Effect of Yeast Culture (*Saccharomyces cerevisiae*) on Adaptation of Cows to Postpartum Diets and on Lactational Performance[1]

P. H. Robinson* and J. E. Garrett†

*Department of Animal Science, University of California, Davis 95616-8521, and †Diamond V Mills Inc., Cedar Rapids, IA 52407

ABSTRACT: Multiparous (n = 26) and primiparous (n = 18) Holstein cows were fed prepartum and postpartum total mixed diets that were, or were not, supplemented with a yeast culture (YC) for approximately 23 d prepartum and 56 d postpartum. Multiparous cows supplemented with YC selected a prepartum diet higher in CP than did unsupplemented cows, although prepartum performance of cows of both parities, as assessed by DMI and measures of body status, was not influenced by YC. The extent of the prepartum DMI depression was not influenced by YC supplementation in cows of either parity. An intake behavior study with six multiparous cows suggested that cows supplemented with YC exhibited repeated diurnal feed intake patterns until approximately 7 d prepartum, vs 10 d prepartum for unsupplemented cows. Cows of both parities supplemented with YC had numerically higher DMI and production of milk and milk components, although only DMI for multiparous cows and milk production for primiparous cows approached statistical significance. Intake behavior results suggested that cows supplemented with YC achieved repeated diurnal feed intake patterns by approximately 14 d postpartum, vs 20 d postpartum for unsupplemented cows. Concentrations of ruminal metabolites and pH did not differ between treatments, although ruminal fluid collection occurred while diurnal feed intake patterns were repeated (regular). Overall, our results can be interpreted to support a trend toward a modest postpartum improvement in performance of primiparous and multiparous cows supplemented with this YC for 23 d prepartum and 56 d postpartum. However, primiparous cows seemed to achieve this modest overall improvement primarily through enhanced postpartum DMI, whereas in multiparous cows it was due almost equally to enhanced postpartum DMI and higher energy density of the diet.

Key Words: Yeasts, Cultures, Dairy Cows, Parturition, Transition

 J. Anim. Sci. 1999. 77:988–999

Introduction

Dairy cows with the potential to produce high volumes of milk can increase DMI by as much as 150% between calving and wk 8 postpartum. To facilitate and stimulate this increase, it is important that cows remain on feed immediately prior to and during calving. However, Bertics et al. (1992) and Van Saun et al. (1993) have demonstrated depressions in DMI of up to 40% beginning 7 to 10 d prepartum in cows fed a diet with a high intake potential. Although a more recent study (Robinson, 1997) only showed a DMI depression of approximately 15% in multiparous cows fed a prepartum diet with a low intake potential, this intake depression would be expected to make cows more susceptible to metabolic diseases associated with calving, such as ketosis and milk fever, and slower to adapt to the postpartum diet.

Yeast culture (**YC**) products have been shown to modify ruminal fermentation (Wiedmeier et al., 1987; Harrison et al., 1988), to increase numbers of ruminal bacteria (Harrison et al., 1988) and stimulate their growth (Dawson et al., 1990; Erasmus et al., 1992), and to increase milk production in early-lactation cows (McCoy et al., 1997; Sanchez et al. 1997). If the reduction in DMI in the 7 to 10 d prior to calving is precipitated by an imbalance in ruminal fermentation, it is possible that YC added to the diet may prevent this reduction by stimulating microbial growth. However, if the prepartum reduction in DMI is caused by reduced rumen volume due to fetal growth, or by a change in intermediary metabolism leading to a reduced ability to metabolize absorbed nutrients, then the addition of dietary YC would be expected to have little effect.

[1]This study was completed under the auspices of the Atlantic Dairy and Forage Institute, in Fredericton Junction, NB, Canada.

Received May 14, 1998.
Accepted September 21, 1998.

DA010-j

The objective of this study was to examine the impact of adding a YC to the diet of dairy cows for 21 d prepartum and 56 d postpartum on DMI before, during, and immediately after parturition. In addition, the influence of YC on postpartum performance of dairy cows was determined.

