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Effect of milk replacer feeding rate, age at weaning, and method of reducing milk replacer to weaning on digestion, performance, rumination, and activity in dairy calves to 4 months of age

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ABSTRACT

The objectives of this study were to evaluate calf performance, diet digestibility, and rumination activity when feeding 4 milk replacer (MR) feeding programs. Male Holstein calves (n = 96; 43 ± 1.2 kg of body weight; 1 to 2 d of age) were housed in individual pens for 56 d. Calves were fed a common MR [25% crude protein (CP), 17% fat, dry matter (DM) basis]. Feeding programs were (1) 0.66 kg of DM/d of MR and weaning at 42 d (MOD6); (2) up to 1.09 kg of DM/d of MR weaned at 42 d (HIGH6); (3) up to 1.09 kg of DM/d of MR weaned at 53 d (HIGH8); and (4) up to 1.09 kg of DM/d of MR and gradually weaned from d 35 to 53 (GRAD8). Calves were fed a textured starter containing whole grains with 20% CP and 37% starch (DM basis). From 38 to 56 d of age, 4 calves/treatment had ear tag accelerometers fitted to provide measurements for eating, rumination, and activity. Calves were moved into groups by treatment (4 calves/pen) at 56 d and fed the same starter blended with 5% hay. Fecal samples were collected for individual calves between d 31 to 35, 45 to49 (MOD6 and HIGH6 only), and 56 to 60 from 5 calves/treatment. Fecal samples were collected by pen from d 80 to 84 and 108 to 112. Data were analyzed as a randomized complete block design with repeated measures when appropriate. Preplanned contrasts of MOD6 versus others, HIGH6 versus HIGH8, and HIGH8 versus GRAD8 were used to separate the means. Calves fed MOD6 were 3.4 kg lighter at 56 d than calves fed other treatments. Starter intake was greatest for MOD6 compared with other treatments (0.78 vs. 0.43 kg/d) from 0 to 56 d. Hip width and body condition score change from 0 to 56 d were similar among treatments. Average time ruminating, eating, and activity did not differ among treatments. Total-tract digestibility of DM, OM, CP, and fat were least for calves fed MOD6 versus other treatments on d 35, whereas NDF and starch digestibility were greatest for MOD6 at d 35. Digestibility of ADF and NDF were also greatest for MOD6 at d 49 (compared with HIGH6 only) and 60. From d 56 to 112, calves previously fed MOD6 had greater ADG versus other treatments. At 84 d, DM, OM, CP, NDF, ADF, and fat digestibility were greatest for calves fed MOD6 versus others. Calves fed HIGH6 and GRAD8 had greater digestibility of NDF and ADF compared with HIGH8 at 84 d. At 112 d, digestibility was similar among treatments. Calves were not different in BW and hip width at 112 d, with growth driven by less digestion of DM and fiber around and after weaning for calves fed >0.66 kg of MR. Gradual weaning did improve postweaning digestion.
Key words: calf, weaning age, digestibility, activity

INTRODUCTION

A major difficultly in feeding large amounts milk or milk replacer (**MR**) is that the greater preweaning ADG and weaning BW typically reported is lost by approximately 4 mo of age compared with moderate MR programs feeding approximately 0.66 kg of DM (Hill et al., 2007, 2016a,b). Calves fed MR with computerized automatic feeders that allotted increasing amounts of MR from 6 to 12 L/d had starter intake in the first 6 wk of age that averaged 0 to 0.1 kg/d on the 8-, 10-, and 12-L allotments, whereas intake was 0.3 kg/d with the 6-L/d treatment (Rosenberger et al., 2017). Similarly, low early solid feed intakes were reported among calves on noncomputer-fed ad libitum systems (Nocek and Braund, 1986; Hill et al., 2013) and calves hand-fed MR at more than 0.7 kg of DM/d (Cowles et al., 2006; Hill et al., 2007, 2010). Although the transition period of reducing milk or MR is affected by MR feeding rate (more MR results in less starter intake; Rosenberger et al., 2017), postweaning starter intakes are not typically affected by preweaning feeding MR rates (Hill et al., 2007, 2013; Osorio et al., 2012).

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The results of MR feeding rate on postweaning ADG has varied among research groups. Some researchers report no effect (Miller-Cushon et al., 2013; Rosenberger et al., 2017), whereas others report a reduction in ADG (Cowles et al., 2006; Hill et al., 2007, 2010). However, a common result of increased MR feeding rate is reduced postweaning structural growth (Hill et al., 2016a,b). Several researchers identified that feeding high amounts of MR reduces post-weaning starter digestion (Terre et al. 2007a,b; Hill et al., 2010). This reduction in postweaning digestion can last 4 wk or more (Hill et al., 2016b); however, few researchers measured effects of MR feeding rates beyond 2 wk postweaning. Therefore, the reported reductions in ADG and structural growth of calves fed over 0.7 kg of DM from MR after weaning may be due to reduced starter digestion (Terre et al. 2007a,b; Hill et al., 2010, 2016b), rather than starter intake (Osorio et al., 2012; Hill et al., 2016a,b).

