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Effects of forage source and forage particle size as a free-choice provision on growth performance, rumen fermentation, and behavior of dairy calves fed texturized starters

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ABSTRACT

We investigated the interactive effects of forage source and forage particle size (PS) as a free-choice provision on growth performance, rumen fermentation, and behavior of dairy calves fed texturized starters. Forty-eight Holstein calves (42 ± 3 kg of body weight) were randomly assigned (n = 12 calves per treatment) in a 2 × 2 factorial arrangement of treatments with the factors of forage source [alfalfa hay (AH) and wheat straw (WS)] and forage PS [(AH: medium = 1.96 mm or long = 3.93 mm) and (WS: medium = 2.03 mm or long = 4.10 mm), as geometric mean diameters]. The treatments were (1) AH with medium PS (AH-MPS), (2) AH with long PS (AH-LPS), (3) WS with medium PS (WS-MPS), and (4) WS with long PS (WS-LPS). Regardless of forage PS, the preweaning starter intake, dry matter intake, metabolizable energy intake, weaning body weight, and forage intake were greater for AH calves than WS calves. Average daily gain, average daily gain/metabolizable energy intake, feed efficiency, and final body weight of the calves did not differ among groups. An interaction of forage source and forage PS influenced acetate, propionate, and acetate-to-propionate ratio in the rumen on d 35, with the greatest acetate proportion and acetate-to-propionate ratio, but the least propionate proportion for AH-MPS calves than the other calves. The total volatile fatty acid concentration and the rumen proportions of propionate (d 70), butyrate (d 35), and valerate (d 35) were greater in AH-MPS calves than in AH-LPS calves. Calves fed AH had greater total volatile fatty acid concentration (d 35 and 70) and propionate proportion (d 70), but lesser ruminal proportions of butyrate (d 35 and 70), valerate (d 35 and 70), and acetate-to-propionate ratio (d 70) compared with calves fed WS. The ruminal valerate proportion (d 70) was greatest in WS-MPS calves than the other calves. An interaction of forage source and forage PS influenced preweaning standing time and starter eating time, with the least standing time for WS-MPS calves and the greatest eating starter time for AH-LPS calves. Calves fed AH spent less time for rumination, but devoted more time to non-nutritive oral behaviors than WS calves. Calves fed forage with long PS spent more time for rumination, eating forage, and spent less time lying and non-nutritive oral behaviors than medium PS. In conclusion, forage source and PS interacted, affecting behavior and rumen fermentation when calves were fed texturized starters. In addition, a desirable ruminal pH in dairy calves can be obtained with texturized starters.
Key words: calf, forage, texturized, particle size

INTRODUCTION

Considerable evidence exists in the literature that provision of forage can improve growth performance (Castells et al., 2012; Overvest et al., 2016; Imani et al., 2017), feed efficiency (Coverdale et al., 2004), rumen fermentation (Beiranvand et al., 2014; Mirzaei et al., 2015), and feeding behavior (EbnAli et al., 2016; Hosseini et al., 2016) of young calves fed ground starter feeds, although gut-fill could confound the results on weight gain from dietary forage intake (Khan et al., 2011). Studies showed that dairy calves could benefit from some dietary forage to maintain abrasion in their rumen and prevent abnormalities in the rumen epithelium (Greenwood et al., 1997), especially if the starter diet does not have an adequate particle size (**PS**). For example, feeding starters containing fine particles in mash form or processed in a pelleted form has triggered rapid ruminal acid production from fermentation of carbohydrates (Laarman et al., 2012), reduced ruminal pH (Laarman and Oba, 2011), and impaired

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rumen epithelial development (Greenwood et al., 1997). Previously, Terré et al. (2013) reported that forage provision rather than an increase in fiber content of the starter feed could improve pelleted starter intake and calf performance around weaning, and supplemental forage right after weaning is necessary to enhance calf performance. Moreover, Terré et al. (2015) showed that provision of straw to dairy calves promoted starter intake, regardless of the physical form of starter diets (pelleted or texturized forms). However, the literature on the effects of different physical forms of starter feed on calf performance is inconclusive and the discrepancies among studies could be due to differences in forage source (Imani et al., 2017), variations in physical and chemical structure of starter diets (Khan et al., 2016), or the PS of calf starters among the studies.