Materials and Methods

Production Study

Cows and Diets. Forty-seven pregnant Holstein cows were used. Cows were tethered in tie stalls and had free access to water. All cows began the experiment between 21 and 28 d prior to their expected calving date. One of two grain-based concentrates, either with or without a YC supplement (27.2% of DM; Table 1), corn silage (24.9% of DM; Table 2), and timothy silage (47.8% of DM; Table 2) was used to formulate two total mixed rations (**TMR**; Table 3) that were fed for ad libitum consumption (5% orts) in two meals per day, at 1630 (2/3 of the daily offer) and 0600 (the balance), to cows on the respective treatments. Orts were removed and weighed between 1300 and 1330 daily, and all cows received between 60 and 90 min/d of drylot exercise beginning at 0730.

At calving, all cows were changed abruptly to a TMR (Table 3) of corn silage (23.7% of DM; Table 2), timothy silage (18.9% of DM; Table 2), and one of two grain-based concentrates, either with or without a YC supplement (57.4% of DM; Table 1). These TMR were fed for ad libitum intake (5% orts) in two meals per day, at 1630 (2/3 of the daily offer) and 0600 (the balance), to cows on the respective treatments. Housing, exercise, water, and orts removal were all completed as described for the prepartum period.

Cows entered the experiment at an estimated 21 to 28 d prepartum, at which time they were assigned to diets. A total of 20 primiparous and 27 multiparous cows were assigned. To be assigned, cows must have calved no earlier than 14 d after assignment to the diets. No cows were eliminated because of this requirement. However, two primiparous cows and one multiparous cow were removed from the experiment because of health problems that were not considered to be associated with the treatments. These health problems were multiple abomasal displacement requiring two surgical interventions (one primiparous cow fed the control TMR), diagnosed hardware disease (one primiparous cow fed the TMR with YC), and diagnosed clinical mastitis at calving (one multiparous cow fed the TMR with YC). Thus, a total of 18 primiparous (nine control and nine YC) and 26 multiparous (13 control and 13 YC) cows were included. The average period that cows were fed the assigned prepartum diet was 24.1 ± 3.3 d for primiparous cows and 22.8 ± 5.7 d for multiparous cows. All reported data represent these 44 cows.

Experimental Design. Cows were blocked into pairs within parity. Multiparous cows were blocked according to lactation number, BW, and body condition score (**BCS**) at assignment 21 to 28 d prepartum as well as "Breed Class Averages" (a Canadian production index) for milk, fat, protein, fat/milk, and protein/milk from the previous lactation. Primiparous cows were blocked according to BW and BCS at assignment 21 to 28 d prepartum as well as genetic indices for milk, fat, protein, fat/milk, and protein/milk. There were two treatments. The "Control" TMR contained the appropriate control concentrate (Table 1) both prepartum and postpartum. The "YC" TMR contained the appropriate YC concentrate prepartum and postpartum. The feeding level of the YC concentrates was designed to deliver approximately 57 g/d of a yeast product (XP yeast culture preparation from *Saccharomyces cerevisiae* containing approximately 4×10^7 cfu/g, which are a residue of the fermentation process used to produce the product; Diamond V Mills Inc., Cedar Rapids, IA) both prepartum and postpartum. All cows finished the experiment at 56 d postpartum.

Sampling. Silages and TMR were sampled on d 1, 3, and 6 of each week that any cow was assigned to the experiment and composited by week. Batch lots of ingredients used in the concentrates were sampled upon arrival. Each batch of concentrate was sampled individually and pooled to create one composite sample for each of the four concentrates. Orts were sampled on d 7 of each week and composited by cow to create a single prepartum orts composite sample and two postpartum orts composite samples representing wk 1 to 4 and 5 to 8, respectively. Milk samples for compositional analyses were collected weekly on d 4 (p.m.) and 5 (a.m.) of each week. All cows were weighed and assessed weekly for BCS by two experienced scorers according to Edmonson et al. (1989).

Patterns of Feed Consumption and Ruminal Fermentation

Cows. Seven of the multiparous cows in the production study had been previously fitted with a large-diameter ruminal cannula. These cows constituted the feed consumption and ruminal fermentation study, and none was eliminated due to health problems. The spare cow (i.e., the seventh) was not used as a ruminally cannulated cow. Thus, all reported data represent six multiparous cows (three control and three YC).

