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Effects of milk replacer acidification and free-access feeding on early life feeding, oral, and lying behavior of dairy calves

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ABSTRACT

Acidification is a practical way of preserving the bacteriological quality of milk so that it can be fed to calves under free-access conditions. The objectives of this study were to evaluate how milk replacer acidification and free-access feeding affect dairy calf behavior during the first week of life. Sixteen Holstein male calves were purchased at birth and transported to the University of Guelph Kemptville Campus Dairy Education and Research Centre. Calves were randomly assigned to 1 of 4 milk feeding programs: (1) free-access (ad libitum) feeding of acidified milk replacer (22% crude protein and 17% fat, 150 g/L; FA); (2) restricted (6 L/d, 150 g/L) feeding of acidified milk replacer (RA); (3) free-access feeding of nonacidified milk replacer (FN); and (4) restricted feeding of nonacidified milk replacer (RN). Formic acid was used to acidify milk replacer to a target pH between 4.0 and 4.5. Video recordings of each calf at 1, 2, and 6 d were analyzed continuously over 24 h for all occurrences of each behavior in the ethogram. Feeding behavior observations were organized into sucking bouts, from which feeding behavior outcome variables were calculated. Calves consuming acidified milk replacer demonstrated more fragmented feeding patterns, characterized by more pauses within a sucking bout (FA, FN, RA, and RN calves = 12.4, 4.4, 13.7, and 11.9 pauses/bout, respectively) and longer sucking bout duration (FA, FN, RA, and RN calves = 8.8, 5.2, 9.3, and 8.1 min/bout, respectively), than calves fed nonacidified milk replacer. Restricted-fed calves tended to have longer sucking bouts and performed more within-bout sucks (FA, FN, RA, and RN calves = 10.7, 5.8, 13.5, and 14.1, respectively) and pauses than free-access calves. Acidification and free-access feeding did not affect lying duration. Calves assigned to the acidified feeding treatments tended to perform more grooming behavior than those fed nonacidified milk replacer (FA, FN, RA, and RN calves = 0.9, 0.5, 0.8, and 0.6 h/d, respectively). Free-access feeding did not affect grooming duration. The observed differences in feeding and grooming behavior suggest that acidification to a pH between 4.0 and 4.5 may have altered the palatability of milk replacer. Calves assigned to the acidified milk replacer feeding treatments did not, however, show avoidance toward this feedstuff during the first week of life.
Key words: acidification, free-access feeding, behavior, calf

INTRODUCTION

Early life nutrition programs have traditionally restricted dairy calf daily intake of milk or milk replacer to approximately 10% of birth BW, with the aim of encouraging greater solid feed consumption during the first weeks of life, promoting rumen development, and facilitating early weaning off milk (Drackley, 2008; Khan et al., 2011). However, there is growing interest in enhanced feeding strategies that allow calves to consume greater amounts of milk (Hammell et al., 1988; Jasper and Weary, 2002; Borderas et al., 2009a). Enhanced milk feeding supports greater nutrient intake and increased growth performance over traditional feeding methods (Diaz et al., 2001; Khan et al., 2007a,b; Borderas et al., 2009a), and is associated with improved milk production later in life (Soberon et al., 2012; Soberon and Van Amburgh, 2013; Gelsinger et al., 2016). Another advantage of enhanced milk feeding is the reduction in behavioral signs of hunger, including fewer unrewarded visits and competitive interactions at the feeding station, less nonnutritive sucking after milk ingestion and more time spent lying compared with traditional feeding practices (Jensen and Holm, 2003;

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De Paula Vieira et al., 2008; Borderas et al., 2009a; Rosenberger et al., 2017). Moreover, enhanced milk feeding promotes a more natural type of feeding behavior, wherein each calf has greater control over its milk intake, feeding duration, and meal patterns than calves reared under traditional feeding conditions (Appleby et al., 2001; Jensen, 2009; Miller-Cushon et al., 2013).

