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Effects of feeding alfalfa stemlage or wheat straw for dietary energy dilution on nutrient intake and digestibility, growth performance, and feeding behavior of Holstein dairy heifers

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ABSTRACT

Feeding high-quality forage diets may lead to excessive weight gains and over-conditioning for dairy heifers. Restriction of energy density and dry matter intake by using low-energy forages, such as straw, is a good approach for controlling this problem. Alfalfa stems contain high fiber and moderate protein content and have the potential to be used to replace straw to reduce dietary energy. The objective of this study was to compare nutrient intakes, digestibilities, growth performance, and feeding behaviors of dairy heifers offered an alfalfa silage/corn silage high energy diet (HE; 13.1% crude protein, 65.4% total digestible nutrients, 39.7% neutral detergent fiber) with 2 energy-diluted diets that replaced various proportions of the corn or alfalfa silages with either alfalfa stemlage (STM; 12.6% crude protein, 59.1% total digestible nutrients, 46.4% neutral detergent fiber) or chopped wheat straw (WS; 12.6% crude protein, 61.9% total digestible nutrients, 43.7% neutral detergent fiber). Seventy-two pregnant Holstein heifers (16.8 ± 1.3 mo) were stratified into 3 blocks (24 heifers/block) by initial body weight (light, 440 ± 18.0 kg; medium, 486 ± 18.6 kg; heavy, 534 ± 25.1 kg), with each block composed of 3 pens (8 heifers/pen), with diets assigned randomly to 1 pen within the block. Diets were offered in a 56-d feeding trial. Both dry matter intake and energy intake were decreased with the addition of low-energy forages to the diets, but no differences in dry matter intake were observed across diluted diets. Digestibility of dry matter, organic matter, neutral detergent fiber, and apparent N were greater for HE compared with diluted diets, and for WS compared with STM. Total body weight gain (74 vs. 56 kg) and average daily gain (1.32 vs. 1.00 kg/d) were greater for heifers offered HE compared with diluted diets. Feed efficiency tended to be less for heifers offered the diluted diets compared with HE (10.7 vs. 8.6 kg of feed/kg of gain). Heifers did not sort for or against particles when offered HE. However, increased sorting behavior was observed for diluted diets. Compared with ad libitum feeding dairy heifers a diet with high nutrient content forages (corn silage and alfalfa silage), use of diet diluted with alfalfa stemlage or wheat straw is an effective feeding management strategy to control total daily dry matter and energy intake by increasing gut fill, and maintain desirable body condition and growth rates, even though the diluted diets had greater sortability.

Key words: dairy heifer, alfalfa stem, energy dilution, growth

INTRODUCTION

Replacement heifers represent the future potential of the dairy industry; as such, the feeding strategy for dairy heifers is to rear these animals at a minimum economic and environmental cost without reducing their future lactation performance (Hoffman et al., 2007). Dairy replacement heifers are typically fed a high-forage diet to control their body condition, while still meeting their nutrient requirements. However, in many cases, forage-based diets for dairy heifers contain significant proportions of corn silage or other high-quality forages with low NDF concentrations. As a result, the energy densities of the diet can exceed the energy requirements of heifers, and subsequently, increase weight gains and lead to over-conditioning (Hoffman et al., 2008). In addition, DMI may be inadequately restricted when forage fiber concentrations are too low. Over-conditioning of dairy heifers has been associated with various deleterious effects on their mammary development and

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subsequent first lactation performance (Hoffman et al., 1996; Lammers et al., 1999; Radcliff et al., 2000).

