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# Sorghum forage in precision-fed dairy heifer diets

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## ABSTRACT

Sorghum forage is an alternative crop that is more adapted to drier conditions and more resistant than corn to drought conditions. Thus, sorghum forage maximizes water utilization. The objective of this study was to evaluate sorghum silage (SS), including digestibility and fermentation parameters, in precision-fed dairy heifers. Eight Holstein heifers (13.7 ± 0.6 mo of age and 364.8 ± 17.64 kg of body weight) fitted with rumen cannulas were used in a replicated 4 × 4 Latin Square design; treatments were 4 levels of forage to concentrate ratios (85:15, 75:25, 65:35, and 55:45). Rumen contents were sampled at various times to determine pH and volatile fatty acid concentrations. Dry matter (DM) and neutral detergent fiber (NDF) in situ degradation kinetics were compared between SS and corn silage (CS) diets. Fecal total collection was used to estimate apparent total-tract digestibility. Fecal grab samples at 0, 6, 12, and 18 h after feeding were used to estimate total-tract starch digestibility. Amount of concentrate in the diet affected the time that heifers spent eating as well as rumen pH. When the concentrate proportion of the diet increased, eating time and rumen pH decreased linearly. Total volatile fatty acid concentrations were not affected by treatment, but butyrate increased as the proportion of concentrate increased in the diet. Digestibility of DM and starch were higher in diets with lower forage to concentrate ratio, but NDF, acid detergent fiber, and hemicellulose digestibility were not affected. Corn silage had greater DM and NDF digestibility than SS. Also, fractional rate of digestion was faster for CS than SS (2.78 vs. 2.42% per hour, respectively). We conclude that fecal grab samples are suitable for predicting starch digestibility in heifers given the starch levels studied. In addition, SS was an adequate alternative forage in precision-fed dairy heifers with outcomes very similar to CS-based rations.

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## INTRODUCTION

Climate change and variability have been very important topics for plant and animal agriculture. Climate change modifies crop yields, enabling nontraditional areas for some crop production while disabling others (Schlenker and Roberts, 2009). One way to adjust animal production is to use water-efficient crops, such as sorghum, that provide high yields of forage while consuming low quantities of water (30 to 50% lower than corn; Emile et al., 2006). Sorghum is becoming a reliable forage crop for silage in the United States as well as other areas around the world. Sorghum has low water requirement, excellent drought tolerance, high tonnage yield, and low fertility requirements. It has been shown to have high productivity under limited irrigation systems compared with corn. Furthermore, sorghum can be planted later than corn, and some varieties have regrowth ability, which may allow a second harvest within a single growing season. Cost of production of sorghum silage (**SS**) is lower compared with corn silage (**CS**), because SS requires fewer seeds, less fertilization (30% lower than corn), and less irrigation (McCorkle et al., 2007).

Nutritionally, SS contains a higher proportion of protein, fiber, lignin, and ash but a lower proportion of starch compared with CS (McCorkle et al., 2007). Of course, variety, state of maturity, fermentation, and storage affect SS nutritional value. However, sorghum forage typically has lower DM digestibility compared with CS primarily because of the high lignin content. Lignin, the most indigestible part of a plant, limits ruminal and total-tract digestion. Corn plants usually have lower lignin content than sorghum, making CS more digestible than SS (Aydin et al., 1999; Oliver et al., 2004).

New varieties of sorghum have been selected to reduce undesirable characteristics and improve desirable ones, yielding plants with a lower proportion of tannins in grain (which indirectly decreases fiber digestibility), improved palatability, ability to withstand wind, ongoing high yields, reduced lignin content, and waxy endosperm in the grain that improves starch digestibility (Miron et al., 2007). Brown midrib (**BMR**) sorghum, which is classified as a newer variety, has lower lignin and fiber (NDF) content, which allows for improved DM digestibility and intake of this forage in ruminants. The BMR sorghum forage has nutritional composition comparable to CS and is a viable forage option for dairy rations (Aydin et al., 1999; Oliver et al., 2004).

In situ studies that compared SS, BMR sorghum, and CS found that BMR sorghum had higher NDF digestion than regular SS and CS (Grant et al., 1995; Di Marco et al., 2009). Some in vivo studies have reported milk production and DMI were higher in dairy cows consuming BMR sorghum compared with regular SS or CS (Aydin et al., 1999), but others saw no differences in DMI or milk yield (Oliver et al., 2004; Emile et al., 2006; Miron et al., 2007).

