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Effects of ad libitum milk replacer feeding and butyrate supplementation on behavior, immune status, and health of Holstein calves in the postnatal period

C. Gerbert,* D. Frieten,† C. Koch,*[1] G. Dusel,† K. Eder,‡ T. Stefaniak,§ J. Bajzert,§ P. Jawor,§ A. Tuchscherer,# and H. M. Hammon‖[1]

*Educational and Research Centre for Animal Husbandry, Hofgut Neumuehle, 67728 Münchweiler an der Alsenz, Germany
†Department of Life Sciences and Engineering, University of Applied Sciences Bingen, 55411 Bingen am Rhein, Germany
‡Institute of Animal Nutrition and Nutrition Physiology, Justus-Liebig-University Giessen, 35392 Giessen, Germany
§Department of Immunology, Pathophysiology and Veterinary Preventive Medicine, Faculty of Veterinary Medicine, Wroclaw University of Environmental and Life Sciences, 50-375 Wroclaw, Poland
#Institute of Genetics and Biometry, and
‖Institute of Nutritional Physiology "Oskar Kellner," Leibniz Institute for Farm Animal Biology (FBN), 18196 Dummerstorf, Germany

ABSTRACT

Animal welfare in dairy calf husbandry depends on calf rearing and is probably improved by intensive milk feeding programs. In addition, butyrate supplementation in milk replacer (MR) stimulates postnatal growth and may affect the immune system in calves. We have investigated the combined effects of ad libitum MR feeding and butyrate supplementation on feeding behavior, health, and the immune responses in calves. Holstein calves (n = 64) were examined from birth until wk 11 of age. Calves received MR either ad libitum (Adl) or restrictively (Res) with (AdlB+, ResB+) or without (AdlB−, ResB−) 0.24% butyrate supplementation starting on d 4. From wk 9 to 10, all calves were gradually weaned and were fed 2 L/d until the end of the trial. Concentrate, hay, and water were freely available. Calves were housed in straw-bedded group pens with automatic MR feeders, where feed intake and feeding behavior were documented. Blood was drawn on d 1 before the first colostrum intake; on d 2, 4, and 7; and weekly thereafter until the end of the study to measure plasma concentrations of total protein, albumin, the immunoglobulins IgG_1, IgG_2, and IgM, and the acute phase proteins fibrinogen, serum amyloid A, and haptoglobin. Liver samples were taken on d 50 and 80 to determine gene expression related to acute phase proteins. Body temperature was measured daily for the first 3 wk, and clinical traits were scored daily. Ad libitum MR feeding resulted in greater MR intake, greater MR intake per meal, slower sucking rate, and greater body weight, but in a lower number of unrewarded visits and lower concentrate intake when compared with Res. Butyrate reduced the sucking rate but increased MR intake per meal. Immunoglobulins in the blood plasma increased after colostrum intake in all calves, with only minor differences among groups throughout the study. Plasma fibrinogen and serum amyloid A increased in the first week of life in all calves, and fibrinogen was greater in Res than in Adl on d 21, 49, and 63. Hepatic gene expression of fibrinogen on d 80 was greater in Adl than in Res. Gene expression of *SAA2* was greater on d 50 in Adl than in Res and on d 80 was greater in ResB+ than in ResB−. Body temperature was greater in Adl than in Res during the first 2 wk, but neither MR feeding nor butyrate affected the health status. An improved animal welfare in Adl calves is supported by fewer signs of hunger, but intensive milk feeding and butyrate did not affect the health and immune status of the calves in a consistent manner.

Key words: calf, ad libitum feeding behavior, butyrate, health, immunoglobulin passive transfer

INTRODUCTION

Intensive milk feeding programs may contribute to advanced animal welfare of preweaning calves (von Keyserlingk et al., 2009; Miller-Cushon and DeVries, 2015), indicated by fewer signs of hunger (Hammon et al., 2002; de Paula Vieira et al., 2008; Borderas et al., 2009), greater vitality (de Passillé et al., 2016), and a more robust immune response (Khan et al., 2011; Ollivett et al., 2012; Obeidat et al., 2013) during the postnatal period. Recent findings from a holistic whole transcriptome analysis in a subset of restricted and ad libitum milk replacer (**MR**)-fed calves of the present study indicate a consistently lower activation of the je-

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[1]Corresponding authors: C.Koch@neumuehle.bv-pfalz.de and hammon@fbn-dummerstorf.de

junal mucosal immune system, indicated by a reduction of pathways involved in activation of macrophages and attraction and priming of T cells, in restricted MR-fed calves (Hammon et al., 2018). The milk feeding strategy during the preweaning period may also affect the postweaning immune response in dairy calves (Ballou, 2012; Ballou et al., 2015), pointing to the importance of calf management during early life for long-term health and welfare (Hulbert and Moisa, 2016). However, intensive MR feeding programs are very heterogeneous in their implementation, and some of them revealed negative effects on calf health, especially on fecal scores (Quigley et al., 2006, 2017).

