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Source of carbohydrate and metabolizable lysine and methionine in the diet of recently weaned dairy calves on digestion and growth

T. M. Hill,[1] J. D. Quigley, H. G. Bateman II,[2] J. M. Aldrich, and R. L. Schlotterbeck
Nurture Research Center, Provimi, Brookville, OH 45309

ABSTRACT

Two 56-d trials with weaned Holstein dairy calves (initially 72 ± 1.8 kg of body weight, 58 to 60 d of age) fed 95% concentrate and 5% chopped grass hay diets were conducted. Each trial used 96 calves (4 calves/pen). During 15 of the last 21 d of the first trial and 10 of 14 d of the second and third week of the second trial, fecal samples were taken to estimate digestibility using acid-insoluble ash as an internal marker. Digestibility estimates along with 56-d average daily gain (ADG), hip width change, body condition score, and fecal score were analyzed with pen as the experimental unit. In trial 1, a textured diet (19% crude protein) with high starch [52% starch, 13% neutral detergent fiber (NDF)] based on whole corn and oats or a pelleted low-starch (20% starch, 35% NDF), high-digestible fiber diet were used. Within starch level, diets were formulated from supplemental soybean meal or soybean meal with blood meal and Alimet (Novus International Inc., St. Charles, MO) to provide 2 metabolizable protein levels (1 and 1.07% metabolizable lysine plus methionine). The 4 treatments were analyzed as a completely randomized design with a 2 by 2 factorial arrangement (6 pens/diet). In trial 2, all pelleted diets (19% crude protein) were fed. Diets were based on soybean hulls, wheat middlings, or corn, which contained increasing concentrations of starch (13, 27, and 42% starch and 42, 23, and 16% NDF, respectively; 8 pens/diet). Contrast statements were constructed to separate differences in the means (soybean hulls plus wheat middlings vs. corn; soybean hulls vs. wheat middlings). In trial 1, intake of organic matter (OM) did not differ. Digestibility of OM was greater in calves fed high- versus low starch-diets. Digestibility of NDF and starch were less in calves fed the high- versus low-starch diets. Calf ADG and hip width change were greater for high- versus low-starch diets. Source of protein did not influence digestibility or ADG. In trial 2, intake of OM was not different. Digestibility of OM was greater in calves fed corn versus other diets. Digestibility of NDF was greater for calves fed soybean hulls versus wheat middlings. Starch digestibility was not different among treatments. Calf ADG and hip width change were greater in calves fed corn versus other diets. High-starch diets were more digestible and supported more growth in 2- to 4-mo-old dairy calves than replacing starch with digestible fiber. Manipulating metabolizable protein compared with a control diet that was predominately corn and soybean meal did not alter growth or digestibility.
Key words: starch, fiber, protein, calf

INTRODUCTION

In the US dairy calf industry, a diversity of starter and grower feeds are fed to dairy calves less than 4 mo of age. These feeds vary greatly in their CP and digestible energy (**DE**) or ME concentration and ingredient composition. The NRC (2001) requirements mention the need for digestible fiber components, but limited data exist to substantiate this statement. The recently weaned calf or calf transitioning from milk or milk replacer to dry feed is an area of research in which limited knowledge has been gained since the NRC (2001) requirements were published (Hill et al., 2013).

Manipulation of nutrients offered to weaned calves within the dairy calf submodel of the NRC (2001) requirements suggest that energy, not CP, limits ADG in most circumstances. Digestible fiber sources such as soybean hulls, wheat middlings, and distillers dried grains with solubles have a lower DE (or ME) value than corn or other grains which are high in starch (NRC, 2001). The rumen of a weaned calf is small, leading to short retention times for digestion. Vazquez-Anon et al. (1993) reported mean retention of particles in the rumen of calves approximately double between 7 and 13 wk of age, relating to the increasing rumen size. Because digestible fiber is typically degraded in the rumen at a lower rate than starch, digestible fiber may increase in value to the calf diet as the calf ages;

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[1]Corresponding author: mhill@provimi-na.com
[2]Deceased.

however, recent data suggests there are no benefits to reduced ADG from replacing corn with digestible fiber sources (Hill et al., 2008a, 2012; Suarez-Mena et al., 2011; Terré et al., 2013), substantiating lower DE or ME concentrations than corn in NRC (2001). Despite these data, a pelleted high-fiber diet is frequently fed to calves less than 5 mo of age in the US dairy industry.

