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Fecal and saliva IgA secretion when feeding a concentrated mannan oligosaccharide to neonatal dairy calves

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ABSTRACT

The influence of supplementing milk replacer with a mannan-rich fraction (MRF) on adaptive immunity and growth of neonatal dairy calves was investigated using 2 groups of 30 heifer calves. In conjunction, the potential of measuring salivary and fecal IgA as an indicator of mucosal health was studied. Milk replacer was supplemented with 0 or 1 g/d of yeast-derived MRF (Actigen; Alltech Inc., Nicholasville, KY) and fed through weaning at 6 wk of age. Average daily gain tended to be greater for calves fed MRF (517 vs. 411 g/d; $P < 0.07$), but no effects were observed in measures of skeletal growth. Calves fed MRF in milk replacer had fewer days with high scour scores compared with control calves, and salivary and fecal IgA were elevated earlier in life for MRF-fed calves. No differences were observed in respiratory illness between treatments. In conclusion, salivary IgA was found to be an indicator of fecal IgA; however, it was not as sensitive a measurement of scours because it parallels what is happening in feces. In addition, MRF-fed calves had improved fecal scores compared with control calves in this study where all calves had some level of cryptosporidium infection that was a direct cause of scours.

Key words: dairy calf, mannan oligosaccharide, prebiotic supplement, fecal IgA, salivary IgA

INTRODUCTION

Supplementation of calf milk replacer with mannan oligosaccharide (**MOS**) has become relatively common in the United States and throughout the world, presumably in response to societal pressure to limit the use of antibiotics in animal production. Despite its commercial use in milk replacer, research over the past decade has found calf performance when feeding MOS has varied. In some reports, feeding MOS in milk replacer led to improved ADG and feed efficiency (Król, 2011; Ghosh and Mehla, 2012), whereas in other studies no growth effects were detected (Hill et al., 2008; da Silva et al., 2012). Likewise, in some experiments MOS has improved fecal consistency and reduced severity of diarrhea (Heinrichs et al., 2003; Morrison et al., 2010), but in others this effect has not been observed (Uzmay et al., 2011; da Silva et al., 2012). Many gram-negative bacteria attach to the intestinal epithelium using mannose-specific fimbriae, and MOS has limited bacterial colonization of the gut in monogastric species by providing competitive binding sites (Spring et al., 2000). In a recent review of MOS mode of action in monogastric species, Halas and Nochta (2012) concluded that MOS can efficiently reduce the number of pathogens during an infection but results in a clean environment, and the effects of MOS on beneficial bacteria are inconsistent. Supplementation with MOS has been shown to increase intestinal mucous production in turkeys, aid recovery of damaged intestinal mucosal cells in piglets, and enhance gut maturation in broilers (Halas and Nochta, 2012). In addition, MOS has been found to improve both specific and nonspecific immune responses (Halas and Nochta, 2012). These functions are positive and appear promising in terms of using MOS to reduce diarrhea incidence and severity in the neonatal calf.

Immunoglobulin A is the main element of the humoral response that provides protection against antigens at mucosal surfaces. As such, IgA is normally found in saliva and in small intestinal secretions (Newby and Bourne, 1976). It is important for

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Table 1. Nutrient composition of milk replacer and calf starter fed to 30 Holstein calves[1]

Item	Milk replacer Mean	Milk replacer SD	Calf starter
DM (%)	94.7	0.6	85.5
Moisture (%)	5.2	0.6	14.5
CP (% DM)	20.9	0.5	20.1
Soluble protein (% CP)	—	—	14.1
Fat acid hydrolysis (% DM)	19.9	0.3	—
ADF (% DM)	—	—	7.4
NDF (% DM)	—	—	16.2
Ash (% DM)	—	—	7.2
Ca (% DM)	0.7	0.1	1.15
P (% DM)	0.7	0.0	0.52
Mg (% DM)	—	—	0.35
K (% DM)	—	—	1.51
Na (% DM)	0.9	0.1	0.51
Fe (mg/kg)	—	—	325
Mg (mg/kg)	—	—	79
Zn (mg/kg)	—	—	115
Cu (mg/kg)	—	—	16
TDN (% DM)	—	—	77.9
NE_m (Mcal/kg)	—	—	1.87
NE_g (Mcal/kg)	—	—	1.23