Feeding Behavior. Total feed in the bunk was weighed continuously by means of a permanent stainless steel bunk insert that rested on an angle iron frame attached to a single load cell. Residual feed weights in the bunks were recorded to a computer file every 10 min to determine within-day patterns of feed consumption. Recording began when each cow entered

Table 1. Ingredient and chemical composition of the concentrates used

Item	Prepartum		Postpartum	
	Control	Yeast culture	Control	Yeast culture
	kg/t as mixed			
Ingredient composition				
Ground barley	331	314	344	340
Ground corn	301	301	269	269
Blood meal[a]	65.5	65.5	44	44
Soybean meal[b]	116	116	166	166
Corn gluten meal	92.5	92.5	63	63
Megalac[c]	0	0	37	37
Dicalcium phosphate	0	0	14.4	14.4
Dynamate[d]	0	0	1.6	1.6
Limestone	23.8	23.8	14.4	14.4
Trace-mineralized salt[e]	17.8	17.8	7.9	7.9
Iodized salt[f]	0	0	2.9	2.9
Se-Mar 200[g]	4.5	4.5	1.44	1.44
Vitamin A, D, and E premix[h]	6	6	.8	.8
Vitamin D premix[i]	8.9	8.9	1.44	1.44
Magnesium oxide	3	3	2.2	2.2
Copper sulphate	.060	.060	.014	.014
Yeast culture supplement[j]	0	17.0	0	4.5
Liquid molasses	30	30	30	30
Chemical composition				
DM, 105°C	948.0	945.9	915.9	937.9
	% of DM[k]			
OM	91.67	91.58	92.02	91.99
NDF	9.2	9.9	9.3	10.0
ADF	3.3	4.0	3.2	3.7
NE_l, Mcal/kg[l]	1.76	1.73	1.96	1.95
CP				
Total	23.05	21.80	22.69	22.33
Buffer-soluble	2.75	2.60	3.33	2.52
NDI[m]	.64	.63	.68	.69
ADI[n]	.30	.28	.29	.40
	% of DM			
Ca	1.41	1.34	1.41	1.33
P	.42	.41	.80	.81
K	.70	.70	.79	.81
Mg	.30	.33	.29	.30
S	.35	.34	.34	.35
Na	.99	.96	.55	.56
NaCl	2.53	2.45	1.40	1.43
	ppm of DM			
Zn	128	132	65	61
Fe	376	330	388	401
Mn	118	113	57	58
Mo	<2	<2	<2	<2
Cu	29	33	14	14
Se	ND[o]	ND	.460	.424

[a]Ring-dried (Llomex, Montreal, QC, Canada).
[b]Solvent-extracted; 48% CP as fed.
[c]Church and Dwight Co., Oldfort, OH.
[d]Pitman Moore Inc., Oakville, ON, Canada. Contains a guaranteed analysis of 22% S, 18% K, and 11% Mg.
[e]Guaranteed analysis: 37.6% of Na, 37.5 ppm of Co, 75 ppm of I, 1,875 ppm of Fe, 3,000 ppm of Mn, 5,625 ppm of Zn, 400 ppm of Cu, and 10 ppm of Se.
[f]Guaranteed analysis: 96.5% of NaCl, 4,000 ppm of Zn, 160 ppm of Fe, 1,200 ppm of Mn, 330 ppm of Cu, 70 ppm of I, and 40 ppm of Co.
[g]Central Soya Ltd., Woodstock, ON, Canada. Contains a guaranteed analysis of 200 ppm of Se and 11,000 IU/kg of vitamin E.
[h]Guaranteed analysis: 10×10^6 IU/kg of vitamin A, 1×10^6 IU/kg of vitamin D, and 75,000 IU/kg of vitamin E.
[i]Guaranteed analysis: 1×10^6 IU/kg of vitamin D.
[j]Diamond V. Mills, Inc., Cedar Rapids, IA. XP yeast culture preparation from *Saccharomyces cerevisiae*.
[k]Except NE_l.
[l]Estimated from NRC (1989) tables and assigning no NE_l to the yeast culture supplement.
[m]Neutral detergent insoluble.
[n]Acid detergent insoluble.
[o]Not determined.

the prepartum period and continued through 56 d postpartum.

