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Intensive liquid feeding of dairy calves with a medium crude protein milk replacer: Effects on performance, rumen, and blood parameters

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ABSTRACT

The objective of this study was to evaluate the effects of different liquid-feeding systems using a medium crude protein milk replacer on performance, rumen, and blood parameters. Thirty newborn Holstein calves were blocked according to birth weight and date of birth, and randomly distributed to different liquid-feeding systems: conventional (4 L/d), intensive (8 L/d), or step-up/step-down (wk 1, 4 L/d; wk 2 to 6, 8 L/d; wk 7 and 8, 4 L/d). The commercial milk replacer (12.5% solids, 20.2% crude protein, 15.6% fat) was fed twice daily (0700 and 1700 h) until calves were weaned, at 8 wk of age. Calves were individually housed in wood hutches, with free access to water and starter concentrate, and to hay only after weaning. They were followed through 10 wk of age. Milk replacer and starter intake were inversely affected by feeding system. After weaning, starter intake and hay intake were similar among feeding systems. Total dry matter intake was higher during the liquid-feeding period for calves on the intensive system compared to calves on the conventional system, but conventional feeding resulted in the highest dry matter intake after weaning. Feed efficiency was similar among feeding systems before and after weaning. Average body weight and daily gain were not affected by feeding system before or after weaning. During liquid feeding, diarrhea occurrence was lower for calves on the conventional system; however, when calves on the step-up/step-down system were fed lower volumes of liquid feed, diarrhea occurrence was similar to that of calves on the conventional system. Plasma concentrations of β-hydroxybutyrate were higher for calves on the conventional system, reflecting starter intake. Rumen pH, short-chain fatty acids, and N-NH_3 were not affected by feeding system. Feeding higher volumes of milk replacer with a medium crude protein content had no beneficial effect on the performance of calves up to 10 wk of age.
Key words: starter intake, weaning, rumen development, fecal score, weight gain

INTRODUCTION

Recent research in dairy calves has investigated management and nutrition improvements to benefit future productivity. The literature shows that feeding higher volumes of liquid diet for dairy calves results in higher daily gain and may increase future milk production (Heinrichs and Heinrichs, 2011; Soberon and Van Amburgh, 2013). For this reason, producers are slowly shifting from a restricted feeding system (conventionally 4 L/d) to systems that include higher volumes of liquid diet. The main objective of conventional feeding is to stimulate intake of starter concentrate, which promotes rumen development and allows for early weaning without reduced performance. As well, conventional feeding may lower rearing costs, which is attractive to some milk production systems (Davis and Drackley, 1998). However, although it is possible to attain satisfactory performance with conventional feeding systems, the opportunity to increase future milk production is lost.

Intensive feeding systems lead to higher daily gains, and increased intake of nutrients from the liquid portion of the diet results in higher feed efficiency (Blome et al., 2003). However, this system requires higher CP content in the milk replacer as a way of modulating the composition of the gain, with higher proportions of protein and water and less fat. Animals are heavier when they are weaned, but with a lower percentage of body fat (Kertz and Loften, 2013). The benefits of intensive liquid feeding for future milk production have been consistently observed with milk replacer that contains 28% CP and 15 or 20% fat (Soberon et al., 2012). However, this type of milk replacer is not always available. In Brazil, for example, the highest CP content in commercial milk replacer is 23%, which may be a problem for producers who adopt intensive liquid-feeding systems (Silva and Bittar, 2013).

Another problem for the adoption of intensive feeding is the reduction in concentrate intake, which delays rumen development and hinders weaning. As well, some of the growth advantage realized with intensive feeding may be lost after weaning, because calves are not prepared to maintain growth solely from solid feed (Bach et al., 2013). For this reason, a gradual reduction in

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the volume of liquid feed in the last weeks before weaning (step-down system) has been presented as good strategy for stimulating concentrate intake, facilitating weaning, and preventing performance reduction.

The objective of this study was to evaluate the effects of different liquid-feeding systems (conventional, intensive, and step-down; 20% CP milk replacer; abruptly weaned at 8 wk of age) on performance, rumen activity, and blood parameters in calves up to 10 wk of age.