Ad libitum milk feeding for calves can be achieved by using automated feeders and free-access feeding systems. Automated feeders can be programmed to provide freshly mixed milk replacer each time a calf enters the feeding station. One of the main challenges with free-access feeding systems is that milk kept at ambient temperatures can support rapid microbial growth (Stewart et al., 2005; Cummins et al., 2016). High levels of bacterial contamination are associated with greater risk of calf morbidity and mortality, and reduced growth performance (Jamaluddin et al., 1996a,b; Armengol and Fraile, 2016). Acidification is a preservation method that can be used to inhibit microbial growth in animal feedstuffs (Argagón, 2007). Acidifying milk, milk replacer, or colostrum to a target pH between 4.0 and 4.5 has been shown to effectively preserve the bacteriological quality of milk so that it can be safely fed to calves under free-access conditions (Collings et al., 2011; Parker et al., 2016; Todd et al., 2016).

Effects of milk replacer acidification on calf behavior are largely unknown. Cattle can discriminate between acidic solutions and water at pH 4.8, and exhibit rejection responses at pH levels below 3.6 (Goatcher and Church, 1970). Acidification with formic acid to a target pH between 4.0 and 4.5 has been shown to limit voluntary intake of milk replacer by approximately 1 L/d (Todd et al., 2016). Moreover, some calves reject colostrum or milk replacer acidified to pH less than 4.5 (Collings et al., 2011; Hill et al., 2013). Collectively, these findings suggest that acidification may alter the palatability of milk fed to calves. There is also evidence that calves fed acidified milk replacer ad libitum have lower abomasal and fecal pH than calves fed restricted amounts of nonacidified milk replacer (Woodford et al., 1987). Diets that promote lower gastric pH tend to be associated with inflammation and ulceration of the stomach mucosal epithelium in horses (Nicol et al., 2002), as well as the performance of unwanted oral behaviors, such as wood chewing, coprophagia, and crib-biting (Willard et al., 1977; Nicol et al., 2002). Thus, ingestion of acidified milk replacer may influence digestive function, gastrointestinal discomfort, and nonnutritive oral behavior.

The objectives of this study were to evaluate how milk replacer acidification (acidified versus nonacidified) and feeding level (free access versus restricted) affect the feeding, oral, and lying behavior of calves during the first week of life. The hypothesis underlying this study was that acidification would negatively affect the palatability of milk replacer and increase gastric acidity, which would result in calves having more interrupted sucking behavior, altered feeding patterns, greater nonnutritive oral behavior, and greater lying duration. We also hypothesized that free-access feeding would better satisfy hunger and promote more natural feeding patterns, resulting in greater lying duration than restricted feeding.

MATERIALS AND METHODS

Animals, Housing, and Management

Sixteen male Holstein calves were purchased at birth from 2 commercial dairy farms in eastern Ontario, Canada. Calves were transported within 24 h of birth (0 d of age) from the source farm to the University of Guelph Kemptville Campus Dairy Education and Research Centre (Kemptville, ON, Canada). Calves were housed in individual pens (1.22 m wide and 1.83 m long; Figure 1) on a straw and shavings pack. Due to solid pen partitions, visual contact between calves was only possible when calves had their heads out of the front of the pen (by the feed and water buckets), but they were within auditory range of one another. Individual housing was used to facilitate the collection of individual feed intake data. Management conditions were representative of commercial dairy operations in Ontario, and in accordance with guidelines of the Canadian Council on Animal Care (CCAC, 2009). All study procedures were reviewed and approved by the University of Guelph Animal Care Committee (# 07R109).

Experimental Design and Feeding Treatments

A 2 × 2 factorial design was used to test the following milk feeding programs: free-access (ad libitum) feeding of acidified milk replacer (**FA**), free-access feeding of nonacidified milk replacer (**FN**), restricted (6 L/d) feeding of acidified milk replacer (**RA**), and restricted feeding of nonacidified milk replacer (**RN**). This experimental design allowed for the independent effects of acidification and feeding level, as well as the interaction between these factors, to be tested. Calves were blocked by source farm and randomly allocated to feeding treatment as they arrived at the research facility. The randomization sequence was determined using a random number generator software program. Calves did not differ by treatment group for birth weight (mean ± SD: FA = 50.0 ± 3.8 kg, FN = 46.0