Ruminal Sampling. Concentrations of various soluble metabolites and pH in ruminal fluid were measured in ruminal liquid samples collected for immediate determination of pH as previously described (Robinson and Sniffen, 1985), except that CO_2-gassed centrifuge bottles in ice were used. Samples were collected at 1730, 2030, 2330, 0530, 0830, 1130, and 1430 over three 24-h periods, approximately 14 d prepartum and 14 and 42 d postpartum. Samples were processed and analyzed for VFA and soluble N components as previously described (Robinson and McQueen, 1994).

Calculations

Intake of DM and its components were calculated on a weekly basis from the actual amount of TMR offered and its chemical composition. The chemical composition of orts was assumed to be that of the composite orts sample prepartum or the appropriate postpartum orts sample.

Energy balance of the cows was determined individually by cow. Milk energy was calculated by Tyrrell and Reid (1965) using milk fat, protein, and lactose; energy of BW change as 250 Mcal/unit of change of BCS (Chilliard et al., 1991); and maintenance energy as ($BW^{.75}$) × .08 (NRC, 1989).

Analytical Procedures

All chemical analytical procedures not previously described were completed as described by Robinson and McQueen (1994).

Statistical Analysis

All response variables were analyzed separately by parity as separate experiments for the prepartum and postpartum periods using block, treatment, cow within treatment, time (day, week, or collection period as

Table 2. Chemical composition of the silages and concentrate ingredients

	Silage		Grain		Protein meal		
Item	Corn	Timothy	Barley	Corn	Blood	Soybean	Corn gluten
pH	4.04	4.74	ND[a]	ND	ND	ND	ND
DM, %							
105°C	35.00	48.99	90.33	87.13	92.14	90.64	92.08
Toluene	36.56	50.62	ND	ND	ND	ND	ND
	% of 105°C DM[b]						
OM	95.78	92.04	98.03	98.57	98.09	92.91	97.04
NDF	43.5	57.1	18.8	10.0	AZ[c]	8.8	3.8
ADF	24.0	36.3	5.6	2.4	.8	5.8	3.0
NE_l, Mcal/kg[d]	1.50	1.25	1.94	1.84	1.50	2.01	1.99
CP							
Total	9.24	13.87	12.63	8.50	97.19	51.88	66.13
Ammonia[e]	.81	1.04	ND	ND	ND	ND	ND
Buffer-soluble	4.37	9.26	2.65	.87	5.11	9.72	4.68
NDI[f]	.84	4.49	.96	.49	AZ	.28	2.03
ADI[g]	.27	1.59	.38	.08	.08	.24	.57
Ca	.23	.74	.04	.13	.08	.48	.04
P	.32	.31	.38	.28	.35	.76	.49
K	1.15	2.52	.44	.33	.17	2.56	.27
Mg	.22	.23	.14	.10	.02	.29	.07
S	.12	.18	.14	.12	.71	.44	.86
Na	.01	.02	.01	.01	.28	.01	.02
	ppm of DM						
Zn	37	29	31	22	34	53	38
Fe	453	366	68	50	2315	119	88
Mn	18	29	18	11	1	30	14
Mo	<2	<2	<2	<2	<2	<2	1.7
Cu	7	6	4	2	8	17	3

[a]Not determined.
[b]Except NE_l.
[c]Assumed to be truly zero.
[d]Estimated from the composition of the ingredients and reference to NRC (1989) tables.
[e]CP equivalent.
[f]Neutral detergent insoluble.
[g]Acid detergent insoluble.

