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# Effect of supplementing orchardgrass herbage with a total mixed ration or flaxseed on fermentation profile and bacterial protein synthesis in continuous culture

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## ABSTRACT

A 4-unit dual-flow continuous culture fermentor system was used to evaluate the effects of supplementing fresh herbage with a total mixed ration (TMR) or flaxseed on nutrient digestibility, fermentation profile, and bacterial N synthesis. Diets were randomly assigned to fermentors in a 4 × 4 Latin square design. Each fermentor was fed a total of 70 g of dry matter/d of 1 of 4 diets: (1) 100% freeze-dried orchardgrass herbage (*Dactylis glomerata* L.; HERB), (2) 100% freeze-dried TMR (100TMR), (3) 50% orchardgrass herbage supplemented with 50% TMR (50TMR), or (4) 90% orchardgrass herbage supplemented with 10% ground flaxseed (*Linum usitatissimum* L.; FLAX). Preplanned, single degree of freedom orthogonal contrasts were constructed to assess the effects of feeding system (HERB vs. 100TMR), herbage supplementation (HERB vs. 50TMR + FLAX), and herbage supplemental source (50TMR vs. FLAX). Compared with the HERB diet, the 100TMR diet significantly reduced apparent digestibility of neutral detergent fiber. Herbage supplementation with 50TMR or FLAX significantly reduced or tended to reduce apparent digestibilities of dry matter, organic matter, and neutral detergent fiber, suggesting that replacing high-quality, highly digestible fresh herbage with forage TMR likely caused depressions in nutrient digestibilities. Concentration of total volatile fatty acids, molar proportions of acetate, propionate, and isovalerate, as well as the acetate:propionate ratios were all significantly higher in fermentors fed 100TMR compared with HERB, likely in response to enhanced supply of fermentable energy. In general, feeding system, herbage supplementation, and type of supplementation did not affect N metabolism in the present study. The few significant changes in N metabolism (e.g., flows of total N and non-$NH_3$-N) were primarily linked to increased fermentor N supply with feeding herbage-based diets (HERB and FLAX). Although TMR-based diets decreased nutrient digestibility slightly, TMR offered advantages in bacterial fermentation in relation to volatile fatty acid production, which could potentially translate into better animal performance. Flaxseed shows promise as an alternative supplement for herbage-based diets; however, further in vivo evaluation is needed to determine the optimal level to optimize animal production while reducing feed costs.
**Key words:** flaxseed, herbage, in vitro fermentation, total mixed ration

## INTRODUCTION

In general, dairy cows that are fed a nutritionally balanced TMR usually experience a significant decline in milk production when transitioned to herbage-based diets (Bargo et al., 2002a; White et al., 2002). One of the primary reasons for explaining this reduction in milk production is the low energy density found in most temperate pastures, which comprise primarily cool-season grasses (Bargo et al., 2002a). Therefore, many dairy farmers feeding herbage during the grazing season (April to October in the northeastern United States) also use TMR containing alfalfa haylage or corn silage in addition to concentrate as a major supplemental source. In fact, the use of TMR can boost not only energy to support high milk production, but also effective fiber, yielding a more stable ruminal environment (Bargo et al., 2002b; Soder and Muller, 2007). More recently, interest has increased in supplementing herbage-based diets strictly with a single energy source such as corn meal or molasses (Ross et al., 2011) or flaxseed (Scholljegerdes and Kronberg, 2010; Soder et al., 2012). Although corn has been the most popular energy source fed on northeastern dairy farms, escalating prices due to the shift of corn use from animal feeding to ethanol production have prompted dairy farmers to seek alternative sources of supplemental energy.

