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Effects of grass silage harvesting time and level of concentrate supplementation on nutrient digestibility and dairy goat performance

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ABSTRACT

The effect of harvesting time (HT) of timothy-dominated grass silage and level of concentrate on the chemical composition of silage, and on feed intake and milk production by Norwegian dairy goats, were evaluated. The silages were prepared from the primary growth at three stages of maturity: very early (HT 1), early (HT 2) and normal (HT 3). The silages were fed *ad libitum* to 18 goats of the Norwegian dairy goat breed in early lactation and supplemented with a low (LC; 0.6 kg per goat daily) or normal (NC; 1.2 kg per goat daily) level of concentrate. The experiment was conducted as a cyclic changeover design with four periods of 28 days using three blocks of goats according to their initial body condition (poor, medium or high body condition). Silages contained 771, 696 and 619 g digestible organic matter per kg dry matter in silage (*D*-value) for HT 1, 2 and 3, respectively. Postponing the harvesting time decreased (P<0.001) silage dry matter intake (DMI) and silage DMI per kg body weight (BW). Increased concentrate allowance decreased silage DMI, with substitution rates (decrease in silage DMI when concentrate dry matter intake is increased, kg/kg) of 0.43, 0.21 and 0.27 at HT 1, HT 2 and HT 3, respectively. Milk yield and yields of milk constituents decreased (P<0.001) with delayed harvesting time and thus reflected the changes in silage *D*-value. Milk free fatty acids (FFA) concentration was not affected by dietary treatments. The efficiency of nutrient utilization was best when LC was fed and increased with postponed harvesting time. The higher energy efficiency of the HT 3 LC fed goats indicates that these goats canalized a higher proportion of energy intake to milk production, compared to goats fed NC and earlier harvested silage. Marginal ECM production response to increased net energy lactation (NEL) intake were higher when intake was increased due to higher silage digestibility (0.14 kg ECM/MJ NEL) compared with increased NEL intake due to increased concentrate level (0.12 kg ECM/MJ NEL). Improving silage quality by earlier harvesting time resulted in higher feed intake and milk yield than obtained by the same increase in NEL intake by concentrate supplementation.

1. Introduction

There are about 40,000 dairy goats in Norway and cheese products from goat milk are the main products of goat farming. The level of dry matter intake or ingested energy is the main factor influencing yield and composition of the milk (Morand-

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Abbreviations: AAT, amino acids absorbed from the small intestine; aNDFom, NDF assayed with alpha amylase and expressed exclusive of residual ash; BMI, body mass index; BW, body weight; CP, crude protein; DM, dry matter; DMI, dry matter intake; *D*-value, digestible organic matter in dry matter; ECM, energy corrected milk; FFA, free fatty acids; ME, metabolizable energy; N, nitrogen; NDF, neutral detergent fiber; NEL, net energy lactation; PBV, protein balance in the rumen; SDMI, silage dry matter intake.

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Fehr et al., 2007). Due to the cold climate in Norway, the grazing period is restricted and the goats are fed indoors for 7–9 months per year. This makes grass silage the most important feed resource. Timothy grown with meadow fescue and red clover in a multispecies sward is the main forage crop for silage. The silage fed has traditionally low digestibility and high content of fiber. It is generally recognized that increasing the amount of fiber depresses digestibility of the dietary components in the feeds (Santini et al., 1992). Underfeeding of the goats appears to be an extensive problem, especially in early and mid lactation (Hadjipanayiotou and Morand-Fehr, 1991), resulting in energy mobilization (Eknæs et al., 2006). Improvements of the grass silage quality could potentially increase feed intake and milk yield. There are a number of factors affecting silage quality (Charmley, 2001). However, young stage of maturity at harvest and consequently highly digestible feed is a prerequisite for high intake and better performance (Sauvant et al., 1987; Rinne et al., 1999; Huhtanen et al., 2007).

In the dairy goat winter diet, grass silage is supplemented with concentrate feeds of varying amount. Increased energy and protein intake from concentrate could to some extent solve the underfeeding problem. However, due to the large land area covered by grass, and the cultural value of Norwegian goat farming (grazing on natural pasture), improved grass silage quality should be the main focus on farm practices. The marginal response of dairy cows to increased energy intake (kg ECM per additional MJ NEL) has been found to be higher from improved silage digestibility than from increased concentrate level (Rinne et al., 1999), another argument for putting effort in correct timing of the silage harvest.

