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Influence of Extruded Soybeans With or Without Bicarbonate on Milk Performance and Fatty Acid Composition of Goat Milk

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ABSTRACT

The effects of extruded soybeans (ESB) included at 0, 10, or 20% of dry matter (DM) of the diet in combination with sodium bicarbonate (0 vs. 1% bicarbonate added to DM) on rumen fermentation characteristics, production parameters, and fatty acid (FA) profiles of milk fat were examined in 30 midlactation goats and 6 rumen-cannulated goats fed high-concentrate diets (30:70 forage-to-concentrate ratio) ad libitum in a 3 × 2 factorial design. Diets were fed as total mixed rations. The trial lasted 13 wk with the final 9 wk as the test period. Milk yield and composition were recorded each week throughout the trial. Individual samples of milk were taken in wk 4, 7, 10, 11, and 13 to determine FA profile of milk fat. Dry matter intake and intake of net energy for lactation were not affected by dietary treatments. Feeding ESB did not modify ruminal pH or volatile fatty acids concentration in the rumen fluid, but it increased the molar proportion of propionate. Feeding ESB increased fat-corrected milk, milk fat content, and fat yield compared with the control diets. There was no change in milk protein content when ESB were fed. Feeding ESB increased the proportions of oleic, linoleic, and linolenic acids in milk fat at the expense of most of the saturated FA. It also increased the n-6 to n-3 FA ratio of milk. The largest changes in milk yield and milk composition were generally obtained with ESB included at 20% of DM. The addition of sodium bicarbonate tended to increase ruminal pH, VFA concentrations in the rumen fluid, and the molar proportions of acetate. The addition of sodium bicarbonate increased milk fat content and fat yield, with no change in milk FA composition. It is concluded that during midlactation, the inclusion of ESB to 20% of DM prevented low milk fat content for goats fed high-concentrate diets, with no decrease in milk protein content. The addition of sodium bicarbonate may enhance the effects of ESB on milk fat content and fat yield.

(**Key words:** milk fatty acids, bicarbonate, extruded soybean, goat)

Abbreviation key: ESB = extruded soybeans, **FA** = fatty acids.

INTRODUCTION

In Europe, the popularity of dairy products from goats increased during the last 20 yr because of their nutritional value and a more favorable perception than dairy products from cows. Most dairy products from goats are cheese, in which quality is influenced by milk fat and protein contents (Brown et al., 1995). However, farmers face problems of low milk fat content (Morand-Fehr et al., 2000), which is related to the feeding of high-concentrate diets (Calderon et al., 1984; Santini et al., 1992). With high-concentrate diets, the fatty acids (**FA**) profile of milk fat from goats is altered: the proportions of medium-chain saturated FA (especially capric and lauric acids), long-chain saturated FA, and *cis*-C18:1 are reduced (Calderon et al., 1984; Ledoux et al., 2002). Simultaneously, the proportions of *trans*-C18:1 and linoleic acid in milk fat increase, with conflicting results for linolenic acid (Calderon et al., 1984; Ledoux et al., 2002). Similar results are obtained with high-concentrate diets fed to dairy cows (reduction of milk fat content, increase in *trans*-C18:1 fatty acids in milk). These effects may be reduced by adding a buffer (Kennelly et al., 1999; Khorasani and Kennelly, 2001) that modifies the extent of biohydrogenation of dietary polyunsaturated FA in the rumen (Kalscheur et al., 1997). In dairy goats, the addition of sodium bicarbonate to the diet reduces the milk fat depression associated with high-concentrate diets (Hadjipanayiotou, 1982, 1988) but no effect on the milk FA profile is reported.

In dairy cows, milk fat content and FA profile of milk fat may be altered by the addition of lipids to the diet (Chilliard et al., 2000). When full-fat or extruded soybeans (**ESB**) are fed, the milk fat content and the proportions of lauric, myristic, and palmitic acids are reduced, whereas the proportions of linoleic and linolenic acids are increased (Dhiman et al., 1999; Abu-Gazalleh et al., 2002; Whitlock et al., 2002). In goats, data ob-

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tained from adding oilseeds or oil from oilseeds are scarce (Daccord, 1987; Baldi et al., 1992; Gulati et al., 1997), and goats respond quite differently to lipid supplementation than do cows (Schmidely and Sauvant, 2001; Chilliard et al., 2003). Moreover, the effect of ESB inclusion in the diet on FA profile of milk fat has been poorly documented (Chilliard et al., 2003).

Consequently, this study investigated the effects of different levels of ESB in the diet (with or without sodium bicarbonate) on milk yield and composition, the proportions of FA in milk fat, and the rumen fermentation characteristics in midlactation goats. Parts of these results have been previously published (Schmidely et al., 2001).