MATERIALS AND METHODS

All procedures with animals were in accordance with the ethical standards of the University of São Paulo and approved by the Ethics Committee on Animal Experimentation (CEUA/ESALQ) before the beginning of the study. The study was conducted in the Experimental Calf System of the Animal Science Department at "Luiz de Queiroz" College of Agriculture, University of São Paulo, Piracicaba, SP, Brazil, from May to September 2011. Thirty newborn male Holstein calves (birth weight 39.7 ± 3.4 kg) were used in a completely randomized block experimental design. Calves were blocked according to birth weight and date of birth (10 blocks), so that weight and age were homogeneous within each block. Groups of about 10 calves were transported (95 km) from a commercial dairy farm to the calf facility, at 3 to 5 d of age, in a cattle truck with straw bedding. Calves were separated from their mothers and fed at least 2 L of high-quality colostrum just after birth and 12 h later. Calves were fed 4 L/d of transition milk until they were transported. At the calf facility, calves were individually housed in wood shelters in a grassy field. They were fed a commercial milk replacer (Sprayfo Violeta, 12.5% solids, 20.2% CP, 15.6% fat; Sloten do Brazil Ltd., Santos, SP, Brazil) twice daily (0700 and 1700 h), and had free access to water and a pelleted commercial starter concentrate (Table 1). Animals were randomly distributed to one of the liquid-feeding systems: conventional (4 L/d), intensive (8 L/d), or step-up/step-down (**SUSD**; wk 1, 4 L/d; wk 2 to 6, 8,L/d; wk 7 and 8, 4 L/d). Animals were abruptly weaned, regardless of starter concentrate intake, at the end of wk 8. Pelleted commercial starter was fed ad libitum every morning, and orts were weighed to monitor daily intake. Starting on the weaning day, calves received coast-cross hay [*Cynodon dactylon* (L.) pers.] ad libitum in a bucket, and orts were measured once per week. Animals were weighed weekly, before the morning milk feeding, on a mechanical scale (ICS-300; Coimma Ltd., Dracena, SP, Brazil), and wither height, heart girth, and hip width were also measured. Every morning, calves were examined for diarrhea, receiving a score of 0 (no diarrhea) or 1 (diarrhea).

Blood samples were taken weekly, 2 h after the morning feeding, via jugular venipuncture by vacuum tubes containing sodium fluoride and potassium EDTA (Vacuette of Brazil, Campinas, SP, Brazil). Samples were centrifuged (Universal 320R; Hettich, Tuttlinger, Germany) at 2,000 × *g* for 20 min at 4°C, and plasma was stored in a freezer (−26°C) until analysis. Specific commercial enzymatic kits were used to analyze plasma glucose (Glicose HK Liquiform; Labtest Diagnóstica S.A., Lagoa Santa, MG, Brazil) and BHB concentrations (RANBUT; Randox Laboratories, Life Sciences Ltd., Crumlin, United Kingdom) in an automatic biochemical system (SBA-200; CELM, Barueri, SP, Brazil).

Two hours after morning feeding, ruminal fluid samples were collected at wk 4, 8, and 10 of age using an oroesophageal tube and a vacuum pump (TE-0581; Tecnal Ltda., Piracicaba, SP, Brazil), taking care to avoid saliva contamination. Samples (50 mL) were filtered through cheesecloth, and pH was measured immediately (DMPH-2; DIGIMED, Campo Grande, MS, Brazil). Samples were frozen approximately 20 min after collection for subsequent short-chain fatty acid (**SCFA**) analysis. Samples were then thawed and centrifuged (Universal 320R; Hettich) at 15,000 × *g* at 4°C for 60 min to obtain the supernatant, as described by Ferreira et al. (2009). Samples were analyzed by liquid gas chromatograph (5890 Series II GC; Hewlett Packard, Wilmington, DE) equipped with an integrator (3396 Series II Integrator; Hewlett Packard) and an automatic injector (6890 Series Injector; Hewlett Packard). A volume of 100 μL of the internal standard (2-methylbutyric acid), 800 μL of sample, and 200 μL of formic acid were pipetted into a vial for gas chromatograph injection. A mixture of SCFA of known concentration was the external standard for calibration. To determine N-NH_3, a rumen sample was centrifuged (11,000 × *g*, 4°C, 30 min) to obtain the supernatant and analyzed according to Chaney and

Table 1. Milk replacer and solid feed chemical composition (% of DM)

Item	Milk replacer[1]	Concentrate[2]	Coast-cross hay
DM, %	97.4	89.2	92.2
Ash	8.2	8.1	5.2
CP	20.2	21.6	6.8
Ether extract	15.6	3.4	1.6
NDF	0.5	28.0	77.6
ADF	—	10.2	41.26
NFC[3]	55.5	38.9	8.8
TDN[4]	—	72.9	52.3

[1]Sprayfo Violeta (Sloten do Brasil Ltda., Santos, SP, Brazil).
[2]Rumina 18P (Guabi Nutrição Animal, Campinas, SP, Brazil).
[3]NFC = 100 − (CP + ether extract + NDF free of CP + ash).
[4]Calculated according to Weiss (1993).