J. Dairy Sci. 100:1086–1094
https://doi.org/10.3168/jds.2016-11592

Growth performance, feeding behavior, and selected blood metabolites of Holstein dairy calves fed restricted amounts of milk: No interactions between sources of finely ground grain and forage provision

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ABSTRACT

The objective of this study was to investigate the effects of grain sources and forage provision on growth performance, blood metabolites, and feeding behaviors of dairy calves. Sixty 3-d-old Holstein dairy calves (42.2 ± 2.5 kg of body weight) were used in a 2 × 3 factorial arrangement with the factors being grain sources (barley and corn) and forage provision (no forage, alfalfa hay, and corn silage). Individually housed calves were randomly assigned (n = 10 calves per treatment: 5 males and 5 females) to 6 treatments: (1) barley grain (BG) without forage supplement, (2) BG with alfalfa hay (AH) supplementation, (3) BG with corn silage (CS) supplementation, (4) corn grain (CG) without forage supplement, (5) CG with AH supplementation, and (6) CG with CS supplementation. All calves had ad libitum access to water and starter feed throughout the experiment. All calves were weaned on d 49 and remained in the study until d 63. Starter feed intake and average daily gain (ADG) was greater for calves fed barley than those fed corn during the preweaning and overall periods. Calves supplemented with CS had greater final body weight and postweaning as well as overall starter feed intake than AH and non-forage-supplemented calves. During the preweaning and overall periods, feeding of CS was found to increase ADG compared with feeding AH and nonforage diets. However, feed efficiency was not affected by dietary treatments. Calves supplemented with CS spent more time ruminating compared with AH and control groups; nonnutritive oral behaviors were the greatest in non-forage-supplemented calves. Regardless of the grain sources, the rumen pH value was greater for AH calves compared with CS and non-forage-supplemented calves. Blood concentration of BHB was greater for CS-supplemented calves compared with AH and non-forage-supplemented calves. Furthermore, body length and heart girth were greater for calves fed barley compared with those fed corn, and also in forage-supplemented calves compared with non-forage-supplemented calves. These results showed no interactions between grain sources and forage provision on calf performance; however, the inclusion of CS and barley in starter diets could enhance the growth performance of Holstein calves during the transition from liquid to solid feed.

Key words: forage, grain, dairy calf

INTRODUCTION

Physical and metabolic development of the reticulorumen is important both for easing the transition from preruminant to mature ruminant state and improving calf health (Drackley, 2008; Khan et al., 2011). The preweaning growth of calves is a complex process involving interactions among nutritional components and physiological signals that highly depends on dietary strategies and feeding management (Baldwin et al., 2004). For example, variations in fermentable carbohydrate (Hill et al., 2008; Khan et al., 2008) and forage sources (Castells et al., 2012) of starter feeds can affect the performance of dairy calves. Cereal grains are the primary source of starch in ruminant diets, and corn and barley are commonly used worldwide as starch sources in calf feeds. Although feeding concentrate diets in calves in early life stimulates rumen microbial proliferation and VFA production, and initiates rumen development, forage, or high-fiber feedstuffs, increases rumen muscularization (Beiranvand et al., 2014), volume, and motility (Žitnan et al., 1998).

Sources of fermentable carbohydrates such as grains may differ in their rate of starch ruminal fermentation and therefore in their effects on ruminal pH and short-chain fatty acids (Kiran and Mutsvangwa, 2007), which

Received June 11, 2016.
Accepted October 30, 2016.
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could affect starter feed intake, growth performance, and rumen development in dairy calves. Corn grain is more slowly fermented than barley and slower rates of digestion increase the amount of starch bypassing the rumen (Khan et al., 2008). Differences in starch shape, granule size, and interactions between amylose and surface compounds can alter the rate of enzymatic digestion of corn and barley starches (Kotarski et al., 1992). Previous studies have reported that starter feeds high in ruminal degradable starch (e.g., barley vs. corn) decrease nutrient intake and rumen development (Khan et al., 2008); however, it is not still clear how different starch sources affect ruminal fermentation and contribute to meeting the energy requirements of developing calves (Khan et al., 2016).