High mortality and morbidity rates still occur in dairy calf rearing. The nutritional management of the preweaning calf is one issue that should be questioned with respect to health and farm animal welfare aspects (von Keyserlingk et al., 2009; Mee, 2013; FAWC, 2015). In addition to adequate colostrum management, growing evidence suggests that insufficient milk or MR supply during the first weeks of postnatal life compromises the maturation and health of dairy calves (Khan et al., 2011, 2016; FAWC, 2015). However, the discussion on the extent of the milk feeding level is still ongoing. Restricted milk feeding to less than 6 L/d in 2 daily portions by bucket is still common (Hill et al., 2016) but leads to abnormal behavior, such as cross-sucking and subsequent health problems (Hammon et al., 2002; Khan et al., 2011; Mahmoud et al., 2016). The opposite is true in beef production, where calves are allowed to drink colostrum and milk ad libitum and are not forced to drink the daily ration in 2 meals (Egli and Blum, 1998; Schiessler et al., 2002; Miller-Cushon and DeVries, 2015). The use of automatic MR feeders allows the intake of more milk or MR than commonly fed, and the daily ration can be divided into several meals to avoid an overload of the abomasum (Hammon et al., 2002; Maccari et al., 2015; Schäff et al., 2016). This feeding method is close to the natural situation (except regulation of feed intake by the mother), avoids hunger, discomfort, and metabolic stress, and therefore may provide improved health in preweaning calves. Calves fed MR ad libitum by an automatic feeder gained more BW and had an elevated IGF-I status (Schäff et al., 2016; Frieten et al., 2017, 2018) that reflects improved body growth but may also stimulate the immune system in calves (Clark, 1997; Khan et al., 2011).

Besides intensive milk feeding, butyrate supplementation of the MR may further improve the development and immune response of calves, especially in artificial rearing systems, because of its well-known effects on maturation of the gastrointestinal tract, growth performance, immune response, and health (Guilloteau et al., 2010; Canani et al., 2011; Jiang et al., 2015). Therefore, we combined the positive effects of intensive MR feeding and butyrate supplementation to study the effects of both treatments on calf health as well as the immune and inflammatory status during the preweaning period. We hypothesized that animal welfare improves with fewer signs of hunger and that health and immune status improve when calves are fed MR ad libitum for the first 8 wk of age and when the MR is supplemented with butyrate.

MATERIALS AND METHODS

The present study was conducted at the Educational and Research Centre for Animal Husbandry, Hofgut Neumuehle, Germany, following the guidelines of the German Law for Animal Welfare by permission of the corresponding authority (G 13–20–068; Landesuntersuchungsamt Rheinland-Pfalz, Koblenz, Germany).

Animals, Housing, and Diets

Sixty-four German Holstein calves (32 females and 32 males) were studied from birth until d 80 ± 2 (mean ± SD) of life. Birth was monitored by the birth alarm system iVet (Papenburg, Germany) to ensure that calves did not suck at the udder before beginning the study. Only healthy calves with complication-free births and a birth weight between 35 and 55 kg were included in the study, as described recently (Frieten et al., 2017). Within 2 h after birth, calves were fed 2.5 ± 0.09 kg (mean ± SD) colostrum from their dams with a calf feeder (speedy feeder, Shoof International Ltd., Cambridge, New Zealand). Five calves were fed the same amount of collected colostrum (pool colostrum of the farm), which was stored at −20°C, because the colostrum from their dams was not available. All calves received 10 mL of an iron suspension per os (115 mg of Fe^{3+}/mL, Sinta fero-bac, Sinta GmbH, Schwarzenborn, Germany). Their navels were disinfected with an iodine lotion (Albrecht GmbH, Aulendorf, Germany) to protect against bacterial infections. Calves were weighed with an electronic scale (Tru-Test Ltd., Auckland, New Zealand) after the first meal. For birth weight determination, colostrum intake was subtracted. Calves were brought 2 to 3 h after birth into straw-bedded single hutches (Flixbox, Mayer Maschinenbaugesellschaft mbH, Tittmoning, Germany) for the first 10 ± 3 (mean ± SD) days of life. Calves were allocated to 1 of 4 treatment groups and were blocked by birth weight, sex, and the number of lactations of their respective dams. Acidified transition milk from their dams (2 mL of Schaumacid/L of milk, H. W. Schaumann GmbH, Pinneberg, Germany) was