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Different milk feeding intensities during the first 4 weeks of rearing in dairy calves: Part 1: Effects on performance and production from birth over the first lactation

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ABSTRACT

We aimed to test the effects of ad libitum feeding of whole milk (WM) or milk replacer (MR) versus restrictive feeding of MR during the first 4 wk of life on growth performance and on milk yield in the first lactation. We studied 57 German Holstein calves (29 females, 28 males) from birth until d 110 of life (trial 1). The 28 females from trial 1 were further studied during their first lactation (trial 2). In trial 1, all calves were randomly allocated at birth to 1 of 3 groups: MR-res [n = 20, 6.78 kg MR (11.5% solids)/calf per day], MR-ad lib (n = 17, 13.8% solids) or WM-ad lib (n = 20). All calves received colostrum ad libitum from their dam until d 3 of age. From d 4 to 27, calves were fed according to their group regimen. From d 28 to 55, all calves received MR-res feeding and were then gradually weaned until d 69. We recorded body weight (until d 110) and feed intake (amount, metabolizable energy, and frequency of liquid feed intake until weaning). We estimated the profitability of the different feeding regimens, taking into account income from milk yield (trial 2) and feed costs during rearing. In trial 1, the calves from WM-ad lib and MR-ad lib had total metabolizable energy intakes 2.02- and 1.65-fold greater than the MR-res group during the first 4 wk of life. During this period, concentrate intake did not differ among groups, but tended to be greater in WM-ad lib than in MR-ad lib calves from d 28 to 69. The MR-res calves visited the automatic feeders more often than the ad libitum-fed groups during differential feeding, but 70% of the visits were unrewarded (<10% in the ad libitum-fed calves). When all calves were fed at the MR-res level, the average proportion of unrewarded visits was 65% in all groups. Average daily gain and body weight were greater among MR-ad lib and WM-ad lib calves than among MR-res animals during the first 4 wk of life, but not from d 1 to 110. In trial 2, age at first calving, dry matter intake, and body weight over the first 10 mo of lactation were not different among groups, nor was milk composition. Milk yields (305 d) were numerically but not statistically greater in the ad libitum-fed groups during the first lactation (+765 kg for WM-ad lib vs. MR-res; +612 kg for MR-ad lib vs. MR-res). Feeding WM-ad lib and MR-ad lib was 1.37- and 1.21-fold more costly than MR-res, respectively, but amounted to 18, 15, and 13% of the total estimated feed costs until first calving in WM-ad lib, MR-ad lib, and MR-res, respectively. Our study confirms that ad libitum feeding is an attractive measure for rearing dairy calves, both for animal welfare and—with the caveat of a small sample size in trial 2 that led to insufficient power—economic profit from milk.

Key words: calf, nutrition, growth, milk yield

INTRODUCTION

Calves are born without a functional rumen, and nutrients are provided mainly in liquid form—as whole milk (**WM**) or milk replacer (**MR**) during the first week of life (Baldwin et al., 2004; Khan et al., 2011). Over the past decades, feeding strategies for dairy calves have focused on early weaning to stimulate intake of solid feed and development of a functional forestomach system (Baldwin et al., 2004; Khan et al., 2011, 2012, 2016). Restricting liquid feed before weaning is meant to drive the intake of concentrate and the production of VFA (in particular butyrate), which are the primary drivers of rumen development (Quigley et al., 1991). However, restricting the amount of liquid feed results in lower growth rates, abnormal behavior, and negative effects on rumen development (Khan et al., 2011, 2016).

The effects of increasing nutrient supply with WM or MR on feed intake, growth rate, and milk yield in

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the first lactation have been investigated recently (Soberon et al., 2012; Eckert et al., 2015; Kiezebrink et al., 2015). Increasing WM or MR intake decreased concentrate intake (Khan et al., 2007a,b; Raeth-Knight et al., 2009), delayed rumen development, and decreased BW at weaning (Suarez-Mena et al., 2011). However, Robelin and Chilliard (1989) and Moallem et al. (2010) found that increased ADG during the first 2 mo of life resulted in greater BW at 24 mo of age. Higher growth rates in early life reportedly improve gastrointestinal development at weaning (Eckert et al., 2015), lower age at first calving (Raeth-Night et al., 2009), and increase first-lactation milk yield, although not always significantly (Margerison et al., 2013; Soberon and Van Amburgh, 2013).