Table 3. Ingredient and chemical composition of the total mixed diets

Item	Prepartum		Postpartum	
	Control	Yeast culture	Control	Yeast culture
Ingredient composition, % of DM				
Corn silage	24.94	24.95	23.84	23.55
Timothy silage	47.82	47.85	18.99	18.76
Concentrate	27.24	27.20	57.17	57.69
Chemical composition				
DM, %				
105°C	48.14	48.17	55.14	56.73
Toluene	49.90	46.66	56.54	57.20
	% of 105°C DM[a]			
OM	91.62	86.84	93.19	93.15
NDF	42.9	43.9	30.2	28.4
ADF	26.3	27.0	17.3	15.9
Fat	2.9	2.2	3.4	3.6
NE_l, Mcal/kg[b]	1.45	1.44	1.72	1.71
CP				
Total	14.81	14.19	17.19	17.19
Ammonia	.75	.75	.56	.50
Buffer-soluble	4.20	3.77	3.30	3.01
NDI[c]	2.51	2.71	1.43	1.03
ADI[d]	1.18	1.25	.58	.63
Ca	.77	.76	.95	1.00
P	.36	.37	.52	.54
K	1.93	2.05	1.27	1.26
Mg	.25	.29	.27	.28
S	.21	.21	.24	.24
Na	.21	.23	.30	.32
NaCl	.54	.58	.75	.81
	ppm of DM			
Zn	58	55	56	53
Fe	373	370	317	338
Mn	48	48	48	47
Mo	1.7	1.6	3.1	2.3
Cu	11	12	12	12
Se	.285	.297	.290	.318

[a]Except NE_l.
[b]Estimated from NRC (1989) tables and assigning no NE_l to the yeast culture supplement.
[c]Neutral detergent insoluble.
[d]Acid detergent insoluble.

appropriate), and the interaction of time × treatment as factors. Significance was determined using cow within treatment as the error term. Treatment means were considered to differ if $P < .05$, and a tendency to differ was considered to exist if $.05 < P < .10$.

Results

Feedstuff Composition

The chemical composition of both silages reflected their early cutting dates (Table 3). Both had moderate fiber concentrations and relatively high CP concentrations for their respective materials. Mineral values were typical for these types of silages. The grains and protein meals also had typical chemical compositions, with the exception of the rather high CP concentration of the blood meal.

The chemical composition of the prepartum and postpartum mixed concentrates was similar between treatments and consistent with the formulation (Table 1). Little week-to-week variation occurred in the ingredient composition of the TMR over the course of the study. In addition, the average TMR ingredient compositions between treatments within stage of lactation were virtually identical (Table 2). This trend was also evident for the chemical composition of the TMR; few differences existed between the two treatments within stage of lactation. All mineral values were within accepted ranges for lactating dairy cows (NRC, 1989), although Cu (12 ppm) and Se (.3 ppm) were marginal.

Prepartum Performance

Supplementation with YC had no impact on the prepartum performance of primiparous or multiparous cows (Table 4; Figures 1, 2, and 3). However, multiparous cows supplemented with YC selected a diet with a higher concentration of CP than did cows that were not supplemented with YC. In addition, the diet selected by the cows supplemented with YC was 1.18% units higher in CP than that in the TMR offered, which contrasts with the unsupplemented cows, whose selected diet was only .09% units higher in CP than that offered. These differences are consistent with the differentials between the CP concentrations of the TMR offered and the diet selected for primiparous cows; supplemented cows consumed a diet .72% units higher than that offered, whereas unsupplemented cows consumed a diet .36% units lower than that offered. Thus, the net difference in the CP concentration of the TMR offered and the diet actually consumed was similar between YC-supplemented and unsupplemented cows between parities, with a net difference of 1.08% units for primiparous cows and 1.09% units for multiparous cows. In contrast to CP, cows of both parities selected diets with NDF concentrations that were very similar to those in the TMR offered.

Transition Performance

Intake of DM started to decline approximately 10 d prepartum for multiparous cows, but not until approximately 5 d prepartum for primiparous cows (Figure 3). No substantive statistical (Table 4) or visual (Figure 1) evidence suggests that supplementation with YC inhibited this depression in cows of either parity. Although the DMI of cows of both parities supplemented with YC was numerically approxi-

Table 4. Prepartum[a] intake, BW, and BCS as influenced by prepartum and postpartum supplementation with yeast culture

