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The effects of increasing amounts of milk replacer powder added to whole milk on passage rate, nutrient digestibility, ruminal development, and body composition in dairy calves

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ABSTRACT

The aim of this study was to evaluate the effects on feed intake, calf performance, feed efficiency, fecal score, passage rate, apparent nutrient digestibility, development of rumen and other organs, and body composition of increasing the total solids content of liquid feed (whole milk) by adding increasing amounts of milk replacer powder during the preweaning period. Crossbred Holstein-Gyr calves (n = 32) were assigned to 1 of 4 treatments (n = 8 per group), which consisted of different total solids concentrations: 12.5, 15.0, 17.5, and 20.0% of liquid feed. Calves received 6 L of liquid per day, divided into 2 equal meals (0800 and 1600 h) and provided in buckets, from 5 to 55 d of age. Starter and water were provided ad libitum during the entire experiment. At 56 d of age, animals were killed. Laboratory analysis determined that the actual total solids contents of the liquid feed were 13.5, 16.1, 18.2, and 20.4%, for the proposed 12.5, 15.0, 17.5, and 20.0% total solids treatments, respectively. The osmolality of liquid feed treatments was 265 to 533 mOsm/L. Fecal score was similar among treatments, except for wk 2 and 7. Intake of liquid feed was similar among treatments from 6 wk of age. During wk 4, 5, and 6, we detected a linear decrease in starter intake. After wk 7, we observed greater starter intake for calves fed approximately 16.1% total solids. Water intake, feed efficiency, and withers height were similar among treatments. Increasing concentrations of total solids in liquid feed quadratically affected average daily gain, final body weight, and empty body weight. We observed a greater average daily gain for calves fed approximately 20.4% total solids. Passage rate, nutrient digestibility, development of pre-stomachs and intestine, and body composition were similar among treatments. Increasing the concentration of total solids in liquid feed up to 20.4% reduced starter intake between 4 and 6 wk of life, but increased average daily gain. It did not affect passage rate, nutrient digestibility, ruminal and organ development, or body composition in calves during the preweaning period, indicating that this strategy may be a viable alternative for feeding without increasing the total volume of liquid feed provided to dairy calves.
Key words: calf performance, feed intake, preweaning, total solids

INTRODUCTION

Restricting liquid feed intake to approximately 10% of calf BW during the preweaning period is a common practice in calf-rearing systems (Jasper and Weary, 2002; Terré et al., 2009; Sweeney et al., 2010) and, when associated with early weaning, it can reduce feed costs and stimulate the early onset of starter intake (Eckert et al., 2015; Yavuz et al., 2015; Chapman et al., 2016). However, solid feed intake in the first month of life may be low (Sweeney et al., 2010) and, when combined with a liquid feed restriction regimen, can limit calf performance (Khan et al., 2007a). This condition can explain the hunger behavioral characteristics demonstrated by dairy calves (De Paula Vieira et al., 2008; Miller-Cushon et al., 2013).

Conflicting results are found in the literature related to the performance of calves fed a greater volume of liquid feed versus calves fed conventionally (Omidi-Mirzaei et al., 2015). The greater supply of liquid feed may (Kristensen et al., 2007) or may not (Khan et al., 2007b; Silper et al., 2014) have negative effects on rumen development, and may reduce (Terré et al., 2007;

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Hill et al., 2010; Chapman et al., 2016) or not reduce (Silva et al., 2015) apparent nutrient digestibility. One way to partially overcome the negative effects of providing greater volumes of liquid feed is to add products commonly sold as "balancers" or milk replacer powder (**MRP**), which increase the TS content in the liquid without increasing the amount of milk feed (Glosson et al., 2015). Terré et al. (2006) have reported that calves fed a greater volume of enriched liquid feed (18% TS) had higher BW, but with a lower starter intake and an apparent delay in rumen development compared with conventionally fed calves (12.5% TS). Glosson et al. (2015) reported that 17.6% TS in a greater volume of liquid feed, increased ADG, BW, and feed efficiency.