Brown et al. (2005) documented that increasing the intake of energy and protein from 2 to 14 wk of age affected the development of the mammary gland in heifer calves: that is, total parenchymal mass and parenchymal DNA and RNA increased, and histological development was stimulated. A recent report (Geiger et al., 2016) confirmed these results and documented that intensified feeding over 8 wk of life resulted in increased organ weights (e.g., liver, mammary gland, spleen).

The "lactocrine hypothesis" emanated from the notion that milk-borne factors may affect the development of specific tissues or physiological functions and exert long-term effects (Bartol et al., 2008, 2013). Such findings were first described in neonatal pigs (Donovan and Odle, 1994; Burrin et al., 1997) and subsequently also in calves (Blum and Hammon, 2000; Rauprich et al., 2000a,b; Blättler et al., 2001). Indeed, the results of these studies showed that neonates may undergo programming by early nutrition that has sustained long-term effects (e.g., on the gastrointestinal tract, liver, and mammary gland). Milk-borne factors are constituents of WM, occurring at particularly high concentrations in colostrum (Blum and Hammon, 2000), whereas MR contains few such bioactive substances. The potentially sustained effects of early intensive WM feeding might thus be due to these bioactive substances, but also to energy and protein intake.

We aimed to test the following hypotheses: (1) Feeding WM or MR ad libitum for the first 4 wk of life and continuing thereafter on a restrictive regimen with MR until weaning at 10 wk of life will result in improved performance until d 110 of life, and thereafter during the onset and course of the first lactation; (2) calves fed ad libitum with WM will perform better in later life than calves fed MR ad libitum; and (3) the costs of the 4 wk ad libitum feeding will be balanced by the returns achieved with the lactating animals. The effects of the different feeding strategies on the metabolic and endocrine status from birth over the first lactation are described in a companion paper by Kesser et al. (2017).

MATERIALS AND METHODS

The animal experiments were performed in strict accordance with the German Law for the Protection of Animals and were approved by the relevant authority (Landesuntersuchungsamt Rheinland-Pfalz, Koblenz, Germany; G 11-20-026). Two trials, 1 with calves and 1 with heifers recruited from the initial calf trial, were conducted at the Educational and Research Centre for Animal Husbandry, Hofgut Neumuehle, Muenchweiler a.d. Alsenz, Germany.

Trial 1

Animals, Housing, Feeding, and Sampling. German Holstein calves (29 females and 28 males) were studied from April 2012 to January 2013 during their first 110 d of life. All calves were born spontaneously at term and received 10 mL of iron suspension per os (Sinta fer-o-bac, 115 mg of Fe^{3+}/mL and 108 mg of dextran/mL; Sinta GmbH, Schwarzenborn, Germany). Colostrum milked from their respective dams was provided ad libitum within 2 h after birth in the calving pen next to their dam. Calves were randomly allocated directly after birth to 1 of 3 different feeding groups, but differential feeding was not started until d 4 of life (i.e., after the colostrum phase). From the second feeding time until d 3 of age, all calves received colostrum and transition milk, respectively, ad libitum from their dam. From d 4 to d 27 of age, calves were fed according to their group regimen: calves in the milk replacer restricted group (**MR-res**, n = 20, 10 males and 10 females) received MR (11.5% solids; 42°C mixing temperature and 39°C drinking temperature) limited to 6.78 kg of liquid fed/d (i.e., 0.78 kg of MR powder/d); calves in the milk replacer ad libitum group (**MR-ad lib**, n = 17, 8 males and 9 females) and the whole milk ad libitum group (**WM-ad lib**, n = 20, 10 males and 10 females) had free access 24 h/d to MR (13.8% solids) or WM, respectively. The acidified MR (pH 4.7) was provided by Trouw Nutrition Deutschland GmbH (Burgheim, Germany; Table 1). The WM was saleable bulk tank milk from Hofgut Neumuehle (average 3.9% fat and 3.3% protein) and was acidified with 2 mL of acidifier per L of WM (Schaumacid; H. W. Schaumann GmbH, Pinneberg, Germany) to attain a pH of 4.6. The WM was supplemented with a mix of trace elements and vitamins (1 mL/L Milkivit Quick-Mix, Trouw Nutrition Deutschland GmbH). Neither birth weight (presented in the results section) nor