Because sorghum can be an important source of fiber and energy in ruminant nutrition and may be substituted for corn in many aspects, information needs to be available on the feeding and digestibility of this crop (Oliver et al., 2004). Therefore, additional research is required for the most efficient use of this crop in dairy diets. To our knowledge, no published research exists on the use of SS in a limit-fed diet for dairy heifers. Precision feeding, which relies on high-density nutrient diets that meet the needs of growing heifers by using highly digestible feedstuffs, is being widely used in the industry. With this type of diet, heifers can achieve higher than normal digestibility of feeds in the rumen and can reduce energy expenses associated with digestion of large volume of feeds (ad libitum diet) because of a reduction in visceral organ size and less oxygen consumption. Thus more dietary energy can be partitioned to growth instead of maintenance (Zanton and Heinrichs, 2009). This reduction in the metabolic expenses and the increase in rumen degradation of nutrients improves feed efficiency (Zanton and Heinrichs, 2016). The objective of this study was to evaluate total-tract nutrient utilization, ruminal environment, and digestibility parameters of precision-fed dairy heifers using BMR SS in different forage to concentrate ratios (**FOR:CON**). Additionally, we wanted to validate the use of rectal grab samples for estimating starch digestibility of heifer diets. We hypothesized that BMR SS would respond similarly to CS in precision-fed dairy heifer diets, with similar digestibility and fermentation parameters that will allow additional use of this crop in the dairy industry.

## MATERIALS AND METHODS

All procedures involving the use of animals were approved by the Pennsylvania State University Institutional Animal Care and Use Committee (no. 46266). Eight Holstein heifers (13.7 ± 0.6 mo of age and 364.8 ± 17.64 kg of BW) fitted with a 10-cm silicone rumen cannula (Kehl, SP, Brazil) were used in a 4 × 4 Latin Square design with 19-d periods including 15 d of adaptation and 4 d of sampling. Treatments included 4 levels of FOR:CON (85:15, 75:25, 65:35, and 55:45) using SS as the forage source in a precision-feeding program.

Heifers were kept in tie-stalls for 40 d before the experiment (pretrial adaptation period to adapt heifers to the facility and management as well as to recover from the cannulation surgery) and were then randomly assigned to treatments. Heifers were weighed weekly, and BW was determined by the average of 2 measurements taken on the same day before feeding. The amount of TMR offered during the experiment was adjusted weekly based on BW to allow an average of 0.95 to 1.0 kg/d of ADG. Heifers were housed in individual tie-stalls and individually fed in a mechanically ventilated barn. Heifers had free access to water in the stalls. The animals were released to a paved exercise pen for 3.5 h/d on nonsampling days.

Rations were mixed in a Calan Super Data Ranger (American Calan, Northwood, NH) every 4 d, and the diets were mixed prior to the 4 d of sampling to avoid variability. The different diets were kept in closed nylon bags to avoid oxygenation and stored in a cooler room until fed. Predicted DMI was calculated for each animal based on BW and energy intake. Grain mixes were formulated to provide the same energy level (0.23 Mcal of ME intake/kg of empty $BW^{0.75}$) in each diet, and N intake in the different FOR:CON diets (N was balanced to 1.82 g of N/kg of empty $BW^{0.75}$). Grain mixes were prepared before each period as a single mix. Rations were fed daily as TMR at 1200 h. Sorghum silage DM was measured every day of ration preparation in a microwave as described by Pino and Heinrichs (2014). Eating time (hours to consume the whole ration) was recorded daily during sampling days. Ration was considered totally consumed when less than 50 g remained in the feed bunk.

The variety of sorghum used in this study was an early BMR-6 brachytic dwarf (AF7102, Altaseed, Amarillo, TX). This variety was planted July 1, and it could be harvested between 85 and 90 d after planting; brachytic dwarf genes provide stout stalks and good standability without compromising high yield and forage quality. This hybrid was recommended because its short growing season suits the area of Pennsylvania where it was to be grown. Unfortunately, planting was delayed because of late harvest of the previous crop (sorghum was double cropped following wheat), and the yield and quality were lower than expected. Sorghum was used as the only source of forage in the diets.