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Effect of maternal dry period length on colostrum immunoglobulin content and natural and specific antibody titers in calves

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ABSTRACT

The objective was to study the effect of dry period length in dairy cows on immunoglobulin content and natural antibodies (NAb) titers in colostrum, growth, and plasma natural and specific antibody titers in plasma of calves. Holstein-Friesian dairy cows (n = 167) were randomly assigned to 3 dry period lengths (0, 30, or 60 d). Colostrum production, concentration of colostrum IgG and IgM, and titers of NAb (isotypes IgG and IgM) binding keyhole limpet hemocyanin (KLH) and human serum albumin (HuSA) in colostrum were measured. Female calves were immunized with both KLH and HuSA at wk 6 and 10 of life. Titers of NAb and specific antibody (SpAb) for isotypes IgG, IgM, and total immunoglobulin (IgT) binding KLH or HuSA were determined in plasma of female calves. Primary and secondary antibody responses to KLH or HuSA from wk 6 and 10 were expressed as the increase in antibody titers to wk 10 and 11 of life after primary and secondary challenges, respectively. Pregnancy length for cows with a 0-d dry period was 3 d shorter compared with cows with a 30- or 60-d dry period. Birth weight of calves from cows with a 0-d dry period was lower compared with calves from cows with a 30-d dry period. Growth of calves until 12 wk of life was not affected by dry period length. Colostrum production and IgG and IgM concentration in colostrum were lower for cows with a 0-d dry period than a 60-d dry period. Natural IgG and IgM titers binding KLH or HuSA were lower in colostrum from cows with a 0-d dry period compared with cows with a 60-d dry period. Natural antibody titers (IgG, IgM, and IgT) binding KLH or HuSA in plasma were lower during the first 2 wk of life for calves from cows with a 0-d dry period compared with calves from cows with a 30- or 60-d dry period. After primary and secondary immunization of calves with KLH and HuSA, SpAb titers of calves were not affected by dry period length. After secondary immunization, the response of IgG and IgT binding KLH was higher in plasma of calves from cows with a 0-d dry period. The results of this study demonstrate that, although omission of the dry period of dairy cows leads to lower plasma NAb titers in calves during the first 2 wk of life, SpAb titers in calves were not affected and even the secondary antibody responses were enhanced compared with calves from cows with a 30- or 60-d dry period.

Key words: continuous milking, colostrum, antibodies, calf

INTRODUCTION

Omission of the dry period of cows results in better energy balance and metabolic health in the next lactation (Andersen et al., 2005; Rastani et al., 2005). Omission of the dry period is controversial because of a potential decrease in milk production in the subsequent lactation (Annen et al., 2004; Santschi et al., 2011a). A meta-analysis including 24 randomized controlled trials (van Knegsel et al., 2013) reported that shortening or omitting the dry period reduced milk production and increased milk protein content. In addition, shortening the dry period tended to reduce the incidence of ketosis in the subsequent lactation. Earlier studies showed that shortening the dry period to 4 wk did not affect colostrum immunoglobulin content (Annen et al., 2004; Rastani et al., 2005; Watters et al., 2008; Klusmeyer et al., 2009), pregnancy length (Santschi et al., 2011b), and birth weight of calves (Rastani et al., 2005; Pezeshki et al., 2007) compared with a dry period of 8 wk. Omission of the dry period, however, reduced colostrum immunoglobulin content (Annen et al., 2004; Rastani et al., 2005; Klusmeyer et al., 2009; Verweij et al., 2014), which may affect the immune competence of the calf. Adequate and sufficient passive immune transfer of maternal antibodies via colostrum intake may improve the immune competence of calves and would

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reduce the risk of diseases and infections during the preweaning period (Oliveira et al., 2010).