Recommendations for the maximal concentration of TS in liquid feed are still not well-established, and further research on the effects of different concentrations of TS in liquid feed on calf performance and development are needed. Tikofsky et al. (2001) determined the effect of varying concentrations of dietary fat and carbohydrate on changes in body composition of Holstein calves fed under isocaloric and isonitrogenous intake conditions. Although dietary fat varied among treatments without compromising ADG and final BW, body composition was altered by diet, demonstrating that the evaluation of animals based only on ADG does not reflect the efficacy of feeding regimens for dairy calves. An evaluation is needed of the effects of different feeding regimens on digestibility, and on rumen development, and body composition in calves. We are unaware of data showing the effects on passage rates in preweaned calves of increasing TS concentrations in liquid feed by adding MRP in whole milk.

The final osmolality of a liquid feed must also be considered. When osmolality increases, it can lead to digestive problems (Kertz and Loften, 2013). According to Glosson et al. (2015), an increase in osmolality resulting from the addition of milk balancer to whole milk can affect water absorption by the intestines, leading to an increase in incidence of diarrhea. According to McGuirk (2003), normal serum osmolality is about 280 to 290 mOsm/kg, and milk is an isosmotic food. Although reference values are not well-established, fluids with an osmolality >600 mOsm/L should be offered with caution (McGuirk, 2003), because the gradient is no longer as effective, and absorption in the small intestine is inhibited, possibly leading to osmotic diarrhea (Floren et al., 2016). Feeding concentrations may be as important to calf health as the total nutrients offered, and care should be taken to not concentrate replacers to the point where they might be harmful (Floren et al., 2016).

The objective of this study was to evaluate the effects of increasing concentrations of TS in whole milk on feed intake, performance, feed efficiency, body frame development, fecal score, passage rate, apparent nutrient digestibility, development of the rumen and other organs, and body composition in dairy calves during the preweaning period. Our hypothesis was that increasing TS concentrations in whole milk by adding MRP would alter feed intake and performance, indirectly affecting fecal score, passage rate, apparent nutrient digestibility, development of the rumen, and body composition.

MATERIALS AND METHODS

This study was approved by the Ethics Committee of Embrapa Dairy Cattle, Brazil (protocol no. 06/2014). The experiment was conducted at the Embrapa Dairy Cattle Experimental Farm, located in Coronel Pacheco, Minas Gerais, Brazil.

Animals, Housing, and Treatments

Holstein × Gyr crossbred male calves (n = 32) were used; their genetic composition was 5/8 or more Holstein and 3/8 or less Gyr. Calves were born during Brazilian fall (April to May 2014), removed from their dams, fed 3 L of colostrum (>50 g/L of IgG) within 6–8 h of birth, and transferred to individual shelters over tropical grass pasture (*Cynodon* spp.) for the study period. Blood samples were collected via jugular venipuncture within 48 h after birth. Samples were centrifuged at 800.6 × *g* for 10 min to measure total serum protein using a refractometer (Serum protein REF-301; Biocotek, Beilun, Ningbo, China).

Between 2 and 4 d of age, calves were fed 6 L/d of transition milk divided into 2 equal meals offered at 0800 and 1600 h. At 5 d, calves were assigned to 1 of 4 treatment groups (n = 8 per group), maintaining a balance of birth BW and genetic composition in each group. Treatments consisted of increasing amounts of MRP (Sprayfo Violet SSP, Deventer, the Netherlands; Table 1) added to 6 L/d of whole milk (12.6 ± 0.7% TS; mean ± SD; Table 1) to adjust the TS to expected concentrations of 12.5, 15.0, 17.5, and 20.0% of liquid feed. The initial TS content in the whole milk was measured daily, immediately after milking and before each feeding, using a Brix refractometer (DD-3 Palm Abbe Digital, Misco, Solon, OH). Brix grade values were converted to TS content using the equation proposed by Moore et al. (2009) [TS = 0.9984 × (Brix refractometer reading) + 2.077], and the amount of MRP to be added to the whole milk was adjusted to achieve the desired TS content for each treatment. The MRP was added to the whole milk immediately before it was supplied to the calves. The time between milking and feeding the calves was not more than 30 min.