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Grazing season and forage type influence goat milk composition and rennet coagulation properties

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ABSTRACT

Two different types of pasture (cultivated and rangeland) and 2 different hay qualities (high and low quality) were examined for their effects on goat milk composition and rennet coagulation properties. Furthermore, the effect of dietary treatments in both the early and late grazing season was studied. As lactation stage is known to influence milk composition, the goats in the early and late grazing season were in the same lactation stage at the start of the experiment. The milk composition was influenced both by dietary treatment and season. Milk from goats on pasture was superior to those on hay by containing a higher content of protein and casein, and the goats on cultivated pasture had the highest milk yield. Casein composition was significantly influenced by forage treatment. Goats grazing on cultivated pasture had higher contents of α_{s1}-casein and also of κ-casein compared with the other treatments, whereas goats grazing on rangeland had the highest content of β-casein. Factors such as milk yield, casein micelle size, α_{s2}-casein, and calcium content were reduced in late compared with early season. More favorable rennet coagulation properties were achieved in milk from the early grazing season, with shorter firming time and higher curd firmness compared with milk from the late grazing season, but the firming time and curd firmness were not prominently influenced by forage treatment. The content of α_{s2}-casein and calcium in the milk affected the firming time and the curd firmness positively. The influence of season and forage treatment on especially milk yield, casein content, and rennet coagulation properties is of economic importance for both the dairy industry and goat milk farmers.

Key words: goat milk, milk rennet coagulation properties, individual casein composition, pasture

INTRODUCTION

Norway has a long tradition of goat milk production. Most of the milk from about 40,000 dairy goats is used for production of the traditional brown whey cheese (Brunost). The demand for brown whey cheese among Norwegian consumers is declining, and the interest in rennet- and acid-coagulated cheeses is increasing among the dairy industry and consumers. However, production of these cheeses requires a milk of a more stable and higher quality than milk used for brown whey cheese. Quality cheese milk has high DM content (casein and fat is most important), low SCC, and low susceptibility to excessive lipolysis, maintaining a low content of FFA. In addition, the ability to clot by the action of rennet and achievement of a firm curd are important factors in cheese manufacture (Skeie, 2010).

Previous studies have shown that the population of Norwegian goats has a high frequency of animals with low or no synthesis of α_{s1}-CN (Devold et al., 2011). This is caused by an extremely high frequency (0.73) of a defective allele with a single nucleotide deletion in exon 12 of the gene encoding α_{s1}-CN (*CSN1S1*; Hayes et al., 2006; Dagnachew et al., 2011). Until now, Norwegian dairy goats are the only breed known to carry this deletion. In addition to low or no expression of α_{s1}-CN in the milk, this deletion correlates with a reduced content of protein, fat, and lactose; a high content of FFA; and tart and rancid flavor (Dagnachew et al., 2011). Milk from Norwegian goats shows poor rennet coagulation properties and sensory quality in periods of the year. The milk-quality challenges are more pronounced during the grazing season (Eknæs and Skeie, 2006). Traditionally, goat milk production is seasonal, with kidding in winter and early spring and with peak milk production during the summer grazing season. During the grazing season, the goats graze to a large extent on natural unimproved grassland or free range in forest and mountain grasslands. The quality of these pastures is variable and declines with forage production during the grazing season (Lunnan and Todnem, 2011). The

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decline in forage and milk quality coincides with advanced lactation stage, another factor associated with increased FFA content in goat milk (Chilliard et al., 2003). Thus, the effects of the grazing season and the lactation stage on milk quality may be confounded. The high degree of polymorphism at the α_{s1}-CN locus (for review, see Marletta et al., 2007) is known to affect both casein content and rennet coagulation properties (Clark and Sherbon, 2000; Devold et al., 2011). However, few studies exist focusing on the effect of forage quality on rennet coagulation properties and protein quality (i.e., the casein content and composition of individual caseins in milk from dairy goats).

Hence, the objective of this work was to study the effects of grazing season (early and late), forage type [hay (high- and low-quality hay)], and pasture (cultivated and rangeland) on milk composition and rennet coagulation properties. To separate the effects of these factors from the effect of lactation, all goats were in the same lactation stage at the start of the feeding experiment.

