: normal lactation (NL), 218–240 DIL; late lactation (LL), 241–265 DIL; and very late lactation (VLL), 266–284 DIL. Lactation period did not significantly influence milk composition, percentages of milk fat or protein recovered to cheese, cheese yield and composition, primary proteolysis or cooking properties during storage. The curd firmness of the rennet-induced gels from the LL or VLL milk samples was significantly higher than that of the NL milk. The mean firmness over the 40-d storage period of cheese from the LL and VLL milks was significantly higher than that of the cheeses from the NL milk. Satisfactory Mozzarella cheese making characteristics of milk from spring-calved cows can largely be sustained into late lactation by maintaining good dietary nutrition and herd management practices.

Keywords: Mozzarella cheese; Late lactation; Milk; Texture; Cooking properties

1. Introduction

Milk for cheese manufacture in Ireland is mainly obtained from pasture-fed, spring-calving cow herds, with a compact calving pattern between January and March. This system of milk production is characterized by marked seasonal changes in gross composition, mineral composition, ratio of different nitrogen fractions, somatic cell count and enzymatic activity of the milk over the main cheese-making season, which typically runs from February/March to October/November (Mehra, O'Brien, Connolly, & Harrington, 1999; O'Brien, Mehra, Connolly, & Harrington, 1999a; Phelan, O'Keeffe, Keogh, & Kelly, 1982). Similar changes in milk composition have been reported in other countries, e.g., Australia (Auldist et al., 1996; Walker, Dunschea, & Doyle, 2004), Canada (Kroeker, Ng-Kwai-Hang, Hayes, & Moxley, 1985), France (Martin & Coulon, 1995), New Zealand (Auldist, Walsh, & Thomson, 1998; Nicholas, Auldist, Molan, Stelwagen, & Prosser, 2002) and the UK (Banks & Tamime, 1987). Factors contributing to these changes include the combined effects of differences in stage of lactation (which alters the udder physiology and metabolism), plane of nutrition (especially for cows fed on pasture grass), somatic cell count and season (Benslimane, Dognin-Bergeret, Berdague, & Gaudemer, 1990; Givens, Moss, & Adamson, 1993; Hurley & Ford, 2003; Nicholas et al., 2002).

Seasonal changes in milk composition and quality, especially those that occur during late lactation, have a major impact on curd forming properties and the yield and composition of the resultant cheeses (Kefford, Christian, Sutherland, Mayes, & Grainger, 1995; Lucey & Fox, 1992; O'Brien et al., 1999a), and are thus conducive to

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inconsistencies in cheese quality (Lawrence et al., 2004). Late lactation milk generally gives poor rennet coagulability (low curd firmness), impaired curd syneresis, high moisture Cheddar cheese and lower recovery of milk fat to cheese (Auldist et al., 1996; Banks & Tamime, 1987; O'Keeffe, 1984). These defects coincide with low levels (<4.3%, w/w) of milk lactose and increased levels of serum casein (>40% total protein), which was non-sedimentable at $30{,}000 \times g$ (O'Keeffe, 1984). Similarly, Lucey, Kindstedt, and Fox (1992) found that late lactation milk from spring-calved herds [258–280 days in lactation (DIL) in October] had impaired rennet coagulability, and resulted in Mozzarella cheeses that had a higher moisture level, were softer and had a lower apparent viscosity when melted compared with the corresponding cheeses from mid-lactation milk from an autumn-calved herd. In contrast, Kefford et al. (1995) reported no differences between the compositions of Cheddar cheeses made from early or late lactation milk; they also observed a higher recovery of milk fat to cheese with late lactation compared with mid lactation milk. Discrepancies between the above studies may be due to differences in diet, somatic cell count, and the definition of late lactation milk, which Irish studies (Lucey et al., 1992; O'Keeffe, 1984) typically refer to as milk from cows ~>250 DIL compared with ~200–220 DIL in Australia (Auldist et al., 1996; Kefford et al., 1995) and New Zealand (Auldist et al., 1998; Nicholas et al., 2002). O'Keeffe (1984) found that the extent of these cheese-making defects in late lactation spring-calved herds in Ireland was accentuated when both the plane of nutrition of the cow and the milk yield at drying off were low (e.g., high stocking density on pasture in October/November without dietary supplementation, and <6 L of milk per cow per day, respectively).

