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Effect of concentrate level on feeding behavior and rumen and blood parameters in dairy goats: Relationships between behavioral and physiological parameters and effect of between-animal variability

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ABSTRACT

This work aimed first to compare 2 diets differing in their percentage of concentrate [low (LO): 30% concentrate vs. High (HI): 60% concentrate] by measuring simultaneously feeding behavior, rumen parameters, blood and plasma parameters, and milk yield and composition in 8 mid-lactation goats. The second aim was to study the interrelationships between these variables and to analyze the between-animal variability to better understand the between-animal differences in acidosis susceptibility. All of the animals received the 2 diets ad libitum as total mixed ration according to a crossover design of two 4-wk periods. Mean daily DMI was similar between the 2 diets but the variability was higher for the HI than for the LO diet. Goats produced more milk when fed the HI diet compared with the LO diet but with a lower fat:protein ratio (0.81 vs. 0.99). They ate more rapidly the HI than the LO diet but stopped eating sooner after the afternoon feed allowance, and spent less time chewing. The increase in concentrate percentage modified rumen parameters: the pH and acetate:propionate ratio decreased and total VFA, ammonia, and soluble carbohydrate concentrations increased. Hematocrit, plasma NEFA, and blood K and Ca concentrations decreased but glycemia and uremia increased. Other parameters were not modified: milk fat content, blood pH, and bicarbonate and Na concentrations. A large between-animal variability was detected for all the measured parameters, especially for feeding behavior, with important consequences on rumen and blood parameters. This work confirmed the effects of a high percentage of concentrate on feeding behavior, rumen and blood parameters, and milk production, and some known relationships such as the positive link between rumen pH and chewing index. It also pointed out other relationships between parameters seldom measured at the same time, such as rumen redox potential or blood pH and chewing index, or the negative link between blood and rumen pH. When the animals spent a lot of time chewing, they probably produced a lot of saliva that buffered the rumen pH and prevented them from suffering from subacute ruminal acidosis. However, they used part of their blood bicarbonates reserve, which might have induced metabolic acidosis, as rumen and blood pH were inversely related. This could explain why some animals suffer from acidosis and others do not in a herd receiving the same diet, and why some animals seem to suffer more from subacute ruminal acidosis and others from metabolic acidosis.
Key words: dairy goat, percentage of concentrate, feeding behavior, rumen and blood parameters

INTRODUCTION

The effect of increasing the percentage of concentrate on milk production or on digestion has been studied for a long time (Bloom et al., 1957; Kesler and Spahr, 1964). The consequence of this increase on the occurrence of SARA is also well known in dairy cows as stated in some reviews (Nocek, 1997; Owens et al., 1998; Sauvant and Peyraud, 2010) but has seldom been studied in dairy goats (Hadjipanayiotou, 2004; Desnoyers et al., 2009b). However, there is a lack of papers dealing with the relationship between feeding behavior and rumen function (González et al., 2012) and with the consequent outcomes on blood composition and milk production measured in the same animals. The ruminant is a complex organism. A relationship exists between feeding behavior, rumen function, nutrients entering the blood, and nutrients available to the udder for milk production. Feeding behavior and rumen function are interrelated and metabolism is very dependent on what happens in the rumen. Milk production and composition are linked to the blood flow and metabolites arriving in the udder and can be modified when the rumen environment is disturbed, such as in the case of SARA (Nocek, 1997; Owens et al., 1998; Fievez et

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al., 2012). Moreover, the occurrence of ruminal acidosis is dependent on between-animal variability in feeding behavior (Desnoyers et al., 2011).

The aim of this work was first to compare 2 diets differing in their percentage of concentrate in 8 mid-lactation goats fed in a crossover design by measuring simultaneously feeding behavior, rumen parameters, blood and plasma parameters, and milk yield and composition, as data are lacking for goats. The second aim was to study the interrelationships between these variables and to analyze the between-animal variability to better understand the between-animal differences in acidosis susceptibility and the underlying mechanisms preceding acidosis when ruminants are fed a high-concentrate diet.