Feeding a forage source of adequate PS is thought to be required for dairy calves to promote chewing activity and saliva secretion, which elevate ruminal pH (Laarman and Oba, 2011; Nemati et al., 2015) and promote rumen health (Mirzaei et al., 2015). The results of a recent meta-analysis showed that forage provision to dairy calves had a beneficial effect on growth performance, but its effects can be modulated by forage source (Imani et al., 2017). It is known that the type of forage can influence a ground starter feed intake (Castells et al., 2012) and calf performance (Movahedi et al., 2017). This is likely because different forage have different nutrient compositions with varying effects on ruminating behavior (Castells et al., 2012) and feeding patterns (Miller-Cushon et al., 2013), which mainly influences buffering capacity in the rumen (Plaizier et al., 2008). These results suggest that if forage provision affects growth performance of dairy calves, it is worth investigating how changes in forage type and PS can improve the health and performance of calves during the transition from liquid to solid feed.

It has been demonstrated that the forage PS may also influence the effective fiber requirement of dairy calves. Nemati et al. (2015) found that increasing PS of alfalfa hay (**AH**) from fine (1 mm, as a geometric mean) to medium (3 mm, as a geometric mean) can improve calf performance and reduce their nonnutritive oral behaviors (**NNOB**) when calves were fed finely ground starter feeds. Mirzaei et al. (2015) also showed that the physical effectiveness of AH on performance and rumen development of dairy calves fed finely ground starters were affected by forage level, as the long PS of AH (5.04 mm as a geometric mean) rather than the medium PS of AH (2.92 mm, as a geometric mean) increased starter intake and weaning weight at 8% inclusion rate. Recently, Suarez-Mena et al. (2016) reported that increasing the PS of starter by changing the PS of straw (from about 3.04 to 12.7 mm, as a geometric mean, at a 5% inclusion rate) resulted in minimal changes in ruminal fermentation and had no effect on rumen development parameters of dairy calves. The requirement for forage source is dependent on several factors, including diet ingredient composition and physical form of starter feeds. To our knowledge, limited information is available on how changes in PS and source of supplemental dietary forage might influence the growth performance of dairy calves fed starters in a textured form.

We tested the hypothesis that the effects of different forage sources on calf performance would be dependent on the PS of forage when offered as a free-choice provision. Therefore, 2 types of forage [AH and wheat straw (**WS**)] were provided with 2 PS (medium vs. long) to investigate their interactions on starter intake, growth performance, rumen fermentation, and behavior of dairy calves fed texturized starters during pre- and postweaning.

MATERIALS AND METHODS

Animals, Management, and Treatments

The current study was carried out from September 2016 to November 2016 on a local dairy farm (Goldasht-Nemone Agri. Animal Production Co., Isfahan, Iran) according to the guidelines of Iranian Council of Animal Care (1995). Air temperature and relative humidity data were obtained from the daily reports released by the Meteorological Network Station at Najaf-Abad (Isfahan, Iran). The average daily temperature was 18°C (range = 15–22°C) and the relative humidity was 38.9% (range = 26–48%) for the study period. A total of 48 Holstein calves (42 ± 3 kg of BW) were blocked by sex and randomly assigned to 1 of the 4 dietary treatments (n = 12 calves, 6 male and 6 female calves per treatment) in a 2 × 2 factorial arrangement. Two forage sources (AH and WS) and forage PS (AH: medium = 1.96 mm or long = 3.93 mm, WS: medium = 2.03 mm or long = 4.10 mm; as geometric means) as a free-choice provision were used in dietary treatments of (1) AH with medium PS (**AH-MPS**), (2) AH with long PS (**AH-LPS**), (3) WS with medium PS (**WS-MPS**), and (4) WS with long PS (**WS-LPS**).

Calves were separated from their dams immediately after birth, weighed, and moved to a naturally ventilated barn with individual pens (1.2 × 2.5 m) bedded with sawdust, which was renewed every other day. The calves received 2.5 L of colostrum within 1.5 h of life and another 2.5 L 12 h later. From the second feeding time until d 3 of life, all calves received colostrum and transition milk. The quality of colostrum was measured with a digital Brix refractometer (PAL-1, Atago Co.