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Effects of energy supplementation in pasture forages on in vitro ruminal fermentation characteristics in continuous cultures[1]

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ABSTRACT

A dual-flow, continuous-culture system was used to assess the effects of energy supplementation with 4 pasture forages on in vitro ruminal fermentation characteristics. Twelve dietary treatments were tested in a split-plot design: energy supplementation (no concentrate, 30% ground corn, or 30% dried distilled grains with solubles) as a whole plot and pasture forages [tall fescue (TF) without N fertilizer, TF with N fertilizer (TF+NF), TF-alfalfa mixture, and TF-birdsfoot trefoil mixture (TF+BFT)] as a subplot. Three replicated runs lasted 9 d each, with 7 d for adaptation period and 2 d for data collection. The greatest total VFA and propionate concentrations ($P < 0.01$) were detected when corn was supplemented. Supplementing corn in the TF+BFT increased total VFA and propionate concentration ($P < 0.05$). Greater concentrations of acetate and propionate were found in the TF+NF ($P < 0.01$), but no effects were detected among other pasture forages. Energy supplementation decreased acetate:propionate ratio across pasture forages, and corn supplementation in the TF+NF resulted in the lowest ratio ($P < 0.01$). Lower ammonia-N and methane concentrations ($P < 0.01$) were achieved due to energy supplementation, in particular when corn grain was supplemented. Feeding the TF+NF or the TF+BFT elicited similar ammonia-N:VFA ratios with no energy or corn supplementation, which indicates that the TF+BFT was effectively fermented in cultures, resulting in similar efficiency of ruminal fermentation compared with the TF+NF. Data from this experiment imply that interseeding birdsfoot trefoil with TF may be a suitable sward to establish in a grazing experiment to further evaluate ruminal fermentation, nutrient utilization efficiency, and performance of grazing cattle.

Key words: continuous culture, energy supplementation, in vitro fermentation, pasture forage

INTRODUCTION

Finishing steers in a forage-based system has been extensively studied over the years as an alternative to high-grain finishing diets (Duckett et al., 2009; Noviandi et al., 2012). However, cattle consuming diets solely composed of forages are often unable to meet desired levels of production. The main challenge of high-quality forage-fed beef production is the lack of energy and low N-utilization efficiency in the rumen (Noviandi et al.,

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2012). For example, Noviandi et al. (2012) reported as the grazing season progressed, the nonfiber carbohydrate (**NFC**) concentration of pasture forages decreased, causing increased ruminal ammonia-N (NH_3-N) concentration in grazing steers. The increased ruminal NH_3-N concentration may reflect reduced ruminal capture of CP for microbial protein synthesis due to the lack of carbohydrates in the rumen. Fieser and Vanzant (2004) stated that supplementing energy in forage-based steer diets can improve N utilization efficiency. In addition, energy supplementation in a forage diet also improved feed utilization by increasing ruminal propionate proportion, decreasing acetate:propionate (**A:P**) ratio, and reducing methane (CH_4) production by the providing readily fermentable energy sources for microbes (Reis et al., 2001; Vibart et al., 2010).

Energy supplementation in forage-based diets has been typically accomplished with corn grain (Pavan and Duckett, 2008; Duckett et al., 2009). For instance, corn grain supplementation on steers grazing tall fescue (**TF**; *Schedonorus arundinaceus* Schreb.) increased ADG, carcass weight, and subcutaneous fat thickness (Pavan and Duckett, 2008). However, feeding starch-based energy supplements, such as corn grain, typically causes depressions in forage intake and negative associative effects on fiber digestibility (Pordomingo et al., 1991). Although low in starch, dried distillers grains with solubles (**DDGS**) is high in digestible fiber and contains 11 to 12% fat (Lodge et al., 1997). Therefore, DDGS may be a viable source of supplemental energy to forage-based ruminant diets. The objective of this experiment was to test a hypothesis that supplementation of corn grain or DDGS in grass monocultures [TF without (**TF−NF**) or with (**TF+NF**) N fertilizer] and grass–legume mixtures with low-condensed tannins (**CT**; TF and alfalfa) and high-CT (TF and birdsfoot trefoil) would improve ruminal fermentation by increased N utilization and decreased CH_4 production in continuous cultures.

