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Effect of forage level and replacing canola meal with dry distillers grains with solubles in precision-fed heifer diets: Digestibility and rumen fermentation

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ABSTRACT

Objectives of this study were to determine the effects of feeding differing forage-to-concentrate ratios (F:C) and inclusion rates of corn dry distillers grain with solubles (DDGS) on digestion and rumen fermentation in precision-fed dairy heifer rations. A split-plot design with F:C as whole plot and DDGS inclusion level as sub-plot was administered in a 4-period (19 d) 4 × 4 Latin square. Eight rumen-cannulated Holstein heifers (12.5 ± 0.5 mo of age and 344 ± 15 kg of body weight) housed in individual stalls were allocated to 2 F:C [50:50, low forage, or 75:25 high forage; dry matter (DM) basis] and to a sequence of DDGS inclusion (0, 7, 14, and 21%; DM basis). Forage was a mix of 50% corn silage and 50% grass hay (DM basis). Diets were fed to allow for 800 g/d of body weight gain and fed 1×/d. Rumen contents were sampled at –2, 0, 2, 4, 6, 8, 10, 12, and 20 h after feeding for rumen fermentation measures. Low-forage rations had greater DM and organic matter apparent digestibility. We detected a quadratic effect for DM, organic matter, acid detergent fiber, and neutral detergent fiber apparent digestibility, with the 14% DDGS inclusion level having the highest values. Nitrogen retention decreased with increasing levels of DDGS. Molar proportions of acetate tended to be greater for HF and decreased as DDGS increased; propionate increased as DDGS increased, resulting in the opposite effect on acetate to propionate ratio. Rumen protozoa count decreased as DDGS increased. Moderate levels (14% of DM) of DDGS appear to enhance nutrient utilization and fermentation in precision-fed dairy heifers fed different F:C diets.

Key words: precision feeding, canola meal, dried distillers grains with solubles, heifer diet

INTRODUCTION

Improvements in dairy heifer growth and nutrition programs have resulted in an increase in efficiency through various strategies. One of the strategies to reduce feed cost and increase efficiency is to limit DMI (McLeod and Baldwin, 2000). Controlling DMI increases nutrient efficiency mainly because metabolic nutrient costs of digestion are lower when nutrient amounts are precisely supplied in heifer diets (Zanton and Heinrichs, 2007; Lascano and Heinrichs, 2011). Precision-feeding programs provide the heifer with the amount of nutrients necessary to reach the targeted ADG. Following these results, enhancement in nutrient utilization through manipulation of other nutrient fractions such as fiber, nonstructural carbohydrates, and protein have yielded results that contribute to precision-feeding programs in dairy heifers (Zanton and Heinrichs, 2008; Lascano and Heinrichs, 2011; Lascano et al., 2012). To further increase efficiency and reduce feed costs, a viable option is the inclusion of alternative ingredients and by-products such as canola meal and dry distillers grains (**DDGS**) to the aforementioned programs.

Using canola meal and DDGS as a protein supplement to replace soybean meal has yielded similar lactation performance in dairy cows (Christen et al., 2010). Both of these ingredients have been minimally investigated under precision-feeding scenarios for dairy heifers. High concentrations of DDGS have been successfully incorporated for growing feedlot cattle rations (Klopfenstein et al., 2008). Although research with feedlot animals is valuable, the objectives are very different compared with those for replacement dairy heifers. Dairy heifer growth needs to be controlled (NRC, 2001; Zanton and Heinrichs, 2009b), whereas feedlot programs target maximum growth in minimum time. Maximal DMI, ADG, and final BW in feedlot finishing diets have been reported with 15% DM inclusion of DDGS (Depenbusch et al., 2009a). However, similar DDGS inclusion levels in research from the same group

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did not improve ADF or feed efficiency (Depenbusch et al., 2008, 2009b) and reduced DM apparent digestibility (Depenbusch et al., 2009b). The conflicting findings could be related to differences in diet composition and the interaction between DDGS and other ingredients in the ration. Moreover, other researchers have observed that ADG and feed efficiency improve at inclusion levels of 50 and 40%, respectively (Firkins et al., 1985; Ham et al., 1994); this increased efficiency was attributed to a reduction in subacute ruminal acidosis because of the lower starch content compared with corn-based diets (Firkins et al., 1985). Additional concerns with feeding high levels of DDGS are the high sulfur concentration and high levels of fat. High levels of sulfur in DDGS come from the sulfur-containing compounds used to control pH and clean equipment in the ethanol plants and can approach the maximum recommended level of sulfur intake (Klopfenstein et al., 2008; Schingoethe et al., 2009). The high fat content in some DDGS may restrict its inclusion level because of the reduction in DMI and ruminal fermentation (NRC, 2001).

