J. Dairy Sci. 101:1–12
https://doi.org/10.3168/jds.2017-13798

Performance, nutritional behavior, and metabolic responses of calves supplemented with forage depend on starch fermentability

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ABSTRACT

This study evaluated the interactive effects of forage provision on performance, nutritional behavior, apparent digestibility, rumen fermentation, and blood metabolites of dairy calves when corn grains with different fermentability were used. Sixty 3-d-old Holstein calves were randomly assigned to 1 of 4 treatments in a 2 × 2 factorial arrangement. Dietary treatments were (1) steam-flaked (SF) corn without alfalfa hay (AH) supplementation (SF-NO), (2) SF corn with AH supplementation (SF-AH), (3) cracked (CR) corn without AH supplementation (CR-NO), and (4) CR corn with AH supplementation (CR-AH). All calves received the same amount of pasteurized whole milk and weaned on d 56 of the experiment; the study was terminated on d 70. Steam-flaked corn contained higher amounts of gelatinized starch in comparison with cracked corn (44.1 vs. 12.5% of total starch, respectively). Starter intake was not affected by corn processing methods or AH provision during the pre- or postweaning periods. However, we noted an interaction between corn processing methods and forage supplementation for starter intake during d 31 to 50 of the experiment, where calves fed on SF-AH starter had greater starter intake than those fed SF-NO starter, but the starter intake was not different between CR-NO and CR-AH fed calves. Furthermore, AH increased average daily gain (ADG) of calves fed an SF-based diet but not in calves fed a CR-based diet during the preweaning and overall periods. Interaction between forage provision and time was significant for ADG and feed efficiency, as calves supplemented with forage had higher ADG (0.982 vs. 0.592, respectively) and feed efficiency compared with forage unsupplemented calves at the weaning week. Forage supplementation resulted in more stable ruminal condition compared with nonforage-fed calves, as evidenced by higher ruminal pH (5.71 vs. 5.29, respectively) at postweaning and lower non-nutritive oral behavior around weaning time (55 vs. 70.5 min, respectively). The concentration of blood β-hydroxybutyrate was also greater in calves supplemented with forage than in unsupplemented calves. Results of the present study indicated that performance response and skeletal growth were the same between 2 corn processing methods. Forage provision improved ADG of calves fed the SF-based diet, but not the CR-based diet throughout the study.
Key words: calf, cracking, forage provision, steam flaking

INTRODUCTION

In neonatal calves, physical and metabolic development of rumen is an important factor for soft transition from preruminant to functioning solid-fed ruminants (Khan et al., 2016), which can improve efficiency of solid feed utilization and ultimately performance and general health status (Drackley, 2008). Many factors, such as the nature of the offered solid feed (Khan et al., 2011), may affect rumen development by inducing early establishment of a microbial ecosystem (Baldwin et al., 2004), enhancing ruminal fermentation products (i.e., VFA), and triggering rumen epithelium development. Because of limited starch digestion in corn, various methods of processing, such as steam flaking, steam rolling, dry rolling, and grinding, are normally applied to improve digestibility at periweaning period (Lesmeister and Heinrichs, 2004). However, data suggested that over-processed grains and extensive gelatinization of starch or large amounts of fine particles may trigger rapid ruminal acid production and disturb ruminal fermentation (Lesmeister and Heinrichs, 2004; Suárez et al., 2006), which can cause lower performance responses of calves (Lesmeister and Heinrichs, 2004). Previously, Porter et al., (2007) reported that providing calves with concentrate feeds containing adequate large particles (75% of particles of starter >1.19 mm), such as coarse mashed corn with a mean particle size of approximately 2 mm or greater, could improve ruminal health, which