MATERIALS AND METHODS

Pasture Forage Harvest and Dietary Treatments

Pasture forages used in this experiment were TF−NF, TF+NF, TF-alfalfa mixture (**TF+ALF**), and TF-birdsfoot trefoil (*Lotus corniculatus* L.) mixture (**TF+BFT**). The forages were planted in a randomized complete block design with 4 replications on August 4, 2010, at the Utah State University Agricultural Experiment Station Intermountain Irrigated Pasture Project Farm (Lewiston, UT). Irrigation was used for establishment and during the growing season. Nitrogen fertilizer was applied to the TF+NF at 134 kg of N/ha in 3 equal applications during the growing season (April 19, July 8, and August 8, 2011). Forages used in this experiment were harvested on July 8, 2011. Plots were harvested to a height of 8 cm with a sickle bar harvester (Swift Machine & Welding LTD, Swift Current, SK, Canada). This was the second harvest of the season, and therefore the TF was in the vegetative stage, whereas the BFT was at approximately 5% bloom and the alfalfa late bud to 1% bloom. Forage samples were placed in sealed plastic bags, immediately cooled, and transported to the laboratory to be frozen at −40°C. Pasture forage samples for dietary treatments were freeze-dried (FreeZone 12 L Freeze Dry Systems, Labconco Corp., Kansas City, MO) and then ground to pass a 4.0-mm screen (Wiley mill, Standard Model 4; Arthur H. Thomas Co., Swedesboro, NJ).

One control (no energy supplementation) and 2 types of energy supplement (30% DM corn grain or 30% DM DDGS) were combined with 4 types of pasture forage (TF−NF, TF+NF, TF+ALF, or TF+BFT) resulting in 12 dietary treatments. The corn grain used in this experiment contained 10.4% CP, 9.12% NDF, 3.14% ADF, 73.5% starch, and 4.43% ether extract (**EE**), whereas the DDGS contained 28.4% CP, 34.3% NDF, 11.3% ADF, 3.55% starch, and 12.4% EE on a DM basis. The corn grain and the DDGS were ground to pass a 4.0-mm screen in a Wiley mill to be supplemented in the pasture forages. A subsample of each dietary treatment was pooled, ground to pass a 1.0-mm screen in a Wiley mill, and stored in room temperature until nutritive-value analysis.

Continuous-Culture Operation, Feeding Schedule, and Experimental Design

Rumen inoculum was taken from 3 ruminally fistulated beef cows fed a forage diet of alfalfa and TF hay for ad libitum DMI. Care, handling, and sampling of the donor cows were approved by the Utah State University Institutional Animal Care and Use Committee.

Ruminal contents (mixture of liquid and particle) were obtained from various locations within the rumen, placed in a preheated insulated container, and transported to the laboratory. Then, ruminal fluid was strained through polyester material (PeCAP, pore size of 355 μm; B & SH Thompson, Ville Mont-Royal, QC, Canada) and mixed before added into fermentors. Approximately 700 mL of strained ruminal fluid was added to each of 8 continuous-culture fermentors.

A dual-flow, continuous-culture system based on Teather and Sauer (1988) was used, and it consisted of 1-L gastight fermentor vessels (Prism Research Glass Inc., Research Triangle Park, NC). The design of the fermentors and operation of the continuous cultures were described by Williams et al. (2011). Briefly, anaerobic condition in the fermentors was ensured by maintaining a constant flow of 20 mL of CO_2/min. Artificial saliva (Slyter et al., 1966) was delivered at a rate of 0.78 mL/min using a pump (Model 323, Watson-Marlow Inc., Wilmington, MA) to maintain