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Flaxseed is an oilseed rich in the n-3 FA α-linolenic acid (Ambrose et al., 2006), which is known to be transferred to milk (Caroprese et al., 2010) and meat (Kronberg et al., 2011), resulting in improved human health (Zachut et al., 2010). Flaxseed is also available in organically certified form in the Northeast, and has been gaining interest as a potential alternative energy source to corn for certified organic dairy farms. We recently demonstrated that whereas nutrient digestibility (DM, OM, and NDF) and methane emissions decreased, molar proportions of acetate and propionate increased by replacing orchardgrass herbage with incremental levels (0, 5, 10, or 15% of the total diet DM) of ground flaxseed in a dual-flow continuous-culture fermentor system (Soder et al., 2012). Conversely, Scholljegerdes and Kronberg (2010), supplementing ground flaxseed at 0.18% of BW on a DM basis to beef cattle grazing summer native rangelands on the northern Great Plains, reported no changes in ruminal NDF digestibility and molar proportion of propionate compared with the herbage-only diet or to herbage plus a corn/soybean meal-based concentrate. Despite these recent reports (Scholljegerdes and Kronberg, 2010; Soder et al., 2012), there is still limited in vitro or in vivo scientific information regarding the effect of supplementing herbage-based diets with TMR on ruminal fermentation and bacterial N synthesis. Soder and Muller (2007) reported increased interest by graziers in incorporating a TMR into an herbage-based diet; however, little nutritional guidance was available on reformulating the TMR for optimal ruminal fermentation and animal performance. Vibart et al. (2008, 2010) reported improved ruminal fermentation (Vibart et al., 2010) and lactational performance (Vibart et al., 2008) in diets with a greater proportion of herbage than TMR. Bargo et al. (2002b) reported that supplementing herbage with TMR depressed ruminal proteolysis in lactating dairy cows grazing mixed grass species but depressed ruminal nutrient digestion was also observed. Gregorini et al. (2010) found that supplementing corn silage 9 h as opposed to 1 h before feeding an herbage diet improved N utilization and VFA profiles in continuous-culture fermentation.

As stated above, a handful of studies exist that compare an herbage diet with TMR, supplementing herbage with TMR, and 1 in vitro study that evaluated flaxseed supplementation of an herbage diet. However, we are not aware of studies that directly compare the effects of TMR compared with flaxseed as supplemental feed sources in herbage-based diets. Therefore, the objectives of this study were to evaluate the effects of supplementing an herbage diet with TMR or flaxseed on nutrient digestibility, fermentation profile, and bacterial N synthesis during continuous-culture fermentation. Compared with an all-herbage diet, we hypothesize that partially replacing herbage with TMR or ground flaxseed will increase energy capture by bacteria, thus improving both bacterial protein synthesis and overall fermentation characteristics in a dual-flow continuous-culture fermentor system.

## MATERIALS AND METHODS

### *Experimental Design and Diets*

This study was conducted at the US Department of Agriculture-Agricultural Research Service Pasture Systems and Watershed Management Research Unit (University Park, PA) from July to September 2011. Orchardgrass herbage was harvested on May 5, 2011, in the afternoon at the Russell Larson Agricultural Research Farm (Rock Springs, PA) from a pure stand with a forage plot harvester (HEGE 212; Wintersteiger AG, Waldenburg, Germany; 1.5-m-wide swath) at 10 cm above soil level, approximately 3 wk after the previous cutting so that herbage was in a vegetative stage of growth typical of high-quality herbage (25 to 30 cm tall). Within 30 min of harvest, the herbage was placed in cloth bags and frozen (−4°C) until being freeze dried (Ultra 35 Super ES; Virtis Co. Inc., Gardiner, NY) and ground (Wiley mill; Thomson Scientific Inc., Philadelphia, PA; 2-mm screen). The TMR was collected on April 26, 2011, from The Pennsylvania State University (University Park) dairy barn (Table 1), freeze dried, and ground as done with herbage. The TMR consisted of a forage:concentrate ratio of 69:31 and was typical of a TMR fed in central Pennsylvania to moderate-producing dairy cows. Whole, certified organic, brown flaxseed (United Natural Foods Inc., Dayville, CT; product of Canada) was ground in small batches before each period (2-mm screen) and stored in the refrigerator before and after grinding to minimize oxidation of lipids.

Each fermentor was fed a total of 70 g of DM/d of 1 of 4 diets (Table 2): (1) 100% freeze-dried orchardgrass herbage (**HERB**), (2) 100% freeze-dried TMR (**100TMR**), (3) 50% orchardgrass herbage supplemented with 50% TMR (**50TMR**), or (4) 90% orchardgrass herbage supplemented with 10% ground flaxseed (**FLAX**). We chose to supplement herbage with 50% TMR to yield a relatively similar proportion of forage:concentrate ratio between the 2 herbage-supplemented diets (50TMR and FLAX). In fact, the forage:concentrate ratios averaged 84:16 and 90:10 for 50TMR and FLAX diets, respectively. The proportion of ground flaxseed (10% of total diet DM) fed in the current study was chosen based on our previous experiment (Soder et al., 2012), in which no major differences