MATERIALS AND METHODS

Goats and Diets

Thirty-six Alpine or Saanen multiparous goats (20 Alpine, 16 Saanen), 6 of which were fitted with rumen cannulas, were used for 13 wk from 90 ± 15 DIM. The first 4 wk were for adaptation to the experimental diets, and the final 9 wk were used as the test period. The goats were housed individually in 2- × 1-m shaded pens with wooden floors and they had free access to water and to a trace-mineralized salt block. They were machine-milked twice daily (0700 and 1600 h). Milk yield, milk fat content, and milk protein content were recorded on 2 consecutive days each week throughout the trial. Samples from 2 consecutive (a.m. and p.m.) milkings were taken in wk 4, 7, 10, 11, and 13 for the determination of FA profile of milk fat. Once weekly, the goats were weighed at 1400 h.

All diets were fed twice daily in 2 equal meals (0800 and 1700 h) to achieve ad libitum intake; orts always represented more than 5% of distributed feed. The amount of feed distributed and orts were recorded daily. During the first 2 wk of the trial, the goats were fed a control diet as TMR, consisting of 30% dehydrated alfalfa pellets (DM basis), 20% sugar beet pulp silage, and 50% concentrate (50:50 mixture of barley and soybean meal). For the next 2 wk, the goats were gradually introduced to 1 of 6 experimental diets by mixing the control and the experimental diet at 80:20 on d 1, at 60:40 on d 3, at 40:60 on d 6, at 20:80 on d 8, and at 0:100 on d 10.

The 6 experimental diets fed as TMR contained dehydrated alfalfa pellets, sugar beet pulp silage, and an experimental concentrate (Table 1) in similar proportions as in the diet fed in the first 2 wk. The concentrates were formulated by a factorial combination of 2 levels of sodium bicarbonate (0 vs. 1% bicarbonate added in the DM of the TMR) and 3 levels of inclusion of ESB (0 vs. 10 vs. 20% of DM in the TMR) in substitution of soybean meal and part of soybean hulls. The substitution was calculated to maintain approximately the same protein content in the 6 diets. Full-fat soybeans were purchased locally and they were dry-extruded in an experimental extruder at the CETIOM (Center d'Etudes Technique pour les Oléagineux Métropolitains, CREOL, Pessac, France). The flux of extrusion was 225 kg/h with a maximal measured temperature of 100°C.

The 30 uncannulated and the 6 cannulated goats were randomly assigned to the 6 experimental diets. At the end of the trial (wk 13), rumen fluid samples were collected before and 1, 2, and 3 h after morning feeding. The pH of the ruminal fluid was determined using a glass electrode pH meter after straining through cheesecloth. An aliquot of 1 mL of ruminal fluid was mixed with 1 mL of distilled water and 0.1 mL of $HgCl_2$ (5%, wt/vol) was thoroughly shaken, and frozen at –20°C for later analysis of VFA. A second 1-mL aliquot was mixed with 0.1 mL of $HgCl_2$ and 5 mL of trichloracetic acid, (2.5% wt/vol) shaken, and frozen to -20°C for subsequent analysis of ammonia.

Sampling Procedures and Chemical Analysis

Representative samples of diets and orts were collected 4, 8, and 12 wk after the start of the trial and frozen for analysis. Samples (100 g) of diets and orts were used to determine DM and ash content (only for diets) in duplicate. Samples of diets (1 g) were used for the determination of N and ether extract contents in duplicate, and for NDF and ADF content in triplicate. The DM content of diets and orts was measured by 72-h freeze-drying to a constant weight. The OM content of diets was obtained after ashing at 550°C for 12 h. The NDF and ADF contents were determined according to the method of Van Soest et al. (1991). Total N of diets was determined by the microKjeldahl technique. Ether extract of diets was determined using petroleum ether (Soxtec, 1043 Extraction Unit, Tecator, France). For each diet, the FA composition was calculated using published values of the FA profile of each ingredient (INRA-AFZ, 2002). The daily intake of each FA was then calculated by goat, by multiplying daily DMI by the proportion of each FA in the DM.

The ruminal ammonia concentration was determined as described by Wheatherburn (1967) using an Autoanalyzer (Technicon, France). The ruminal VFA concentrations were analyzed by gas chromatography (Variant 3400, Les Ulis, France), with a 2-m glass column packed with SP 1200 (10%) + 1% H_3PO_4 on Chromosorb W AW (80/100 mesh) (Supelco, Bellefonte, PA) as described by Kristensen et al. (2000).

Milk fat and protein were determined by near infrared analysis (Milkoscan; Foss Electric, Hillerød, Den-