	Treatment		Contrast[b]		
Item	Control	Yeast culture	Trt	Trt × time[c]	SEM
			P-value		
Primiparous cows					
Intake					
DM, kg/d	9.31	9.32	.98	.83	.36
% of BW	1.62	1.57	.26	.86	.03
OM, kg/d	8.50	8.62	.78	.88	.33
NDF, kg/d	4.09	4.13	.84	.85	.17
% of DMI	43.9	44.4	.25	.12	.3
% of BW	.71	.70	.47	.89	.01
CP, kg/d	1.35	1.39	.60	.74	.06
% of DMI	14.45	14.91	.87	.70	.24
BW					
Average, kg	573	593	.33	.93	15
Change, kg/d	1.59	.93	.30	.95	.40
BCS					
Average, units	3.59	3.50	.15	.74	.05
Change, units/wk	–.029	–.039	.80	.04	.027
Multiparous cows					
Intake					
DM, kg/d	12.89	13.19	.54	.96	.39
% of BW	1.79	1.85	.59	.99	.07
OM, kg/d	11.78	12.26	.33	.96	.37
NDF, kg/d	5.46	5.70	.23	.86	.15
% of DMI	42.2	43.2	.18	.29	.5
% of BW	.76	.80	.41	.95	.04
CP, kg/d	1.92	2.03	.18	.95	.06
% of DMI	14.90	15.37	.02	.97	.14
BW					
Average, kg	724	720	.88	.99	20
Change, kg/d	2.20	1.98	.63	.16	.31
BCS					
Average, units	3.69	3.59	.29	.99	.07
Change, units/wk	.030	.027	.96	.97	.027

[a]Includes the day of calving.
[b]Time was significant ($P < .05$) for DMI (% of BW), NDF intake (% of DMI and % of BW), and CP intake (% of DMI) for primiparous cows and for DMI (kg/d and % of BW), OM intake (kg/d), NDF intake (kg/d and % of BW), and CP intake (kg/d) for multiparous cows.
[c]Time is week prepartum.

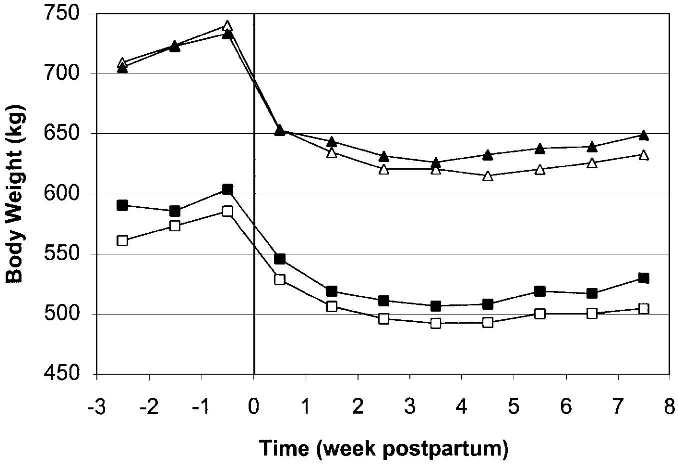

Figure 1. Body weight by week relative to parturition for primiparous and multiparous cows. Key: primiparous cows fed the control diet (□); primiparous cows fed the yeast culture diet (■); multiparous cows fed the control diet (△); multiparous cows fed the yeast culture diet (▲).

mately 1 kg higher on the day of calving and was consistent with an earlier observation (Robinson, 1997), this higher DMI was not sustained in the immediate 24-h postpartum period for multiparous cows or in the 72-h period for primiparous cows.

Postpartum Performance

The DMI of primiparous cows increased slowly postpartum, reaching only approximately 15 kg/d by 28 d postpartum and 17 kg/d by 56 d postpartum (Figure 3). Intake of DM, OM, and CP were all numerically higher for supplemented cows, and this was consistent throughout the 56-d postpartum period (Table 5). The DMI of multiparous cows increased rapidly postpartum, reaching approximately 20 kg/d by 28 d postpartum and 23 kg/d by 56 d postpartum. Intake of DM, and its components, tended to be (DM) or was (OM and CP) numerically higher for YC-supplemented cows, and this was consistent throughout the 56-d postpartum period. In contrast to the prepartum period, there was no evidence of selective TMR consumption by cows of either parity in the postpartum period.