Provision of forage to young calves has been recommended because it has been shown to increase starter feed intake, ADG, as well as improve rumen fermentation (Daneshvar et al., 2015; Mirzaei et al., 2016), stimulate the muscular layer of the rumen (Suárez et al., 2007; Beiranvand et al., 2014; Mirzaei et al., 2015), promote rumination (EbnAli et al., 2016; Hosseini et al., 2016), and reduce behavioral problems (Phillips, 2004). In previous studies, the positive effect of alfalfa hay (**AH**) on stimulating starter feed intake observed when AH was supplemented to the finely ground starter feed (Beiranvand et al., 2014; Daneshvar et al., 2015) to young calves; however, this was not the same in the textured starter feed (Porter et al., 2007; Hill et al., 2008, 2010). Castells et al. (2012) reported that free-choice provision of forage sources (with the exception of AH) to young calves improved both starter feed intake and total DMI compared with nonforage supplementation.

Limited information is available on how changes in the dietary content of ruminal fermentable carbohydrate and source of supplemental dietary fiber might influence the performance of dairy calves during the pre- and postweaning periods. In this study, we tested the hypothesis that providing a diet supplemented with fiber can alleviate the negative effects associated with rapidly degradable starch such as barley grain, which may modify rumen conditions and improve calf performance. Further, we assume that increasing ruminal fermentation of starch can improve dairy calves' performance if acidosis is avoided with a proper source of forage in the diet.

MATERIALS AND METHODS

Animals, Management, and Treatments

The experiment was conducted between March 17 and June 22, 2014, on a local dairy farm (Ghiam Dairy Co.), Isfahan, Iran. All the calves were cared and managed according to the guidelines of Iranian Council of Animal Care (1995). Sixty 3-d-old Holstein dairy calves (42.2 ± 2.5 kg of BW) were randomly assigned (n = 10 calves per treatment: 5 males and 5 females) in a 2 × 3 factorial arrangement with the factors of dietary grain sources (barley vs. corn) and forage provision (without forage, alfalfa hay, or corn silage). Calves were separated from their dams immediately after birth, weighed, and moved to individual pens (1.2 × 2.5 m) bedded with sand, which was renewed every 24 h. The animals were fed 3.0 L of colostrum at each of the first 2 feedings (i.e., within 1.5 h of life and at 12 h after the first feeding). Colostrum feeding was carried out for the first 2 d of life.

Calves received 4 L/d of milk containing 3.14 ± 0.13% fat, 3.02 ± 0.08% CP, 4.73 ± 0.06% lactose, and 11.45 ± 0.17% TS in steel buckets twice daily at 0900 and 1800 h from d 3 to 46 of the study followed by feeding 2 L/d milks until d 49 of the study. Calves were assigned to 1 of 6 dietary treatments: (1) barley grain (**BG**) without forage supplement, (2) BG with AH supplementation, (3) BG with corn silage (**CS**) supplementation, (4) corn grain (**CG**) without forage supplement, (5) CG with AH supplementation, and (6) CG with CS supplementation. All calves were weaned on d 49 of study and the study was terminated on d 63. From d 3 to 63 of the study, all the calves had free access to fresh water and the starter ration formulated according to the current NRC (2001). All diets were formulated to be isonitrogenous. The ingredient and nutrient composition of the starter feed are given in Table 1.

Starter feeds were fed ad libitum to permit at least 10% orts (i.e., the portion of the starter not consumed over a 24-h period), and feed refusal from each individual calf was collected at 0800 h. The forage-supplemented calves received a starter feed containing 15% chopped AH (particle size distribution: 1.0 ± 0.2% greater than 18 mm, 26.0 ± 1.9% between 8 and 18 mm, 35.1 ± 0.9% between 1.18 and 8 mm, and 37.8 ± 2.3% less than 1.18 mm and geometric mean particle 2.9 ± 0.1 mm) or CS (particle size distribution: 21.3 ± 1.5% greater than 18 mm, 62.6 ± 2.0% between 8 and 18 mm, 14.6 ± 1.1% between 1.18 and 8 mm, and 1.3 ± 0.58% less than 1.18 mm and geometric mean particle size 12.07 ± 1.98 mm) as a TMR mixed with concentrates throughout the study. Corn and barley grain were ground using a hammer mill with 3 mm screen size (model 5543 GEN, Isfahan Dasht, Isfahan, Iran). All the calves were healthy with no clinical symptoms of systemic disease or mortality other than diarrhea and few pneumonia occurrences throughout the experiment.