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Subacute ruminal acidosis challenge changed in situ degradability of feedstuffs in dairy goats

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ABSTRACT

This study investigated the effects of wheat-induced subacute ruminal acidosis (SARA) on rumen bacterial populations and in situ degradabilities of NDF, starch, and crude protein of feeds. Four multiparous dairy goats (BW = 60 ± 3.3 kg) fitted with ruminal cannulas were assigned to a 2 × 2 crossover design (28-d treatment periods separated by a 7-d washout interval). The treatment diets consisted of 2 levels of cracked wheat: 0 (control, corn based concentrate) and 35% (diet-induced SARA, wheat-based concentrate), with a constant forage- (45% alfalfa hay and 5% corn silage of DM) to-concentrate (50% of DM) ratio. Results indicate that diets with a 35% wheat decreased ruminal pH (6.21 vs. 5.98) and increased the duration (1.13 vs. 4.72 h/d) and area (0.12 vs. 0.78 pH × h/d) of ruminal pH below 5.6 and induced SARA. The SARA increased ruminal total volatile fatty acid concentration, from 105.0 to 123.8 m*M*, and decreased the acetate molar proportion (62.8 vs. 56.6 mol/100 mol) and the acetate-to-propionate ratio (3.5 vs. 2.8). Compared with the control group, SARA decreases the relative abundance of *Fibrobacter succinogenes* (−59.3%) and *Ruminococcus flavefaciens* (−68.4%), whereas it increased *Succinimonas amylolytica* (198.1%) and *Ruminobacter amylophilus* (125.2%). The SARA decreased 24- and 48-h dry matter (DM) and neutral detergent fiber (NDF) degradabilities of corn silage. The 48-h degradabilities of DM (51.0 vs. 48.2%) and NDF (40.3 vs. 36.0%) in alfalfa hay were not affected by SARA, but the SARA tended to reduce the 24-h DM (49.6 vs. 46.3%) and NDF (37.8 vs. 33.2%) degradabilities. The effective ruminal degradabilities of DM and NDF in alfalfa hay and corn silage were reduced during SARA. In situ degradability parameters of DM and starch of wheat were not affected by SARA, but starch degradability of corn (9.5 vs. 13.3%/h) increased. The SARA reduced in situ 12-h degradabilities of DM and crude protein of soybean meal and extruded soybean without affecting the degradabilities of the other protein supplements (corn gluten meal, cottonseed meal, corn dried distillers grains with solubles, rapeseed meal, and wheat germ meal). These results indicated that the cracked wheat-induced SARA reduced the degradation of NDF in roughages and that of protein in soybean meal (−19.8%) and extruded soy (−18.9%) and increased the starch degradability in corn, due to the increased amylolytic bacteria and decreased cellulolytic bacteria counts in the rumen.

Key words: in situ degradation, protein, starch, subacute ruminal acidosis

INTRODUCTION

Subacute ruminal acidosis is characterized by a long duration of low ruminal pH (pH <5.6 for more than 3 h/d; Gozho et al., 2005), and approximately 20% of high-yielding dairy herds experience SARA (Kleen and Cannizzo, 2012). Subacute ruminal acidosis reduces cellulolytic bacteria counts because of undesirable ruminal pH (<5.8; Russell and Wilson, 1996), resulting in low fiber degradation. Plaizier et al. (2001) observed that SARA reduced in situ 48-h DM (−7%) and NDF (−22%) degradabilities of mixed hay in dairy cows. Several studies reported that ruminants fed highly fermentable carbohydrate diets stimulated the proliferation of ruminal amylolytic bacteria (Goad et al., 1998; Fernando et al., 2010; Petri et al., 2012). With the possible exception of the main cellulolytic species (*Fibrobacter succinogenes*, *Ruminococcus albus*, and *Ruminococcus flavefaciens*), most rumen microorganisms (e.g., *Butyrivibrio fibrisolvens*, *Bacteroides amylophilus*, and *Bacteroides ruminicola*) are proteolytic (Hobson et al., 1982; Wallace, 1996), and ruminants consuming high-grain diets increased proteolytic activity (Furchtenicht and Broderick, 1987; Hristov et al., 2002). In contrast, Rotger et al. (2006) reported that the dietary forage-to-concentrate ratio had no effect on in situ CP degradation kinetics of 7 plant protein supplements in heifers.

