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On effects of subclinical mastitis and stage of lactation on milk quality in goats☆

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ABSTRACT

Bulk milk is the mixture of all the milked udders in a given herd. Nowadays, about 15–40% of the udders in most herds are intramammary infected by different bacteria species, mainly coagulase negative staphylococci. The presences of bacteria in the lumen of the mammary gland induce impairment of milk quality and increase the number of somatic cells. A positive relationship between % casein (casein/total protein) and curd firmness (CF) and negative relationship between lactose, or somatic cell count (SCC) and CF are associated with bacterial infection and with late lactation milk, and therefore with reduction in cheese yield and quality. On the other hand, in milk of goats with intramammary infection, the correlation between the levels of fat, protein, casein and curd yield is minor compared to milk of uninfected animals. Thus, gross milk composition is an insufficient predictor of milk quality for cheese production, since a high percent of the bulk milk originates from subclinically infected glands. Research carried out in the past few years highlighted the effectiveness of lactose as a predictor of milk quality. The correlation between lactose and CF was higher than that for % casein and SCC. Lactose concentration of ≤4% is associated with non-coagulating milk and therefore, such milk is unsuitable for making cheese, but still meets the criterion for consumption as pasteurized milk. A model that describes the simultaneous and close association between reduction in lactose concentration and milk yield on the one hand and reductions in lactose concentration and milk quality on the other hand is presented. The physiological and biochemical basis for deterioration of milk quality in subclinically infected and in late lactation animals is reviewed and suggestions to improve the quality of milk produced by farmers and acquired by dairies are presented.

1. Introduction

Goats are among the earliest domesticated farm animals and their milk has been consumed by humans for thousands of years. Goat herding practice dates back to 8000 BC (Colledge et al., 2013) and evidence of using goats milk for making dairy products goes back to ancient Egypt, where remains of pots that has been used to make or store cheese were discovered in Pharaohs burial tombs (Edelstein, 2014). On a global scale, total goat milk production reaches 15,510,411 tons per year, of which 80% are produced in developing countries where goat's milk plays an important role in the livelihood of hundreds of millions of human beings (FAO, 2013; Silanikove et al.,

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2010). In Europe and North America the vast majority of goat's milk is used to make dairy products, most notably cheese (Morand-Fehr et al., 2004). The yield and quality of cheese is crucially depended on milk quality. Milk quality for cheese production is influenced by many factors such as nutrition, genetics, husbandry, which are mostly covered in the publications of this special issue. The most important single factor that determines cheese yield and quality in dairy ruminant (sheep and cows) in general and in goats in particular are the deleterious effects of subclinical mastitis (SCM)(Leitner et al., 2006; Silanikove et al., 2010; Martí-De Olives et al., 2011), bearing in mind that milk from clinically infected goats should not reach the food-chain. Milk produced at the end of lactation also significantly and negatively affects milk quality for cheese production in sheep, cows and goats, and the effect is particularly evident in goats (Leitner et al., 2011a). Both, SCM and end of lactation effects on milk quality are imposed through inducing inflammatory stress on milk components (Leitner et al., 2012). Thus, separation of these effects is confounded and imposes difficulties on the dairy industry for grading milk quality for cheese production (Silanikove et al., 2010). The aim of this review is to critically consider recent advances on how SCM and end of lactation affect milk quality for cheese production and to devise recommendations on how to deal with these conditions.

2. Effects of subclinical mastitis and end of lactation on milk yield and quality

The first step in producing cheese is producing curd. In milk from uninfected glands, curd yield depends mainly the content and subtypes of αS1-, β- and κ-caseins (Hyslop, 2003; Vazquez-Flores et al., 2012; Mestawet et al., 2014), fat level, and protein to fat ratio (Guinee et al., 2007). Phosphoseryl residues on αS1- and β-caseins are bound in the micelle to polyvalent cations, mostly Ca^{+2} ions. Expositions of the phosphoseryl residues due to the activity of clotting enzyme lead to charge neutralization, aggregation, and eventually to precipitation of the curd components. During aggregation, casein forms a fine mesh that entraps the fat globules and leaves the soluble lactose in the whey. Thus, the main components of curd are casein and minerals associated with it, most notably Ca^{+2}, fat and components attached to the milk fat globule membranes, such as fat soluble vitamins.

Cheese is prepared by utilizing a wide range of different microbial cultures. In combination with maturation conditions and maturation period, impressive wide varieties of cheeses, each with unique taste, shape, color, texture and rheological properties are produced worldwide. Recently, it was shown that cheese made from milk of SCM infected glands affected negatively the chemical processes that occur during cheese maturation. Despite the fact that the curd mass of cheese made from milk taken from uninfected glands was equal to the curd mass of cheese made from milk taken from infected glands, the final produced from milk coming from the infected glands had lower yield and quality (Merin et al., 2008; Rovai et al., 2014).

2.1. *Experimental models to investigate the effects of SCM*

Use of the half-udder model in which a single gland serves as the experimental unit and the contra-lateral gland as a control has been used extensively by our research group for studying the effect of SCM on milk yield and milk quality (Leitner et al., 2004a,b,c, 2006, 2008a,b, 2011a) and was also used by others (Gonzalez-Rodriguez et al., 1995; Martí-De Olives et al., 2013). This experimental model enables to study the physiological basis and quantification of the negative effects of SCM on milk yield and quality with high statistical reliability, even for a relatively small data set of 20–40 animals. The half-udder model proved as an effective tool for isolating the experimental effect from numerous masking effects. The experimental variability arose from significant individual variations between individual animals and is farther complicated by the effects of factors such as, farm management, environmental conditions, age, and stage of lactation. Obviously, variations caused by all of these factors are neutralized when the units of comparison are the two glands of the same animal. An alternative approach based on conventional whole-udder sampling would have required a data set in the order of 100 animals to account for the large above-described source of variability (Leitner et al., 2004b).

However, because of the tendency of the uninfected gland to compensate for reduction in milk yield of the infected gland, and because such compensation is not possible in the event where both glands are infected, the effect of SCM on a whole animal level was found bigger than that obtained by the average effect found with the half-udder model (Leitner et al., 2008a). Thus, for the purpose of quantifying the effect of SCM on a whole herd level, especially in herds with poor hygienity, it is preferable to carry out experiments that include milk sampling of all the goats in a given flock and to combine this information with information gained by the half-udder model (Leitner et al., 2004b, 2007).

2.2. *The bacteria involved and etiology of infection*

Worldwide, intramammary infection (IMI) in small ruminants (sheep and goats) and large ruminants (cows) is a major cause of economic loss to the dairy industry. Effective control of new IMI cases and, consequently, milk yield, milk quality, including somatic cell counts (SCC) in the milk of dairy animals is aided by an understanding of the pathogens involved, the source of infection and the frequency of spontaneous cures (Lam et al., 1997; Leitner et al., 2007).

In goats, as in sheep and cows, SCM is the prevalent form of mastitis (Bergonier et al., 2003; Leitner et al., 2004b,c, 2007). The prevalence of SCM in small ruminants could be as low as 5% under very good husbandry, but, typically affects 15–40% of the animals in a given flock. On the other hand, annual incidence of clinical mastitis is generally lower than 5–10% (Contreras et al., 2007; Silanikove et al., 2010). Staphylococci: *Staphylococcus aureus* and coagulase-negative staphylococci (CNS) are frequent pathogens isolated from IMI goats (Contreras et al., 1999, 2007; Leitner et al., 2004b). However, CNS,