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Prepartum Intake, Postpartum Induction of Ketosis, and Periparturient Disorders Affect the Metabolic Status of Dairy Cows*

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ABSTRACT

Nutritional management during the dry period may affect susceptibility of cows to metabolic and infectious diseases during the periparturient period. Thirty-five multiparous Holstein cows were used to determine the effect of prepartum intake, postpartum induction of ketosis, and periparturient disorders on metabolic status. Cows were fed a diet from dry-off to parturition at either ad libitum intake or restricted intake [RI; 80% of calculated net energy for lactation (NE_L) requirement]. After parturition, all cows were fed a lactation diet. At 4 d in milk (DIM), cows underwent a physical examination and were classified as healthy or having at least one periparturient disorder (PD). Healthy cows were assigned to the control (n = 6) group or the ketosis induction (KI; n = 9) group. Cows with PD were assigned to the PD control (PDC; n = 17) group. Cows in the control and PDC groups were fed for ad libitum intake. Cows in the KI group were fed at 50% of their intake on 4 DIM from 5 to 14 DIM or until signs of clinical ketosis were observed; then, cows were returned to ad libitum intake. During the dry period, ad libitum cows ate more than RI cows; the difference in intake resulted in ad libitum cows that were in positive energy balance (142% of NE_L requirement) and RI cows that were in negative energy balance (85% of NE_L requirement). Prepartum intake resulted in changes in serum metabolites consistent with plane of nutrition and energy balance. Prepartum intake had no effect on postpartum intake, serum metabolites, or milk yield, but total lipid content of liver at 1 d postpartum was greater for ad libitum cows than for RI cows. The PD cows had lower intake and milk yield during the first 4 DIM than did healthy cows. During the ketosis induction period, KI cows had lower intake, milk yield, and serum glucose concentration but higher concentrations of nonesterified fatty acids and β-hydroxybutyrate in serum as well as total lipid and triacylglycerol in liver than did control cows. Cows with PD had only modest alterations in metabolic variables in blood and liver compared with healthy cows. The negative effects of PD and KI on metabolic status and milk yield were negligible by 42 DIM, although cows with PD had lower body condition score and BW. Prepartum intake did not affect postpartum metabolic status or milk yield. Periparturient disorders and induction of ketosis negatively affected metabolic status and milk yield during the first 14 DIM.
(**Key words:** prepartum intake, ketosis, periparturient disorder, periparturient cow)

Abbreviation key: AP = alkaline phosphatase, **AST** = aspartate aminotransferase, **GGT** = gamma glutamyl transferase, **KI** = ketosis induction, **PD** = periparturient disorder, **PDC** = periparturient disorder control, **RI** = restricted intake, **SDH** = sorbitol dehydrogenase.

INTRODUCTION

Nutritional management during the dry period may affect susceptibility of cows to metabolic disorders and infectious diseases during the periparturient period (Grummer, 1995; Drackley, 1999). The current convention is to maximize DMI and energy intake prepartum and minimize the drop in DMI as parturition approaches (Grummer, 1995; Mashek and Grummer, 2003). Douglas (2002) challenged the convention of maximizing DMI and suggested that moderate feed restriction (allowing only 80% of NE_L requirement) during the dry period actually may result in less total lipid and triacylglycerol accumulation in the liver and higher DMI after parturition. Other reseachers have evaluated feed and energy restriction resulting in a negative energy balance during the dry period and found no effect on postpartum intake (Boisclair et al., 1986), an increase in postpartum intake (Tesfa et al., 1999), no effect on milk yield (Boisclair et al., 1986), an increase

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in milk yield (Tesfa et al., 1999), no effect on blood metabolites and health (Boisclair et al., 1987), and no effect on liver total lipid (Tesfa et al., 1999) compared with cows fed at or above energy requirement.

Douglas (2002) fed diets that were either high in nonstructural carbohydrates or high in fat during the entire dry period. Groups of cows consumed each diet either for ad libitum intake or in amounts restricted to provide 80% of calculated NE_L requirement. During the prepartum period, restricted-fed cows, regardless of diet, had lower concentrations of glucose and insulin and higher concentrations of NEFA in plasma. Postpartum concentrations of total lipid and triacylglycerol in liver were approximately 50% of those in cows that were fed for ad libitum DMI during the dry period. Based on research by Douglas (2002), we speculated that cows that were feed-restricted during the dry period would be more resistant to development of ketosis after parturition. As a first step in testing this hypothesis, the objective of this study was to evaluate the effects of prepartum intake, postpartum health, and postpartum induction of ketosis on the metabolic status of multiparous Holstein cows.