The rate and extent of nutrient (starch, protein, and fiber) degradation in the rumen mainly depends on the complex enzymes system (polysaccharide and proteolytic enzymes) of ruminal microbiota and the struc-

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ture of substrates (McAllister et al., 1994; Wang and McAllister 2002; Bach et al., 2005). Factors affecting fiber degradation during SARA have been well studied (Krajcarski-Hunt et al. 2002; Plaizier et al. 2008). However, the interactions between the ruminal amylolytic and cellulolytic bacteria on starch and protein degradation were seldom estimated in the current feed evaluation systems (Bannink and Tamminga, 2005). Data on the effect of SARA on the degradation of starch and protein in the rumen is limited. Therefore, it was hypothesized that SARA might affect the rumen degradation of fiber, starch, and protein in feeds by changing the ruminal bacteria population (increase in amylolytic species and decrease in cellulolytic species). The objective of the current study was to estimate the effect of wheat-induced SARA on ruminal amylolytic and cellulolytic species, and in situ degradability of NDF (in roughages), starch (in grains), and CP (protein supplements) in dairy goats.

MATERIALS AND METHODS

Animals, Diets, and Experimental Design

All experimental procedures were approved by the Northwest A&F University Animal Care and Use Committee of P. R. China. Four multiparous Xinong Saanen dairy goats (BW = 60 ± 3.3 kg) fitted with ruminal cannulas were randomly divided into 2 groups (each with 2 goats) according to a 2 × 2 crossover design. Treatment diets consisted of 2 levels of cracked wheat: 0 (1; control) and 35% (2; diet-induced SARA) of dietary DM (Table 1). Goats in group 1 received the control diet and goats in group 2 received the SARA diet in period 1. Goats switched diets in the second period after a 7-d washout period during which all goats were fed the control diet to avoid carryover effects of the SARA diet. Contents of starch and CP in the diet were similar between the treatments. Diets were composed of alfalfa hay (45% of DM), corn silage (5% of DM), and concentrate (50% of DM). Each experimental period lasted for 28 d, with 18 d for adaptation to the diet and 10 d for sample collection, in situ degradation assay, and pH measurements. Goats were housed in individual metabolism cages (1.5 × 0.7 m) and fed twice daily, at 0700 and 1900 h, on an ad libitum basis (allowing for 5–10% orts) with free access to fresh water throughout the experiment.

Sample Collection and pH Measurement

Ruminal pH was continuously monitored for 24 h, from 0700 h on d 19 to 0700 h to d 20. The ruminal pH was measured using an industrial electrode linked to a pH transmitter and a data logger was used to record data as described in detail by Zhao et al. (2011). Data of ruminal pH were measured at 30-s intervals and averaged every 5 min. The data were summarized across 24 h for each goat as mean, area (time × pH), and time under pH 5.8 or 5.6.

Approximately 100 mL of ruminal fluid was obtained of each goat from the ventral rumen sac at 0700 (before feed delivery), 1000, 1300, 1600, and 1900 h on d 20 and strained through 2-layer cheesecloth. Four milliliters of filtrate were mixed with 1 mL of 25% (wt/vol) metaphosphoric acid and stored at −40°C for analysis of VFA. To extract microbial genomic DNA, samples of rumen content (about 200 g) of each goat were also obtained at each sample time and stored at −80°C.

In Situ Degradation Procedure

Feedstuffs for in situ incubation were dried at 60°C for 48 h and grounded through a 2-mm screen. The chemical composition of the test feeds is presented in Table 2. A portion of each feedstuff (2 g for roughage, 4 g for grain, and 5 g for protein supplement) was weighed into respective nylon bags (7 × 10 cm, 53-μm pore size) and sealed by suture. Bags were soaked in warm water (39°C) for 10 min before being inserted into the rumen. In situ degradation was sequentially determined in roughages (alfalfa hay and corn silage),

Table 1. Ingredients and composition of the diets

Item, % of DM	Control	Subacute ruminal acidosis
Ingredient		
Alfalfa hay	45	45
Corn silage	5	5
Corn	40	7
Wheat	—	35
Wheat bran	—	4.25
Soybean meal	7.5	0.75
Calcium phosphate	0.25	0.25
Limestone	0.75	0.75
Corn oil	—	1
Urea	0.5	—
Salt	0.5	0.5
Vitamin-mineral mix[1]	0.5	0.5
Nutrient composition		
DM	85.7	87.1
NDF	34.3	35.7
ADF	21.7	22.3
Forage NDF	28.5	28.5
CP	15.2	15.3
Starch	28.9	29.2

[1]Vitamin-mineral mix (per kilogram, DP104, Wangduofu Biotech Co. Ltd., Yangling, China): 1,000 mg of nicotinic acid, 800 mg of Mn, 1,800 mg of Zn, 2,200 mg of Fe, 370 mg of Cu, 30 mg of Se, 30 mg of I, 50 mg of Co, 6,500 IU of vitamin E, 4,500 IU of vitamin D_3, and 200,000 IU of vitamin A.