The impact of harvesting time of the grass silage on intake by cattle has been described in several studies (*e.g.* Rinne et al., 1999; Dawson et al., 2002; Kuoppala et al., 2008; Randby et al., 2010). However, as cattle and goats are reported to have different digestive capacities for silage (Tolkamp and Brouwer, 1993), it may be difficult to draw conclusions about goats from these reports. As far as known, no experimentation investigating the effect of grass silage harvesting time on goats' performance exists. Therefore, the objective of this work was to evaluate the effects of grass silage harvesting time and two levels of concentrate on dairy goats' performance.

2. Materials and methods

2.1. Silage preparation

The silages were made at the experimental farm at Ås, Norway (60°N, 11°E) in 2007 from two fields, one established in 2004 and the second in 2005. The crop was harvested from the primary growth at three stages of maturity (harvesting times (HT)): (1) very early (HT 1), 23–24 May, (2) early (HT 2), 4 June and (3) normal (HT 3), 13 June. The sward consisted of timothy (*Phleum pretense*), meadow fescue (*Festuca pratensis*) and red clover (*Trifolium pretense*) in proportions of 0.47, 0.37 and 0.15, respectively. Other species and weeds made up 0.01. Phenological development stage of timothy at harvest was determined as mean stage by weight (MSW) (Moore et al., 1991). The MSW values of 2.26, 2.93 and 3.19 for the three harvesting times, respectively, indicated that stage 1 and 2 were dominated by tillers in stem elongation with 2 and 3 visible nodes, respectively, and stage 3 was dominated by tillers with visible head, but without head stems (early heading). After mowing, the grass was wilted for 1–10 h during daytime or 16–20 h over night to achieve a target dry matter (DM) content of 250 g/kg DM. Weather conditions during harvest were mainly sunny with only a light rainfall during the first harvesting time. The grass was baled using an Orkel GP 1260 (Orkel AS, Fannrem, Norway) roundbaler with 20 fixed knives, and preserved with the acid-based additive GrasAAT N-Lacto (730 g formic acid and 15 g lactose per kg; Addcon Nordic AS, Porsgrunn, Norway) applied at a rate of 4.4 l/ton. The bales were wrapped in 6 layers of 0.025 mm thick and 750 mm wide white plastic film (Trio Wrap, Trioplast AB, Sweden). Each bale was weighed (720–894 kg on fresh weight basis) and sampled to measure DM yield. Before feeding, the silage was processed through a mixer wagon (Euromix I 1070, Kuhn, Saverne, France) to reduce the possibilities for feed selection and enhance the intake, and then fed within four days. The median particle length of the silages was measured by hand sorting of silage particles into length groups of <25 mm, 25–50 mm, 50–75 mm, 75–100 mm, 100–150 mm, and 150–250 mm.

2.2. Experimental design, animals and diets

The experiment was carried out with 18 goats of the Norwegian dairy goat breed in 2nd to 8th lactation which kidded between 8th and 21st of January 2008. Average body weight (BW) 2 days after kidding was 63 ± 10.5 kg. The experiment started on February 6th after a preparation period for nearly two weeks. It was conducted as a cyclic changeover design (Davis and Hall, 1969) with 4 periods of 4 weeks using three blocks each of six goats. The goats were assigned to blocks according to their body condition, where block 1: poor body condition; block 2: medium body condition; block 3: high body condition. As goats deposit most of their body fat as visceral fat (Colomber-Rocher et al., 1992; Marinova et al., 2001) scoring of body condition of goats may be difficult. Body mass index (BMI) (BW/neck height^2), the same as used for humans, was therefore used as a measure of body condition. A goat body mass index has previously been applied also by Tanaka et al. (2002). The goats within blocks were allocated randomly to one of six treatments. Thus 3 goats (one from each block) were fed the same diet in each period. The six treatments consisted of three silage qualities and two concentrate levels. Animals were offered silage from HT 1, 2 or 3 *ad libitum* and either low (LC; 0.6 kg per goat daily) or normal (NC; 1.2 kg per goat daily) level of concentrate. The concentrate was a mixture made with the following composition (per kg): 120 g extracted soybean meal, 50 g heat-treated, extracted rapeseed meal (ExPro 00E), 523 g barley meal, 175 g oats, 50 g wheat bran, 45 g molasses, 10 g Nutrifeed, 5.7 g limestone powder and 21 g minerals and vitamins. A mineral and vitamin mixture