Natural antibodies (**NAb**) may play an important role in the development of immune competence. Natural antibodies are part of the innate immune system (Matter and Ochsenbein, 2008; Vollmers and Brändlein, 2009) and can be defined as antibodies present in healthy animals under the absence of antigen stimulation (Avrameas, 1991; Baumgarth et al., 2005), as opposed to specific antibodies (**SpAb**), which are raised to antigens after immunization. Natural antibodies are polyreactive with low affinity binding with various antigens (Casali and Notkins, 1989). Natural antibodies link innate and adaptive immunity, as they target antigens to the splenic marginal zone enhancing T-cell and T-cell-dependent antibody responses (Matter and Ochsenbein, 2008), and activate complement activity. Zinkernagel (2012) proposed that NAb form an important protection for resistance to infection. In chickens, NAb binding *Megathura crenulata*-derived keyhole limpet hemocyanin (**KLH**) were related to a higher probability of survival during the laying period (Star et al., 2007; Sun et al., 2011). In mammals (Tomer and Shoenfeld, 1988; Thornton et al., 1994; Ochsenbein et al., 1999) and birds (Lammers et al., 2004; Parmentier et al., 2004), various specific humoral immune responses are enhanced by high NAb titers or are positively correlated with high NAb titers. Conversely, high NAb levels might interfere with or prevent subsequent SpAb responses (Parmentier et al., 2008), whereas low NAb levels might facilitate or initiate higher SpAb responses (Sinyakov et al., 2002).

Natural antibodies were found in plasma of newborn calves (Srinivasan et al., 1999). In dairy cows, calves obtain maternal antibodies passively from the dam through colostrum. Natural antibodies in plasma of newborn calves were lower than in adult cows (Srinivasan et al., 1999) and NAb titers differ widely among adults (Srinivasan et al., 1999; Ploegaert et al., 2011). In addition, titers of NAb binding KLH or LPS were related to the energy balance of dairy cows in early lactation (van Knegsel et al., 2007). Knowledge on the effect of shortening or omitting the dry period of dairy cows on NAb in colostrum and the consequences for immune competence and development of calves is, however, absent.

As calves obtain passive immunity via colostrum, it was hypothesized that management or dietary strategies that affect immunoglobulin content in colostrum may affect immune competence of calves. The first objective of the present study was to evaluate the effect of dry period length in dairy cows on immunoglobulin content and NAb titers in colostrum, and growth and plasma NAb and SpAb titers of calves. The second objective was to study the responses of total immunoglobulin (**IgT**) and the isotypes IgG and IgM binding KLH and human serum albumin (**HuSA**) after primary and secondary immunization in these calves at wk 6 and 10, respectively.

MATERIALS AND METHODS

Experimental Design, Animals, and Colostrum Sampling

The Institutional Animal Care and Use Committee of Wageningen University approved the experimental protocol. Holstein-Friesian dairy cows (n = 167) were selected from the Dairy Campus Research dairy herd (WUR Livestock Research, Lelystad, the Netherlands), blocked for parity, calving date, milk yield, and BCS, and randomly assigned to treatments. Cows enrolled in our study were clinically healthy and had SCC in milk $<250 \times 10^3$ cells/mL. Treatments consisted of 3 dry period lengths, 0, 30, or 60 d, and 2 diets in early lactation (glucogenic or lipogenic) in a 3 × 2 factorial design. The experiment started with 60 primiparous and 107 multiparous cows. Cows were housed in a freestall with slatted floor and cubicles and milked twice daily (0500 and 1630 h).

Diets

Diet composition was described previously (van Knegsel et al., 2014). Prepartum, dry cows received a dry cow diet and lactating cows received a lactation diet supporting 25 kg of milk. From 10 ± 5 d prepartum, cows were fed 1 kg/d of the experimental concentrate (glucogenic or lipogenic). Postpartum, all cows received 1 kg of experimental concentrate, which was increased stepwise by 0.5 kg/d until concentrate supply reached 8.5 kg/d at d 17 postpartum. Experimental concentrates were provided by a computerized feeder located in the freestall. In addition, lactating cows received 1 kg/d of standard lactation concentrate in the milking parlor. Forage did not differ between diets, was supplied ad libitum, and consisted of grass silage, corn silage, wheat straw, and a protein source (rapeseed meal or soybean meal) in a ratio of 39:25:25:11 (DM basis). Postpartum, forage consisted of grass silage, corn silage, straw, and a protein source (rapeseed meal or soybean meal) in a ratio 51:34:2:13 (DM basis).

Management of Calves

Immediately after birth, calves were removed from dam. When calves were born between 2200 until 0500 h (n = 42) they were removed from the dam at 0500