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Good sensory quality and cheesemaking properties in milk from Holstein cows managed for an 18-month calving interval

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ABSTRACT

Extended calving interval (CInt) for high-yielding dairy cows beyond the traditional 12 mo has been suggested as a profitable, environmentally and welfare-friendly production strategy. However, concerns exist on whether extending cow CInt, and consequently prolonging lactation length, impairs milk quality. The aim of this study was to compare the quality of milk produced during the extended lactation period to mid lactation. In particular, milk indicators related to udder integrity and cheesemaking properties when cows were fed low- or high-energy diets in early lactation mobilization period. Forty-seven healthy Danish Holstein cows (15 primi- and 32 multiparous) were fed 2 distinct weight-adjusted diets in early lactation: either a high-density diet for approximately 42 d in milk (DIM) followed by a low-density diet (n = 22), or a low-density diet throughout the whole experiment (n = 25). Milk quality was explored at 3 lactation periods: 140 to 175 DIM (P1), 280 to 315 DIM (P2), and 385 to 420 DIM (P3). Lactation period was found to be the main factor affecting milk yield, quality, and cheesemaking properties. Primiparous cows kept the same daily milk yield throughout the studied periods, whereas multiparous cows produced, on average, 10.2 kg/d less in P3 compared with P1. Fat, protein, and casein concentrations increased, respectively, by 18, 16, and 16%, from P1 to P3. Cheesemaking properties, such as curd-firming rate, gel strength, and wet and dry curd yield, got an improvement from P1 to P3 and were strongly correlated with milk concentrations of protein and casein. The udder integrity indicators, somatic cells count, level of free amino terminals as an index of proteolysis, and milk pH, remained unchanged throughout the studied lactation periods. Feeding cows either high- or low-density diets during the early lactation mobilization period did not exert any relevant carryover effect on milk composition, and thus had no effect on cheesemaking properties in extended lactation. Further, sensory quality of mid- and extended-lactation milk was assessed by a trained sensory panel. The sensory quality of milk from P3 reflected sensory descriptors related to the increased levels of fat and protein over lactation, but, importantly, milk produced in P3 did not present sensory demerits when compared with milk produced in P1. In conclusion, high-yielding Holstein cows undergoing an 18-mo CInt produced high-quality milk from mid to extended lactation.
Key words: milk coagulation, automatic milking system, individual feeding strategy, extended lactation

INTRODUCTION

Extended lactation is a production strategy in which rebreeding is deliberately delayed maximize lactation persistency rather than peak production (Sorensen et al., 2008). In many production systems, dairy cows calve once a year, usually achieving three 12-mo calving intervals (**CInt**) during their lifetimes (Knight, 2005). Extending the lactation period beyond the 12-mo CInt has been suggested as an alternative strategy, and its potential to better exploit modern dairy cow production capacity has been investigated in pasture-based (Kolver et al., 2007), seasonal-grazing (Österman and Bertilsson, 2003; Lehmann et al., 2016), and all-year barn-feeding dairy production systems (Lehmann et al., 2016).

By extending CInt, the number of calves per cow per year is reduced and, accordingly, so is the susceptibility to calving risks and postpartum metabolic disease (Knight, 2005; Sorensen et al., 2008). It is also suggested that fewer calves per cow per year results in reduction of number of dry days per cow per year, replacement heifers, and feed use, thereby potentially lowering greenhouse gas emissions per kilogram of milk produced (Lehmann et al., 2014). Furthermore, some

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economic benefits may exist by extended lactation, such as reducing costs per cow regarding mating, calving, animal health, and cow replacement (Borman et al., 2004).