Recent publications suggest a CP concentration of 20.5% of DM (63 g of CP/Mcal of ME) for calves less than 8 wk of age (Hill et al., 2007a, 2008b; Stamey et al., 2012) and less than 17 (to maximize ADG) to 18% of DM (to maximize feed efficiency; 52 to 56 g of CP/Mcal of ME) for calves 2 to 4 mo of age are adequate (Hill et al., 2008b); this supports the limited data from which NRC (2001) is based. Source of rumen-undegraded protein or high MP has not resulted in more calf growth than diets based on soybean meal and corn (Warner, 1984; Hill et al., 2007a, 2008b). The dairy calf submodel of the NRC (2001) requirements does not consider MP or AA. Additionally, many diets fed to calves in the US dairy market contain sources of undegraded protein and metabolizable Lys and Met beyond what is supplied by soybean meal, especially when high-fiber diets are fed.

The objectives of these trials were to investigate the effect of starch or digestible fiber concentration of a diet and its interaction with metabolizable Lys and Met content of a diet on calf growth and digestion of nutrients. The diets tested represent compositions and forms commonly fed in the United States. Use of digestibility measurements will assist in interpretation of growth data that might be skewed with gut fill. These data will help to fill a void of research before and after the NRC (2001) requirements were published.

MATERIALS AND METHODS

Calves were cared for by acceptable practices as described in the *Guide for the Care and Use of Agricultural Animals in Research and Teaching* (FASS, 2010). Two 56-d trials were conducted with weaned, male Holstein dairy calves (initially 72 ± 1.8 kg of BW, 58 to 60 d of age, sourced from 1 farm) fed 95% concentrate and 5% chopped grass hay diets. The calves had been weaned for 2 wk before the trials started. Each trial used 96 calves (4 calves/pen) with 2 starting times 5 wk apart as blocks (48 calves/block). During 15 of the last 21 d of trial 1 and 10 of 14 d of the second and third week of trial 2, fecal samples were collected to estimate the digestibility of the diets fed. Performance measurements were made over the 56-d trial. The calves were housed in group pens with 5.5 m^2 of outside pen space and 1.35 m^2 of inside pen space per calf. The inside pen space was bedded with straw and there was no added heat.

In trial 1, a textured diet (19% CP on DM basis) with high starch (52% starch, 13% NDF) based on whole corn and oats or a pelleted low-starch (20% starch, 35% NDF), high-digestible fiber diet were used. Within starch level, diets were formulated from all supplemental soybean meal or soybean meal with blood meal and Alimet [Novus International Inc., St. Charles, MO; 84% 2-hydroxyl 4-(methylthio) butanoic acid, 88% methionine activity] to provide 2 MP levels (1 and 1.07% metabolizable Lys plus Met). The trial was conducted from June to September. The average temperature during the trial was 26°C (ranged from 9 to 40°C) and average humidity was 60% (ranged from 29 to 99%). The 4 treatments were analyzed as a completely randomized block design with a 2 by 2 factorial arrangement with pen (6 pens/treatment) as the experimental unit using a mixed procedure of SAS (ver. 8, SAS Institute Inc., Cary, NC). An auto-regressive type 1 covariance matrix was employed as determined using Akaike's information criteria. Factors were starch, protein, and their interaction; differences were declared at $P < 0.05$.

In trial 2, all ground, pelleted diets (19% CP) were fed. Diets were based on soybean hulls, wheat middlings, or corn, which contained increasing concentrations of starch (13, 27, and 42% starch, 42, 23, and 16% NDF, respectively; 8 pens/diet). The trial was conducted from August to November. The average temperature during the trial was 14°C (ranged from −4 to 34°C) and average humidity was 72% (ranged from 30 to 99%). The 3 treatments were analyzed as a completely randomized block design with pen as experimental unit using a mixed procedure of SAS. An auto-regressive type 1 covariance matrix was employed as determined using Akaike's information criteria. Contrast statements were constructed to separate differences in the means (soybean hulls plus wheat middlings vs. corn; soybean hulls vs. wheat middlings); differences were declared at $P < 0.05$.

Every second bag (22.7 kg) of starter feed and every bale of hay was sampled and composited. Composites of feeds were analyzed (AOAC International, 2000) for DM (oven method 930.15), ash (oven method 942.05), CP (Kjeldahl method 988.05), fat (alkaline treatment with Roese-Gottlieb method 932.06 for MR; diethyl ether extraction method 2003.05 for starters and hay), NDF with ash by the procedure of Van Soest et al. (1991) without sodium sulfite or α-amylase, ADF with ash (Robertson and Van Soest, 1981), starch (α-amylase method; Hall, 2009), and sugar (colormetric method; Dubois et al., 1956). Results are in Tables 1 and 2.

Calves were weighed, hip widths were measured, and body condition was scored initially (d 28) and at the end of the trial (d 56). Empty BW was estimated from