To solve this management problem, researchers have investigated a management approach to control energy and nutrient intakes by limit feeding a diet that exceeds energy requirements, but is restricted to 80 to 90% of ad libitum intake. Lammers et al. (1999) and Hoffman et al. (2007) used a limit feeding strategy to control growth rates of Holstein heifers and observed no negative carryover effects on first-lactation performance. Besides allowing for controlled growth rates, limit feeding also has the potential to reduce the feed costs per kilogram of gain, decrease fecal excretion, and improve feed efficiency (Hoffman et al., 2007; Greter et al., 2011; Kitts et al., 2011). In addition, limit feeding strategies also have been used successfully for ewes (Susin et al., 1995), beef cows (Loerch, 1996), and beef heifers (Wertz et al., 2001). Despite these benefits, limit-feeding dairy heifers has shown some potentially negative effects, including increased standing time without eating (Hoffman et al., 2007; Greter et al., 2011; Kitts et al., 2011), vocalization and aggressive reaching for feed (Hoffman et al., 2007), and oral stereotypies (not normally distributed behaviors; Lindstrom and Redbo, 2000). These effects can be interpreted as a sign of hunger derived from lack of satiety (Watts and Stookey, 2000; Valizaheh et al., 2008), which may be indicative of poor animal welfare. A greater potential for subacute ruminal acidosis may be present when limit feeding lower forage diets, with Moody et al. (2007) finding a tendency for longer time with rumen pH less than 6 for heifers limit fed 33% forage diets compared with those fed 77% forage diets. Kruse et al. (2010) found no difference in rumen pH when limit feeding higher forage diets with 65% forage compared with ad libitum feeding a 91% forage diet. Use of higher forage diets for limit feeding can increase feeding and chewing time (Suarez-Mena et al., 2013). Also, addition of a low-nutritive forage in the TMR or offered separately when limit feeding can also increase feeding time and rumination (Kitts et al., 2011).

Another strategy to control caloric intake and growth rates of dairy heifers when diets contain high energy forages is to dilute the ad libitum diet with low-energy forages, such as straw (Hoffman et al., 1996; Greter et al., 2008), corn (*Zea mays* L.) fodder (Coblentz et al., 2015), or eastern gamagrass [*Tripsacum dactyloides* (L.) L.] haylage (Coblentz et al., 2012, 2015). Use of low-energy forages increases the diet NDF content, decreases the energy content, and thus lowers DMI and energy intake when feeding for ad libitum intakes (Coblentz et al., 2015). Ad libitum feeding of an energy-diluted diet to dairy heifers has some advantages, including (1) potentially reducing feed costs due to lower intakes, (2) promoting longer feeding times, (3) controlling growth rates, and (4) providing animals with opportunities for expression of natural foraging behaviors (Greter et al., 2008). Reduction of feed costs would depend on the dilutant forage costs relative to the other diet components. There are concerns with sorting of diets containing low-energy forages, with Coblentz et al. (2015) finding that addition of straw or corn fodder to an ad libitum fed diet led to increased sorting; however, this was not found to affect variation in heifer growth. Ad libitum feeding dairy heifers with an energy-diluted ration may be a good choice to help producers potentially reduce feed costs and target energy intake for desirable growth performance.

Alfalfa (*Medicago sativa* L.) is generally regarded as a desirable forage for ruminants. It is well known that the nutritive value of alfalfa leaves is superior to that of the stems. The CP concentration of the alfalfa leaves is about twice that of the stems, whereas the cell-wall material and lignin fractions of the stem is 2 to 3 times greater than that of the leaves (Albrecht et al., 1987; Shinners et al., 2007). A novel harvest fractionation system has been developed by the US Dairy Forage Research Center (USDA-Agricultural Research Service) that involves stripping of alfalfa leaves from stems. The stripped alfalfa leaves then can be used as a high-CP feed to formulate diets of desired quality for cattle, or further processed to obtain value-added products for ruminants, monogastics, or humans (Shinners et al., 2007). The alfalfa stems, containing high fiber and moderate CP content, have the potential to be used as an option for supplying low-energy forage to reduce the energy density of heifer diets. To date, no information is available summarizing growth and behavioral responses by dairy heifers. We hypothesized that feeding a ration diluted by alfalfa stems, in a manner similar to chopped straw, would allow dairy heifers to control ad libitum intakes, and to meet their nutrient requirements for maintenance and target growth rates. Thus, the objective of this study was to compare the nutrient intakes and digestibilities, growth performance, and sorting behaviors of dairy heifers provided an alfalfa silage/corn silage high-energy diet (**HE**) with energy-diluted diets that include either alfalfa stemlage (**STM**) or chopped wheat straw (**WS**).

MATERIALS AND METHODS

Alfalfa Stemlage Preparation

Alfalfa leaves were harvested at a growth stage of full bloom using a prototype leaf stripper. Alfalfa stems were cut with a discbine after most leaves were removed. Stems were allowed to dry overnight before baling and individually wrapping with white polyethylene stretch