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Effects of Feeding Propionibacteria to Dairy Cows on Milk Yield, Milk Components, and Reproduction[1]

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ABSTRACT

Two weeks before parturition, 38 Holstein primiparous and multiparous cows were assigned to 1 of 3 treatment groups: control animals (n = 13) received regular total mixed rations (TMR), the low-dose group (n = 14) received the control TMR plus 6×10^{10} cfu/cow of *Propionibacterium* strain P169 (P169), and the high-dose group (n = 11) received the control TMR plus 6×10^{11} cfu/cow of P169 from –2 to 30 wk postpartum. Weekly milk samples were analyzed for percentage of milk fat, protein, lactose, and SNF, milk urea nitrogen, and somatic cell counts. Daily milk production expressed as 4% fat-corrected milk was affected by treatment and week × parity. High-dose and low-dose P169-treated cows exhibited 7.1 and 8.5% increases above controls in daily 4% fat-corrected milk, respectively. Treatment × parity and week significantly influenced percentage of milk fat, lactose, and protein, whereas treatment × parity and treatment × week influenced SNF. Ruminal propionate levels were influenced by treatment such that high-dose P169 cows had greater molar percentage of propionate than did low-dose P169 and control cows. Change in body weight postpartum was influenced by week × parity and treatment × parity such that high-dose and low-dose P169 multiparous cows exhibited a more rapid recovery of wk-1 body weight than did control multiparous cows. There was no treatment, parity, or interaction on days to first postpartum ovulation or on estrous behavior at 45 and 90 d postpartum. We concluded that P169 might have potential as an effective direct-fed microorganism to increase milk production in dairy cows.
Key words: propionibacteria, direct-fed microorganism, milk production, estrous detection

INTRODUCTION

After parturition, dairy cows are challenged with a sudden increase in nutrient requirements for lactation (Drackley, 1999; Lucy, 2001). Propionibacteria are natural inhabitants of the rumen and produce propionate, a major precursor for glucose production through hepatic gluconeogenesis (Sauer et al., 1989). Theoretical efficiency of propionate as a source of energy for ATP is 108% compared with glucose (McDonald et al., 2002), and thus directly feeding propionibacteria may be a natural way to increase hepatic glucose production and positively influence metabolism (Francisco et al., 2002). Postpartum dairy cows first partition metabolizable energy toward milk production and body condition gain before reproductive functions (Lucy, 2001); therefore, direct-fed microorganisms have potential to increase reproductive and metabolic efficiency during lactation (Yoon and Stern, 1995; Ghorbani et al., 2002). However, only one study has evaluated the effect of direct-fed propionibacteria (fed at a single amount) on the lactational performance of dairy cows in early lactation (Francisco et al., 2002). The present study was conducted to evaluate the effect of feeding 2 levels of the direct-fed microorganism, *Propionibacterium* P169, for 30 wk on milk production, milk components, and reproductive efficiency of dairy cows.

MATERIALS AND METHODS

Experimental Design and Sample Collection

Two weeks before parturition, 19 primiparous and 19 multiparous Holstein cows housed at the Oklahoma State University (OSU) Dairy Cattle Center were randomly assigned to 1 of 3 dietary treatment groups, based on age, expected calving date, and the previous year's lactation averages (for multiparous) or current PTA (for primiparous). The control group (n = 5 primiparous, n = 8 multiparous) received a lactation TMR (Table 1), the low-dose group (n = 8 primiparous, n = 6 multiparous) received the control TMR plus 6×10^{10} cfu/cow of *Propionibacterium* strain P169 (low-dose P169), and the high-dose group (n = 6 primiparous, n =

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Table 1. Ingredient and nutrient composition of the control transition diet (TD) and lactation diet (LD). The TD was fed from d −14 to parturition and the LD was fed from parturition through 30 wk postpartum.

Ingredient, % (DM basis)	Transition diet	Lactation diet
Sorghum silage	28.53	16.44
Alfalfa (RFV 180)	0.00	16.94
Bermuda grass hay	13.95	6.53
Whole cottonseed	0.00	4.07
Corn gluten feed	21.87	6.60
Megalac-R[1]	0.00	0.91
Grain mix		
Ground corn	21.26	27.84
Wheat middlings	3.92	8.16
Soybean meal (SBM)	3.94	6.79
Extruded SBM	3.43	2.59
Calcium carbonate	1.28	0.94
Sodium bicarbonate	0.00	0.54
Diamond V yeast[2]	0.45	0.55
Magnesium oxide	0.29	0.27
Salt, white	0.20	0.27
Zinpro 4-Plex[3]	0.20	0.07
Vitamin-trace mineral pak	0.38	0.27
Calcium chloride	0.20	0.00
Nutrient		
DM, % (as fed)	60.8	55.9
CP, %	12.8	17.1
ADF, %	33.8	25.1
NDF, %	53.5	38.7
NE_L, Mcal/kg	1.43	1.67
Ca, %	0.80	0.97
P, %	0.31	0.41
Mg, %	0.39	0.36
K, %	1.08	1.44
Na, %	0.23	0.25
S, %	0.15	0.20
Zn, ppm	72.75	58.00
Fe, ppm	247.75	281.25
Cu, ppm	18.75	16.83
Mn, ppm	103.75	75.42
Mo, ppm	<1.0	1.20

[1]Arm & Hammer Animal Nutrition Group, Princeton, NJ; Megalac-R contains: fat (as fatty acids), 82.5%; Ca, 8.5%; IOD (moisture), 3 to 4%.