One possible solution to this challenge may be to gradually reduce MR allowance over several days to wean calves fed high MR rates. Although several researchers tested gradual weaning in high MR-fed calves, postweaning diet digestibility was not reported (Hill et al., 2007, 2012; Sweeney et al., 2010). However, Hill et al. (2016b) reported increased postweaning digestion and growth after gradually weaning high MR-fed calves (stepped-down from 1.1 kg/d of MR to 0.66 kg/d for a 3-wk period before complete MR weaning) compared with high MR-fed calves stepped down over a 1-wk period. Extending the time preweaning when feeding a high rate of MR has been suggested to assist with the success of the programs when measuring BW gain to 10 (Eckert et al., 2015) and 13 wk (Meale et al., 2015) of age. Eckert et al. (2015) reported 8.9-kg heavier calves at 10 wk of age with 8 versus 6 wk of weaning, and Meale et al. (2015) reported 5.2-kg heavier calves at 13 wk of age with 12 versus 8 wk of weaning. However, neither of those studies reported structural growth measurements and postweaning measurements were assessed over a short length of time.

A challenge when interpreting milk and MR feeding rate research is many calf researchers report a short time length for postweaning measures: many report only a week to less than a month of postweaning data (Cowles et al., 2006; Miller-Cushon et al., 2013; Rosenberger et al., 2017). Another challenge is that structural growth is not routinely reported (Miller-Cushon et al., 2013; Rosenberger et al., 2017). Structural growth measurements may be more accurate measures of growing calves than BW and ADG because gastrointestinal tract (**GIT**) fill may influence these measurements, especially during the immediate postweaning period when calves may consume more feed than can be efficiently used within the GIT. For example, when a calf has little starter intake preweaning but a rapid increase in starter intake over a 1- or 2-wk period during and after weaning (Rosenberger et al., 2017), the GIT fills with digesta and passage rate may slow down; therefore, BW may not represent structural growth (i.e., muscle, bone, GIT tissue, and adipose; Khan et al., 2011).

Considering the issue of losing early growth from feeding more milk or MR during the postweaning phase, our objectives were to measure the growth and digestion pre- and in an extended postweaning period from feeding a moderate (0.66 kg) and high (up to 1.1 kg) amount of MR, 2 weaning times (42 and 54 d), with abrupt (7 d) and gradual (14 d) weaning. We hypothesized that a high feeding rate of MR with later and gradual weaning would support more growth and similar post-weaning digestibility as calves fed a moderate amount (0.66 kg of DM) of MR.

MATERIALS AND METHODS

Animals, Facilities, and Treatments

All animals were cared for as described in the *Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching* (FASS, 2010) and under approval of the institutional animal care and use committee. Male Holstein calves (3 to 4 d of age) were received at the Nurture Research Center nursery in southwest Ohio (New Paris) from 1 farm after a 3.5-h transit. The trial used 2 blocks of 48 calves received 70 d apart. The nursery included individual pens for calves in a barn with curtain sides, natural ventilation, and no added heat. Calf pens were bedded with long wheat straw. The day after arrival, at approximately noon, the calves were weighed (d 0; 43 ± 1.2 kg of initial BW, mean ± SE). At this time, blood was sampled intravenously, serum was separated by centrifugation at 3,000 × g (VWR, Batavia, IL) at 20°C for 15 min, and serum protein concentration was estimated using an optical refractometer (ATAGO U.S.A. Inc., Bellevue, WA). All calves were initially fed 0.66 kg of DM from MR for first p.m. and following a.m. feeding, then randomly assigned to 1 of 4 feeding programs: (1) 0.66 kg of DM/d for first 39 d and 0.33 kg for 3 d fed in the a.m. feeding only (**MOD6**); (2) 0.87 kg of DM/d for 4 d, 1.09 kg for 31 d, and 0.54 kg for 7 d in the a.m. feeding (**HIGH6**); 3) 0.87 kg of DM/d for 4 d, 1.09 kg for 42 d, and 0.54 kg for 7 d in the a.m. feeding (**HIGH8**); and (4) 0.87 kg of DM/d for 4 d, 1.09 kg for 35 d, 0.87 kg for 4 d, 0.66 kg for 4 d, 0.44 kg for 3 d, and 0.22 kg for 3 d in the a.m. feeding (**GRAD8**). Calves were fed a common MR (25% CP, 17% fat DM basis; 14% solids; Table 1) in equal meals at 0600 and 1530 h. This MR was formulated with added synthetic AA (Hill et al., 2008) and