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Chewing activities and particle size of rumen digesta and feces of precision-fed dairy heifers fed different forage levels with increasing levels of distillers grains

F. X. Suarez-Mena,* G. J. Lascano,† and A. J. Heinrichs*[1]
*Department of Animal Science, Pennsylvania State University, University Park 16802
†Department of Dairy Science, California Polytechnic State University, San Luis Obispo 93407

ABSTRACT

The objective of this study was to determine the effects of 2 differing forage to concentrate ratios (F:C) and various levels of corn dry distillers grain with solubles (DDGS) replacing canola meal in precision-fed dairy heifer rations on chewing behavior, rumen pH and fill, and particle size of rumen contents and feces. A split plot design with F:C as whole plot and DDGS inclusion level as subplot was administered in a 4-period 4 × 4 Latin square. Eight rumen-cannulated Holstein heifers (12.5 ± 0.5 mo of age and 344 ± 15 kg of body weight, respectively) housed in individual stalls were allocated to F:C 50:50 (low forage) or 75:25 [high forage (HF); dry matter basis] and to a sequence of DDGS level (0, 7, 14, and 21%; dry matter basis). Forage was a mix of 50% corn silage and 50% grass hay (dry matter basis). Diets were fed once daily and formulated to provide equal amounts of nutrients and body weight gain. No differences were found for rumen pH between dietary treatments. Time spent eating tended to be longer for HF and was not affected by DDGS inclusion rate. Ruminating time did not differ by F:C, but linearly increased as DDGS increased (422 to 450 ± 21 min/d). Total chewing time tended to be longer for HF and to increase linearly as DDGS increased (553 to 579 ± 33 min/d). Wet rumen digesta weight and volume were greater for HF. Geometric mean particle length of rumen contents was greater for HF 2 h prefeeding when analyzed with solubles (particles <0.15 mm). Proportion of rumen solubles decreased as DDGS increased 5 h postfeeding. Fecal geometric mean particle length and proportion of particles >1.18 mm increased with increasing levels of DDGS and did not change with F:C. Total chewing time increased by the addition of DDGS and higher F:C. Heifers can compensate for lower physically effective neutral detergent fiber by modifying their chewing behavior. Rumen pH was never at a level that could induce acidosis, and lower eating time at lower F:C was somewhat compensated by time spent ruminating per unit of physically effective neutral detergent fiber intake. Dry distillers grains with solubles, when used in dairy heifer rations as a replacement for canola meal, yielded similar rumen digestion traits.
Key words: heifer, chewing, distillers grain, feeding behavior

INTRODUCTION

Feed represents the largest cost associated with raising heifer replacements (Gabler et al., 2000); thus, controlling feed costs is essential to farm profitability. One strategy to reduce feed cost yet control ADG is to limit intake of nutrient-dense rations. Restricting intake of rations with higher proportions of by-product feeds can allow for optimum growth of replacement heifers without affecting future performance (Zanton and Heinrichs, 2009b). The limit-feeding strategy has given rise to some animal well-being concerns for heifers reared under this management scheme. Redbo and Nordblad (1997) observed that limit feeding induces development and increases frequency of oral stereotypies in heifers. In cattle, stereotypies may be triggered by frustrated feed manipulation (Redbo, 1992); heifers spent less time eating and ruminating when limit-fed (Redbo and Nordblad, 1997). Broom (1983) considered occurrence of prolonged stereotypies to be indicators of poor animal well-being.

Dairy cows spend 4 to 7 h/d eating and 5 to 9 h/d ruminating (Beauchemin, 1991), but heifers have been reported to spend as little as 1.2 (Kitts et al., 2011) and as long as 8.5 h/d eating (Jaster and Murphy, 1983). Thus, these activities in younger cattle have a wider range than in adult cattle depending on diet. Many factors affect these behaviors as observed in lactating dairy cows, among them: level of feed intake, ration composition, forage quality and length, and feeding method (Beauchemin, 1991).