These results suggest that the optimum level of DDGS to maximize nutrient utilization depends on diet composition. To our knowledge, the optimum inclusion level at which DDGS replace canola meal in dairy replacement heifers under precision-feeding management has not been explored. Therefore, the hypothesis of this experiment was that DDGS would improve nutrient utilization and rumen fermentation depending on the level of inclusion in high- and low-forage diets precision fed to dairy heifers.

MATERIALS AND METHODS

Animals, Treatments, and Experimental Design

All procedures involving the use of animals were approved by the Pennsylvania State University Institutional Animal Care and Use Committee. Eight Holstein heifers were surgically prepared with a rumen cannula (7.62 cm i.d.; Bar Diamond, Parma, ID) under local anesthesia, 2 mo before the beginning of the experiment and later refitted with larger cannulas (10.16 cm i.d.; Bar Diamond, Parma, ID). Heifers (12.5 ± 0.5 mo of age and 344 ± 15 kg of BW at the beginning of the experiment) were randomly assigned to a split-plot 4 × 4 Latin square experimental design. Whole plot was forage-to-concentrate ratio (**F:C**)—either 50:50 (low forage, **LF**) or 75:25 (high forage, **HF**) on a DM basis—and subplot was level of inclusion of DDGS: 0, 7, 14, or 21% on a DM basis; these levels have been shown to increased nutrient utilization in growing and lactating beef and dairy animals (Depenbusch et al., 2009a; Schingoethe et al., 2009). The DDGS and canola meal levels were chosen to provide the N level (1.67 g of N/kg of $BW^{0.75}$) that maximizes N utilization in precision-fed dairy heifers (Zanton and Heinrichs, 2009a); DDGS replaced canola meal at an almost 1:1 ratio. Forage was a mix of 50% corn silage and 50% grass hay on a DM basis. Experimental periods were 19 d long, with 14 d for adaptation and 5 d for sampling. Heifers were housed in individual tiestalls (117 × 302 cm) with rubber mat flooring in a mechanically ventilated barn with continuous access to fresh water. During nonsampling days, heifers were let out to an outdoor exercise lot for 3 to 4 h/d before feeding, and BW was recorded on their way in and out of the exercise lot. Rations were balanced to provide equal amounts of nutrients and to allow for 800 g of ADG. The amount of feed offered was adjusted weekly based on BW, except just before and during sampling. Single batches of grain ingredients were stored to last for the length of the experiment. Grain ingredients and a mineral-vitamin premix were mixed for each treatment at the beginning of each experimental period, in a drum mixer (Calan Super Data Ranger, American Calan, Northwood, NH); forages were mixed daily using the same equipment. The forage mix, grain mix, and NPN source of each ration were hand mixed (to ensure mixing and quantities were delivered precisely) and delivered once daily at 1200 h.

Samples and Analyses

The grain mix for each diet was sampled at the beginning and end of each experimental period and composited by diet at the end of the experiment. The forage mix was sampled daily during collection days and composited by period for analyses. Feces and urine were completely collected from d 15 immediately after feeding to d 19 immediately before feeding for 4 d of total collection. Urine was collected using a noninvasive urinary device (Lascano et al., 2010) connected to a container with distilled water and 12 *N* HCl to maintain pH below 3 and minimize ammonia (NH_3) volatilization. The distilled water was added to avoid the formation of precipitates. Feces were collected hourly from vinyl-covered boards and stored in airtight containers. Every 24 h, urine and feces were weighed, mixed, and sampled. Urine samples were immediately frozen at −20°C. Feces were stored at 4°C until the last day of that collection period, and then composited by period proportionally to daily output; one sub-sample was dried and a fresh sub-sample was frozen at −20°C.

Forage mix, grain mix, and feces were dried in a forced-air oven at 65°C for 48 h and ground through a 1-mm screen (Wiley mill, Arthur H. Thomas, Philadelphia, PA). After drying and grinding, forage was composited by period; composited forage mixes, grain