MATERIALS AND METHODS

Experimental Design and Diets

The experiment comprised 80 Norwegian dairy goats, located at Gibostad research farm, Norway (69°21.397′N, 17°56.319E). A simplified overview of the experimental design is shown in Figure 1. The goats were genotyped according to Hayes et al. (2006) with respect to the deletion in exon 12 the gene encoding α_{s1}-CN (*CSN1S1*). The individuals were blocked according to lactation number (5 groups: 1 = first lactation, 2 = second lactation, 3 = third lactation, 4 = fourth lactation, and 5 = more than 4 lactations) and genotype [homozygous (**E12-00**) or nonhomozygous (**E12-01/E12-11**) for the deletion in exon 12], and the goats within each of these blocks were further randomly divided into 2 groups [early (**EGS**) and late (**LGS**) grazing season]. The goats in EGS were mated approximately 8 wk before those in LGS, and the average kidding date was February 2 (SD = 9 d) and April 1 (SD = 12 d) for the EGS and LGS group, respectively. From kidding until the start of the grazing season (June 28, 2010) the goats received the same diet: silage fed ad libitum and 1.1 kg of concentrate/d per goat. The concentrate was produced for this experiment by Felleskjøpet Agri (Storsteinnes, Norway) and was a mixture with the following ingredients (g/kg): barley (278), oat (263), wheat bran (159), sugar cane molasses (65), sugar beet pulp (60), extracted soybean meal (46), oil seed (41), SoyPass (Denofa AS, Fredrikstad, Norway, WI; 34), limestone (19), and other minerals and vitamins (35).

At approximately 130 DIM (June 28 and August 16 for the EGS and LGS group, respectively), the goats were randomly assigned to 4 homogenous treatment groups. The treatment groups were balanced for genotype and lactation number and each consisted of 10 goats. The 4 treatments were cultivated pasture (**PC**), rangeland pasture (**PR**), high-quality hay (**HH**), and low-quality hay (**HL**). The chemical composition for the 2 hay qualities (HH and HL) and concentrate used in the experiment and of the silage fed indoors from kidding to the start of the grazing season are given in Table 1. The goats on hay were kept indoors in pens and the hay was fed ad libitum, allowing 10% refusals. The goats on pasture grazed day and night. The PC was a ley (2.1 ha in area) in its first production year dominated by *Phleum pratense* and *Festuca pratensis*. The daily allowance was on average 13 kg of DM/goat. The PR was approximately 300 ha with the following vegetation types (% of land area): blueberry-birch woodland (41), fen (22), meadow-birch forest (21), lichen/heather-birch woodland (6), wet woodland (4), natural grassland (4), and spruce woodland (2). Dominating species were birch (*Betula pubescens*), bilberries (*Vaccinium myrtillus*), Swedish cornel (*Cornus suecica*), wavy hair-grass (*Avenella flexuosa*), and sweet vernal grass (*Anthoxanthum odoratum*).

The LGS group grazed together with the PR group of the EGS goats until August 16, 2010. The forage treatment periods lasted for 3 wk. All goats during the forage treatment period were supplemented with the same concentrate mixture as fed during the indoor period at a rate of 0.9 kg/d and the concentrate was given during milking twice daily.

To summarize, the design applied was a 2 × 4 factorial with season (EGS and LGS) as one factor and forage type (PC, PR, HH, and HL) as the other factor. The 10 goats in each treatment (PC, PR, HH, and HL) were randomly divided into 2 groups (pens) with 5 goats, accounting for genotype and lactation number. In the 2 hay treatments, the 5 goats in each group within treatment were kept indoors in 2 separate pens, whereas the goats within each pasture treatment grazed together. The procedures in the experiment were according to the regulations set by the Norwegian Animal Research Authority (Oslo, Norway).

Feed Intake, Feed Sampling, and Analysis

Feed intake on pasture was estimated by the use of the *n*-alkane technique (Mayes et al., 1986) and is reported for the current experiment by Steinshamn et al. (2014). Procedures for sampling and preparation of samples of grazed plants, hay, and concentrate are also described by Steinshamn et al. (2014). The chemical composition