[1]Milk replacer contained 0.05 g/kg of Deccox (Alpharma Inc., Bridgewater, NJ).

gut homeostasis and the interactions between B cells and bacterial flora in the gut. Secretory IgA is found in bovine colostrum, but this form of IgA is short lived and has a 2-d half-life (Porter, 1972). Typical IgA concentrations observed in colostrum range from 0.5 to 4.4 mg/mL with an average of 1.66 mg/mL, or approximately 3% of the total Ig found in bovine colostrum (Kehoe et al., 2007). This means that any maternal IgA derived from colostrum fed immediately after birth will be at very low levels in the blood of neonatal calves by 4 to 6 d of age. In total, IgA has been studied very little in the bovine neonate. Our objective was to study the influence of supplementing milk replacer with a mannan-rich fraction (**MRF**) on adaptive immunity and growth of neonatal dairy calves.

MATERIALS AND METHODS

This study was approved by the Institutional Animal Care and Use Committee of the Pennsylvania State University (IACUC #34829). Two groups of 30 heifer calves were randomly assigned to treatment at birth. Calves were fed colostrum for 2 feedings (1 d) and transition milk for 2 d before being changed to milk replacer. Colostrum was analyzed for IgG and IgA concentration using ELISA (Bethyl Laboratories Inc., Montgomery, TX). Immunoglobulin status at 24 h of age was estimated by measuring blood total protein with a refractometer to ensure that calves received adequate antibodies from colostrum by passive transfer.

The control group was fed twice daily using a commercial milk replacer (20% protein, 20% fat; Milk Specialties Global, Eden Prairie, MN; Table 1). The treatment group was fed the same milk replacer supplemented with yeast-derived MRF mixed at 1 g/d (Actigen; Alltech Inc., Nicholasville, KY). Actigen is a second-generation, mannan-rich, bioactive fraction derived from the outer wall of a specific strain of yeast. Milk replacer was fed twice daily at 6% of BW per feeding, and starter grain and water were provided ad libitum. During wk 5 of age, milk was fed at 6% of BW one time a day only; calves were weaned at 6 wk of age. Starter grain (Eastgate Feed Mill, Eastgate, PA; Table 1) was added daily, with uneaten grain collected weekly to monitor feed intake. There were no milk replacer refusals.

Scores evaluating fecal matter, respiratory health, and overall general appearance were assigned daily to evaluate health performance between groups (Lesmeister et al., 2004). All diagnosed illnesses and treatments given were recorded.

Body weight was measured at birth and growth parameters were measured weekly thereafter, including weight, hip height, withers height, and heart girth. Saliva samples were collected at d 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20 using a small cotton ball placed inside the mouth of the calf until it was reasonably wet (1 to 2 min). The cotton with absorbed saliva was placed in a 10-mL syringe and compressed to recover liquid. Fecal samples were taken from the rectum on d 2, 4, 6, 8, 10, 12, 14, 16, 18, and 20. Saliva and fecal samples were analyzed for IgA content using ELISA (Bethyl Laboratories).

Samples of grain and milk replacer were taken weekly. Respective samples were composited and stored at −20°C for standard feed analysis (Cumberland Valley Analytical Service, Hagerstown, MD).

Data were analyzed using the Mixed procedure of SAS (Version 8, SAS Institute Inc., Cary, NC) allowing for repeated measures. Calves were considered random. Nonlinear time was accounted for with polynomial terms when needed. Treatment-by-time interactions up to the highest polynomial needed were considered but removed for reasons of parsimony when not significant. Adjusted means at specific times of interest were compared. After taking advantage of the longitudinal nature of the data in the statistical analysis, the more easily understood estimated concentrations and confidence bands were computed. Where confidence bands do not over-