[2]Diamond V-XP Yeast Culture, Diamond V Mills Inc., Cedar Rapids, IA.

[3]Zinpro Corp., Eden Prairie, MN; Zinpro 4-Plex contains: Zn, 2.58%; Mn, 1.43%; Cu, 0.90%; Co, 0.18%; Methionine, 8.21%; Lysine, 3.8%.

[4]Contents per kilogram: vitamin A (1,650,000 IU), vitamin D_3 (517,000 IU), vitamin E (8,800 IU), biotin (352 mg), Ca (15.4%), Mn (1.0%), Zn (8,600 ppm), Fe (6,000 ppm), Cu (1,500 ppm), iodine (250 ppm), and Se (110 ppm).

5 multiparous) received the control TMR plus 6×10^{11} cfu/cow of P169 (high-dose P169). This particular *Propionibacterium* strain (P169) was originally isolated from rumen fluid collected from fistulated dairy cows at the OSU Dairy Cattle Center (Davidson, 1998), and was manufactured by Agtech Products Inc. (Waukesha, WI) as a viable freeze-dried cell preparation containing strain P169 fermentation product and maltodextran as a carrier. The 305-d mature equivalent milk production for control, low-dose, and high-dose multiparous cows was 10,265 ± 716 kg, 10,439 ± 905 kg, and 10,174 ± 905 kg, respectively, and did not differ ($P > 0.97$) among treatment groups. The PTA for control, low-dose, and high-dose primiparous cows was +120 ± 104, +236 ± 78, and +187 ± 95 kg, respectively, and did not differ ($P > 0.67$) among treatment groups. The TMR was formulated to support daily milk production of at least 45 kg and comprised sorghum/sudan silage, alfalfa hay, Bermuda grass hay, whole cottonseed, corn gluten feed, Diamond V-XP yeast culture (Diamond V-XP Yeast Culture; Diamond V Mills Inc., Cedar Rapids, IA), and mineral concentrate (Table 1). The TMR was sampled weekly and composited monthly throughout the study for analysis by Dairy One Inc., Forage Testing Laboratory (Ithaca, NY). The lactation TMR analysis averaged 17.07 ± 0.33% CP, 1.67 ± 0.006 Mcal of NE_L/kg, 68.67 ± 0.55% total digestible nutrients, 25.06 ± 0.87% ADF, 38.73 ± 1.0% NDF, and 0.97 ± 0.03% Ca on a DM basis. The 2-wk prepartum feeding period consisted of the P169 treatments with substitution of the lactation TMR with the transition TMR (Table 1). The number of treatment days before parturition did not differ ($P > 0.28$) among control, low-dose P169, and high-dose P169 groups (13 ± 2 d, 14 ± 2 d, and 18 ± 2 d, respectively). Cows had free access to water and were housed in the same open-air free-stall barn, but divided into 3 separate free-stall and feeding areas according to treatment group. Cows were individually fed the P169 via top-dress on 4.5 kg of TMR once a day (1700 h) while isolated in a free stall. Otherwise, cows were provided feed ad libitum in 2 allocations fed daily at 0900 and 1800 h.

Cows calved between August 26, 2002 and October 25, 2002, with no difference ($P > 0.36$) in date of birth among groups: average day of birth for the control, low-dose P169, and high-dose P169 groups were Julian d 270 ± 5, 261 ± 5, 269 ± 5, respectively. Local climate data for the 30-wk experiment, collected 1.6 km from the OSU Dairy Cattle Center, were obtained from the Oklahoma Mesonet (Norman, OK). The highest weekly average maximum temperature (24.9 ± 1.6°C) occurred at wk 1 of lactation and lowest weekly average minimum temperature (−4.3 ± 0.7°C) occurred at wk 19 of lactation; no significant differences were observed among groups in weekly average minimum and maximum temperature during wk 1 to 25 or wk 25 to 30 (time of bST administration).

To assess the effects of feeding P169 during concomitant bST administration, bST [Posilac (sterile sometribove zinc suspension; 500 mg); Monsanto, St. Louis, MO] was administered every 2 wk to all cows from wk 25 to 30 of lactation; a total of 3 injections were given in the ischiorectal fossa (s.c.) and diet treatments continued during bST administration. Because all cows were injected with bST, measurements taken before