MATERIALS AND METHODS

Animals

The experiment was based on a crossover design with 8 fistulated goats (3 Alpine and 5 Saanen), in agreement with the French legislation on animal experimentation (code rural: articles R 214-87 to R 214-94) in line with the European Convention for the Protection of Vertebrates used for Experimental and other Scientific Purposes (European Directive 86/609). At the start of the experiment, the animals were in mid lactation and produced 3.1 ± 0.60 kg of raw milk/d. Three goats were in second lactation and the others in third lactation. They were allocated to 1 of 2 groups according to parity (at least 1 second-lactation goat in each group), lactation stage (79 ± 6.5 vs. 79 ± 6.6 DIM), milk yield of the previous year (774 ± 144.8 vs. 781 ± 164.0 kg), and BW at the beginning of the trial (60.1 ± 7.77 vs. 60.3 ± 4.78 kg). The groups were then balanced for these parameters (parity, lactation stage, milk yield of the previous lactation, and BW). They were housed in 1.20 by 0.75-m individual pens throughout the experimental periods with free access to water. The pens were on the same line and each goat had contacts with its neighbors. The diets were alternated to avoid a possible confusion effect between position and diet. Goats walked to the milking parlor twice per day.

Diets and Experimental Design

Two diets were offered successively to the 2 groups of goats in a crossover design of two 28-d periods separated by 3 d of transition diet. The diets differed by the forage:concentrate ratio, which was either 70:30 [low-concentrate diet (**LO**)] or 40:60 [high-concentrate diet (**HI**)]. The LO diet was formulated to sustain the requirements of a lactating goat, and the HI diet comprised twice the concentrate percentage to obtain a big enough difference between the 2 diets to induce SARA. The concentrate part consisted of wheat (20%), barley (20%), oats (20%), soybean meal (35%), vitamin and mineral mixture (3%), and molasses (2%). The concentrate of the LO diet contained twice the vitamin/mineral mixture of the concentrate of the HI diet, because its incorporation was half that of the HI concentrate (Table 1). The roughage was a mixture of chopped grass hay (two-thirds) and ensiled sugar beet pulp (one-third). The LO diet had a lower CP and starch content but a higher cell wall content than the HI diet (Table 1). Energy, nitrogen, and the electrolytic balance values of the diets were calculated according to the additive method from the INRA tables (INRA, 2010). For the energy values, the digestive interactions due to both the feeding level and the concentrate percentage were taken into account (Sauvant and Giger-Reverdin, 2009). Energy and nitrogen values for the LO diet were lower than that of the HI diet but LO and HI diets had similar electrolytic balance.

Each goat received both diets in the course of the experiment. Goats were fed individually ad libitum each diet as a TMR, and quantities of feed offered were adjusted weekly to ensure at least 10% orts. The TMR was offered twice daily after milking, in the proportion of one-third at 0730 h and two-thirds at 1530 h, according to the intervals between milkings. Orts were removed daily around 1330 h.

Measurements and Sampling Scheme

Animals were weighed weekly at 1400 h. They were milked twice per day at 0700 and 1500 h. Orts were measured individually every day to assess the voluntary DMI using the DM percentage of the diet measured on 2 separate days during each 28-d period. Dry matter intake was expressed on a BW basis using the BW measured during the previous week. As off-feed periods and irregularities in DMI are considered to be a sign of SARA, decreases in DMI between 2 consecutive days greater than 10 g/kg of BW were counted (Desnoyers et al., 2009b) during the last 21 d of each period (d 8 to 28).

Dry matter intake was recorded continuously during 2 consecutive days of each period using a weighing-scale manufactured by Baléa SA (Saint-Mathieu-de-Tréviers, France) fitted under the feed. This system recorded every 4 min the weight of the feed contained in the trough with a precision of 5 g and allowed simultaneous recording for 4 goats (d 17, 18, 24, and 25 for one subgroup of goats and d 19, 20, 26, and 27 for the second subgroup). Measurements began with the afternoon feed allowance and ended 22 h later, at the removal of orts.