The relationship between high-concentrate diets and rumen acidosis is well established in lactating dairy

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[1]Corresponding author: ajh@psu.edu

cows (Nocek, 1997), but results in growing heifers fed high-concentrate diets at restricted intake, where average and lowest pH did not reach critical levels (Moody et al., 2007; Robles et al., 2007), suggest that growing heifers can better tolerate low-fiber diets. The primary objective of this study was to determine the effects of forage to concentrate ratio (**F:C**) in precision-fed heifer rations on chewing activities, rumen pH and fill, and particle size of rumen digesta and feces as possible indicators of animal well-being. An additional objective was to determine effects of DDGS level on these parameters when substituting DDGS for canola meal while maintaining similar computed levels of protein solubility and degradability. Precision feeding in this study will be discussed as the practice of providing the animal with the exact amount of nutrients to grow at a targeted gain, as opposed to ad libitum intake.

MATERIALS AND METHODS

Animals and Feeding

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 beginning the experiment and later refitted with larger cannulas (10.16 cm i.d.; Bar Diamond). Heifers (12.5 ± 0.5 mo of age and 344 ± 15 kg of BW, respectively, at the beginning of the experiment) were randomly assigned to a split-plot 4 × 4 Latin square experimental design. Whole plot was an F:C of either 50:50 (low forage; **LF**) or 75:25 (high forage; **HF**) on a DM basis, and subplot was level of inclusion of DDGS, either 0, 7, 14, or 21% DM basis. Forage was a mix of 50% corn silage (**CS**) and 50% orchard grass hay (*Dactylis glomerata* L.) on a DM basis. Experimental periods were 19 d in length 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. Lighting was provided for 13.5 h/d, except on intensive sampling days when light was provided for 24 h. During nonsampling days, heifers were let out in an outdoor exercise lot for 3 to 4 h/d before feeding; BW was recorded on their way in and out of the exercise lot. Rations were balanced to provide equal amounts of nutrients and targeted to allow for 0.8 kg of ADG. Amount of feed offered was adjusted weekly based on actual BW; except the week before and during sampling. Single batches of grain ingredients were stored to provide for the length of the experiment. Concentrates 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. Forage mix, grain mix, and NPN source of each ration were hand mixed (because amounts were too low for mixer) and delivered once daily at 1200 h.

Samples and Analyses

The concentrate 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. Forage mix was sampled daily during collection days. Feeds were analyzed for particle size determination as stipulated by the American Society of Agricultural and Biological Engineers (ASABE, 2007).

Feces and urine were completely collected from d 14 immediately after feeding to d 18 immediately before feeding for 4 d of total collection. Feces was collected hourly from vinyl-covered boards on the floor and stored in airtight containers. Every 24 h, feces was weighed, mixed, sampled, and stored at 4°C until the last day of that collection period, then composited by period proportionally to daily output, and stored at −20°C. Urine separation from feces was accomplished using a noninvasive urinary device as described by Lascano et al. (2010).

Rumen contents were collected from dorsal, ventral, cranial, caudal, and medial areas of the rumen at −2, −1, 0, 1, 2, 4, 6, 8, 10, 12, 16, 20, and 24 h after feeding on d 17 of each period. Rumen contents were mixed thoroughly, sampled, and samples were strained through 2 layers of cheesecloth; fluid was immediately analyzed for pH using a hand-held pH meter (HI 98121, Hanna Instruments, Woonsocket, RI). Whole reticulo-rumen evacuations were done at −2 and 5 h postfeeding at the end of each period to determine digesta weight and volume. Digesta was mixed thoroughly and a sample was stored at −20°C for later analysis.

Frozen fecal and rumen digesta samples were thawed and analyzed for particle size by wet sieving using a control sieve shaker (Retsch AS 200, Haan, Germany) as described by Maulfair et al. (2011). The fraction that passed through the 0.15-mm screen was considered soluble. Data were analyzed considering percentage of DM of each particle fraction retained on screens ≥0.15 mm (retained) and including the soluble fraction (total). Physically effective NDF (**peNDF**) of diets was determined by multiplying diet NDF concentration by the proportion of particles retained on the 1.18-mm screen (Mertens, 1997), although the ASABE particle separator (ASABE, 2007) was used. Proportion of particles retained on the 1.18-mm screen for each ration