Received September 7, 2017.
Accepted January 3, 2018.
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cause more ADG and solid feed intake as compared a pelleted fine particle diet. However, overall gastrointestinal starch digestion in cracked corn without heat processing is relatively low, reducing starch utilization efficiency (NRC, 2001). In this regard, an appropriate grain processing method, such as steam flaking with gelatinization of starch, may maintain good ruminal health (Bateman et al., 2009) and optimize ruminal and postruminal digestion (Zinn et al., 2002); however, to some extent, feeding young calves with steam-flaked corn yielded conflicting results. Moeini et al. (2017) reported that steam flaking of equal combination of corn and barley increased the feed efficiency as well as ADG of dairy calves as compared with ground or pelleted grains in the starter. In contrast, Lesmeister and Heinrichs (2004) reported that calves fed steam-flaked corn had lower ADG, starter intake, and feed efficiency as compared with whole or dry-rolled corn grain, which may indicate that this processing method needs more supportive effective fiber from forage sources to maintain ruminal pH in normal range. However, Bateman et al. (2009) observed that feeding steam-flaked corn showed the same response as calves fed on whole corn or dry-rolled corn. Part of this discrepancy might be related to the level of corn processing, processing condition (steaming time and flaking density), and, more importantly, balance between physically effective fiber and carbohydrate sources in starter diets (Owens et al., 1997; Khan et al., 2016). To our knowledge, little information is available regarding the comparison of steam-flaked and cracked corn with particle size near the recommended coarseness (2 mm).

It has been well described that forage provision to neonatal calves stabilizes ruminal environment and pH by acting as a stimulator of chewing activity and rumen muscularization, as well as maintaining ruminal papillae functionality (Beiranvand et al., 2014b; Mirzaei et al., 2015), resulting in the improvement of feed consumption and growth performance (Castells et al., 2012; Montoro et al., 2013; Beiranvand et al., 2014b; EbnAli et al., 2016). Yet, 2 questions persist: (1) Does increasing the rate of starter particle size to approximately 2 mm with no forage suffice to maintain ruminal health as well as improve performance responses in highly processed corn; and (2) How do young calves respond to forage provision with a high proportion of starter coarse particle size originating from different type of processing? It has been reported that calves fed diets containing rolled corn exhibited more ADG than those fed on ground corn, and 2 other treatments containing 7.5 or 15% of grass hay had higher ADG as well as improved feed efficiency than rolled corn (Coverdale et al., 2004). Therefore, in diets containing a high proportion of overprocessed grain, it is necessary to supply sufficient physically effective particles from forage or nonforage sources to stimulate chewing activity and saliva production of dairy calves, as observed in adult cattle.

The response of dairy calves to supplemental alfalfa hay (**AH**) might be different from their response to cracked (**CR**) corn with low fermentable starch or steam-flaked (**SF**) corn with extended fermentable starch; therefore, the objective of our study was to investigate the interactive effects of 2 different processing methods, including cracking or steam flaking with different extents of ruminal fermentability and AH provision in the starter diet on performance, skeletal growth, nutritional behavior, apparent digestibility, rumen fermentation, and blood metabolites of dairy calves.

MATERIALS AND METHODS

The study was carried out at the facilities of a local dairy farm (Ghiam Esfahan Plantation and Domesticated Co., Isfahan, Iran). It had been previously approved by the Animal Care and Use Committee of the Iranian Council of Animal Care (1995).

Animals, Management, and Experimental Design

Holstein calves (41.4 ± 2.39 kg of BW; mean ± SD) were separated from their dams at birth, weighed, and transferred to individual pens (1.2 × 2.5 m) bedded with sand that was replaced every 24 or 48 h as needed. They were fed 4 L of colostrum within 6 h of birth and colostrum feeding continued for the first 2 d of their lives. Blood samples were taken by venipuncture from the jugular vein at 24 h after the first colostrum intake, and serum total protein was determined as an indicator of passive transfer of immunity using a Reichert AR200 digital hand-held refractometer (Reichert Inc., Depew, NY). Only calves having a serum protein level >6 g/dL were included in the study. A total of sixty 3-d-old calves were enrolled in the study and were bucket-fed twice a day with pasteurized whole milk (at 0800 and 1800 h, 50% each time) with an adjusted step up/step down milk feeding protocol with 4 L/d milk from d 1 to 14, 5 L/d milk from d 15 to 21, 7 L/d milk from d 22 to 42, 5 L/d milk from d 43 to 50, 2 L/d milk from d 51 to 53, and 1 L/d milk from d 54 to 56 of the study; all calves were weaned at 56 d of experiment.

Calves (n = 15, 8 males and 7 females) were randomly assigned to 4 treatments in a 2 × 2 factorial arrangements with the factors of alfalfa hay inclusion as a forage source (0 or 10% on DM basis) and the corn processing as sole source of grain in the starter (SF vs.