Several studies have, to various degrees, covered milk production and compositional aspects in relation to lactation cycle duration (Österman and Bertilsson, 2003; Auldist et al., 2007, 2010; Kolver et al., 2007; Sorensen et al., 2008; Grainger et al., 2009), but studies on milk technological qualities from cows in extended lactation are scarce. Auldist et al. (2010) revealed that milk produced by Holstein-Friesian cows managed for a 24- rather than a 12-mo CInt had superior fat and protein concentration, cheesemaking properties, and cheese yield. Increased milk solids were also found by Sorensen et al. (2008) for Holstein-Friesian cows managed for an 18-mo CInt; however, those authors observed a decrease in the casein-to-protein ratio during the extended lactation period, suggesting that this milk might not be as suitable for cheese manufacturing. Bertilsson et al. (1997) reported a salty taste in the milk produced by cows undergoing extended lactation, drawing attention to a possible sensory demerit. Such findings indicate a possible decline in the udder epithelial integrity when high yield is maintained for longer lactation periods. These changes are comparable to what is normally observed in milk from cows in late lactation, in which concentrations of salts, SCC, serum proteins, and proteases derived from both the plasmin-plasminogen system and somatic cells increase (Korycha-Dahl et al., 1983; Grufferty and Fox, 1988; Larsen et al., 2006); this may potentially result in increased protein hydrolysis as well as impaired cheesemaking and sensory properties (Lucey and Fox, 1992; Lucey et al., 1992; Auldist et al., 1996; Lucey, 1996).

Most of the publications reporting compromised suitability for dairy processing of late-lactation milk date back to the 1980s and '90s, when cows at dry-off had considerably lower yields and high-standard husbandry practices and nutritional plans were not customary. Thereby, these studies might not reflect management of modern high-yielding dairy cows. For instance, recent research has underlined the potential of individual over group feeding strategies for better attending individual energy demands (Bossen and Weisbjerg, 2009). Such a strategy has been proposed as a way to better exploit the productive potential of high-yielding Holstein cows without compromising milk composition. Gaillard et al. (2016c) verified that an individual weight-adjusted feeding strategy, supplying high-energy density diet in early lactation, reduced the magnitude of the mobilization period. But, conversely, cows fed by this strategy had lower lactation persistency compared with cows fed a low-energy diet during the entire extended lactation. However, the effect caused by individual feeding strategies on milk quality, with its implications for cheese processing, will be addressed in the present study.

Given the limited data on detailed composition and characteristics of milk produced during the extended lactation period, the aims of the present study were (1) to investigate possible changes in milk produced during the extended lactation period compared with milk produced in mid lactation of cows managed for an 18-mo CInt, by monitoring indicators related to udder integrity, cheesemaking properties, and sensory quality; and (2) to examine if feeding cows a high-energy diet during the early lactation mobilization period would exert a carryover effect on milk composition, and consequently on cheesemaking properties, in cows managed for an 18-mo CInt. We hypothesized that the milk quality would be reduced toward the end of the extended lactation, with implications on cheesemaking properties and sensory quality. In addition, supplying a high-energy diet in early lactation would not cause long-term changes on milk composition.

MATERIALS AND METHODS

Facilities, Animals, and Feeding Strategy

Sixty-two Danish Holstein cows from the Danish Cattle Research Centre (DKC, Tjele, Denmark), housed in a loose-housing system with slatted floor and cubicles with mattresses, and with access to an automatic milking unit (**AMU**; DeLaval AB, Tumba, Sweden) were followed from October 2012 to October 2014. The experiment was approved by The Animal Experiments Inspectorate under the Danish Veterinary and Food Administration (Glostrup, Denmark).

The cows were blocked according to expected calving date and parity and randomly allocated to 2 feeding strategies at calving (Gaillard et al., 2016b). In short, the high-low energy diet strategy (**HD-LD**) refers to cows that received a 50:50 forage-to-concentrate partial mixed ration with a high energy density (**HD**; 7.81 MJ of NE_L/kg of DM) until they reached at least 42 d of lactation and a live weight gain $\geq$0 kg/d on a 5-d average, and then individually shifted to a diet with a lower energy density (**LD**, 7.49 MJ of NE_L/kg of DM), consisting of 60:40 forage-to-concentrate partial mixed ration. Cows in the low-low energy diet (**LD-LD**) were fed the LD diet during the whole lactation. Diets were formulated using the NorFor model and standards (Volden, 2011). For both groups the mixed part of the diet was offered individually and ad libitum, and each cow was provided 3 kg of concentrate per day at the AMU. For detailed information on the feeding experiment and diet composition, see Gaillard et al. (2016b).