Dillon, Crosse, Stakelum, and Flynn (1995) developed an efficient milk production system for pasture-fed spring-calved herds in Ireland that allows animals to end their lactation on a good plane of nutrition and at a higher milk yield. The system produces milk of good composition and processing characteristics (O'Brien et al., 1997) and has been used successfully to manufacture low-moisture Mozzarella in the mid-lactation period (Guinee et al., 1998). A recent study (O'Brien, Guinee, Kelly, & Joyce, 2006) showed that spring-calved herd milk produced using this system (Dillon et al., 1995) also had good composition, rennet coagulation characteristics and ethanol stability in late lactation (261–307 DIL).

The objective of the current study was to monitor the yield, manufacturing efficiency and functionality of low-moisture Mozzarella cheese from spring-calved herd milk produced according the system of Dillon et al. (1995) throughout advancing lactation. The stage of lactation up to which satisfactory quality low-moisture Mozzarella may be produced from this milk was determined. The lactation period was sub-divided into three periods: normal lactation (218–240 DIL), late lactation (241–265 DIL) and very late lactation (266–284 DIL).

2. Materials and methods

2.1. Milk supply

The spring-calved herd used in this study has been described in detail by O'Brien et al. (2006). A group of 26 cows with a mean calving date of 16 February and a mean lactation number of 3 was selected from the Friesian herd at the Dairy Production Research Centre, Moorepark, Ireland. The herd was fed on pasture at a stocking rate of 2.48 cows ha^{-1} up to 4th November, and thereafter fed indoors on good quality silage of 806 g kg^{-1} dry matter digestibility; all cows received a feed supplement of 2 kg concentrate per cow per day throughout the experimental period. Cows were dried off at a milk yield of ~6 kg per cow per day. Bulk milk from this herd was collected and made into cheese weekly over the 10-week period from 22 September (218 DIL) to 27 November (284 DIL). The 10 weeks of the experiment were divided into three periods, namely 218–240 DIL, normal lactation (NL); 241–265 DIL, late lactation (LL); and 266–284 DIL, very late lactation (VLL).

2.2. Cheese manufacture

Milk (~500 L) for cheese making was collected over 2 d, bulked and stored at 4 °C. On day 3, milk was standardized to a protein:fat ratio of ~1.22, stored overnight at 8 °C, pasteurized (72 °C, 15 s) and cooled to the renneting temperature of 36 °C. The pasteurized milk (~455 L) was inoculated at a level of 1.5% (w/w) with a starter culture consisting of *Streptococcus thermophilus* and *Lactobacillus helveticus* (Chr. Hansen's Laboratory (Ireland) Ltd, Little Island, Cork, Ireland), at a ratio of 2:1. After a 30-min ripening period, the pH of the milk was measured and reduced, if necessary, using 5% (w/v) lactic acid, to a standardized set pH of 6.55. Chymosin (Double Strength Chy-max, 50,000 MCU mL^{-1}; Pfizer Inc, Milwaukee, WI, USA), diluted 1:10 with distilled water, was then added at a fixed rennet-to-protein ratio, equivalent to 0.077 mL undiluted rennet per kg milk with 3.4% protein. The gel was cut at a firmness equivalent to an elastic shear modulus (G') value of 20 Pa, as measured using low-amplitude strain oscillation on a controlled strain Bohlin VOR rheometer (Malvern, Worcestershire, UK), as described previously (Guinee et al., 1997). The curd–whey mixture was cooked to 42 °C and drained at pH 6.15. The curd was cut into slabs and cheddared by turning every 15 min while gradually piling the slabs until the pH reached was ~5.18. The curd was then milled into rectangular chips (~$1 \times 1 \times 6$ cm) and dry salt was added at a rate of 3.3% (w/w). The salted curd was mellowed for 20 min, heated (to 58 °C) and kneaded to a cohesive, molten, plastic mass in hot water at 78 °C (Automatic Stretching Machine, Mod f.; CMT Costruzioni Meccaniche e Technologia S.p.a., Peveragno, Cuneo, Italy). The plasticized curd was moulded into 2.3 kg rectangular blocks (~$23 \times 10 \times 15$ cm),