MATERIALS AND METHODS

Experimental Design and Management of Cows

All procedures were conducted under protocols approved by the University of Illinois Institutional Animal Care and Use Committee. Thirty-five multiparous Holstein cows were fed a diet (Table 1) in the form of a TMR from dry-off (approximately –60 d relative to expected parturition) to parturition at either ad libitum intake (n = 17) or restricted intake (**RI**; n = 18). Intake was restricted to 80% of calculated NE_L requirement (NRC, 1989). A close-up premix (Table 1) and calcium carbonate were added to the prepartum diet beginning –21 d relative to expected parturition; the amount of this TMR offered continued to be restricted to the same amount. After parturition, all cows were fed a lactation diet (Table 1). Alfalfa hay (~2 kg of DM) was top-dressed on the lactation TMR from parturition through 14 DIM.

At 4 DIM, cows underwent a thorough physical examination (described subsequently) and were classified as healthy (n = 15) or having at least one periparturient disorder (**PD**; n = 17). Healthy cows were assigned to either the control (n = 6) group or to the ketosis induction (**KI**; n = 9) group. Cows with PD were assigned to the periparturient disorder control (**PDC**; n = 17) group; no cows with PD were assigned to the KI group. Three cows were excluded from the postpartum data sets for reasons unrelated to this study. Cows in the control and PDC groups were fed for ad libitum intake. Ketosis induction was by feed restriction (Bahaa et al., 1997). Beginning at 5 DIM, cows in the KI group were fed at 50% of their intake at 4 DIM until signs of clinical ketosis (anorexia, ataxia, or abnormal behavior) or until

Table 1. Ingredient and chemical composition of diets fed to multiparous Holstein cows during the dry and lactating periods.

Component	Diet		
	Far-off dry[1]	Close-up dry[2]	Lactation[3]
	(% of DM)		
Ingredient			
Alfalfa hay	14.30	13.12	—
Alfalfa silage	15.30	14.03	20.00
Corn silage	53.20	48.80	25.00
Cottonseed	2.00	1.83	10.00
Ground shelled corn	5.00	4.59	26.65
Soybean meal	4.50	4.13	13.50
Soy hulls	—	—	1.50
Oat hulls	4.47	4.10	—
Mineral-vitamin mix[4]	0.20	0.18	0.25
Vitamin E[5]	0.25	0.23	—
Sodium chloride	0.53	0.49	0.25
Magnesium oxide	0.25	0.23	0.14
Calcium carbonate	—	1.17	—
Close-up premix[6]	—	7.10	—
Sodium bicarbonate	—	—	1.00
Dicalcium phosphate	—	—	0.45
Limestone	—	—	1.10
Sodium sulfate	—	—	0.16
Chemical[7]			
n[8]	8	8	8
CP	15.2 ± 0.4[9]	14.6 ± 0.4	18.7 ± 0.4
ADF	31.8 ± 0.4	29.2 ± 0.4	20.7 ± 0.4
NDF	45.6 ± 0.7	41.8 ± 0.6	29.5 ± 0.4
NE_L,[10] Mcal/kg	1.60 ± 0.04	1.47 ± 0.03	1.77 ± 0.02
Ca	0.58 ± 0.02	1.44 ± 0.02	0.99 ± 0.05
P	0.38 ± 0.01	0.38 ± 0.01	0.50 ± 0.02
Mg	0.37 ± 0.01	0.52 ± 0.01	0.32 ± 0.01
K	1.56 ± 0.06	1.46 ± 0.05	1.22 ± 0.05
Na	0.30 ± 0.01	0.27 ± 0.01	0.49 ± 0.04

[1]Far-off dry period diet was fed from dry-off until –22 d before expected parturition.

[2]Close-up dry period diet was fed from -21 d before expected parturition.

[3]Alfalfa hay (~2 kg of DM) was top-dressed on the lactation diet from parturition to 14 DIM.

[4]Contained a minimum of 5% Mg, 10% S, 7.5% K, 2.0% Fe (from iron sulfate), 3.0% Zn (from zinc oxide), 3.0% Mn (from manganous oxide), 5000 mg/kg of Cu (from copper sulfate), 250 mg/kg of I (from calcium iodate), 40 mg/kg of Co (from cobalt carbonate), 150 mg/kg of Se (from sodium selenite), 2200 kIU/kg of vitamin A, 660 kIU/kg of vitamin D_3, and 7700 IU/kg of vitamin E.

[5]Contained 44,000 IU/kg.

[6]Contained 10% CP, 1% fat, 3% crude fiber, 6.3% Ca, 0.3% P, 2.5% Mg, 3.2% S, 0.43% K, 11% Cl, 6.6 mg/kg of Se, 110 kIU/kg of vitamin A, 44 kIU/kg of vitamin D_3, 1320 IU/kg of vitamin E, and 13,200 mg/kg of niacin.

[7]Calculated from monthly analyses of individual ingredients in diets.

[8]Number of samples used to determine the chemical composition of the diet.

[9]Mean ± standard error.

[10]Calculated by Dairy One (Ithaca, NY) using the NRC (1989) energy equations for concentrates and the Van Soest variable discount method for forages.