Milk production of primiparous and multiparous cows increased rapidly postpartum to peak at approximately 30 kg/d during wk 6 to 8 and at 43 kg/d during wk 5 to 7, respectively (Table 6; Figure 4). Although the production of milk on the 1st d of parturition was the same for cows of either parity between treatments, milk production seemed to diverge between treatments immediately thereafter for cows of both parities and was sustained throughout the 56-d measurement period. This apparent diversion in milk production after 24 h postpartum was not supported statistically, although it was consistent with an earlier observation (Robinson, 1997). Primiparous cows tended to produce more milk and numerically more milk components if they were supplemented with YC. Numerically higher outputs of milk and milk components for multiparous cows supplemented with YC failed to approach statistical significance. Similarly, numerically higher outputs of milk energy, and total energy, within both parities due to supplementation with YC were not statistically significant (Table 7), although total energy output for multiparous cows approached statistical significance. The calculated dietary NE_l density was not influenced by supplementation with

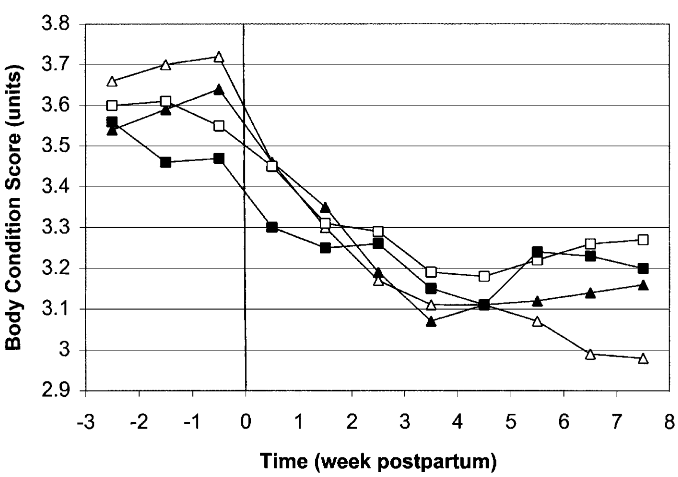

Figure 2. Body condition score by week relative to parturition for primiparous and multiparous cows. Key: primiparous cows fed the control diet (□); primiparous cows fed the yeast culture diet (■); multiparous cows fed the control diet (△); multiparous cows fed the yeast culture diet (▲).

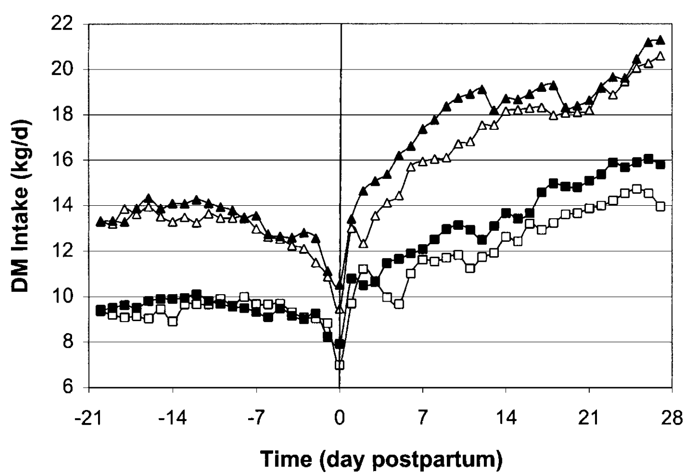

Figure 3. Dry matter intake by day relative to parturition for primiparous and multiparous cows. Key: primiparous cows fed the control diet (□); primiparous cows fed the yeast culture diet (■); multiparous cows fed the control diet (△); multiparous cows fed the yeast culture diet (▲).

YC for primiparous cows, but it tended to be higher for multiparous cows.

Intake Behavior and Ruminal Fermentation

Within-day (diurnal) patterns of TMR intake for the six ruminally cannulated, multiparous cows (data not shown but supplied to reviewers) indicated that the three cows that were not supplemented with YC exhibited the first substantive prepartum alterations to their repeated diurnal feed intake patterns at approximately 14, 10, and 5 d prepartum ($\bar{\chi}$ = 9.7 d), whereas the three cows that were supplemented with YC showed similar changes at 9, 8, and 3 d prepartum ($\bar{\chi}$ = 6.7 d). However, none of these cows calved with anything less than substantial modification to their repeated diurnal feed intake patterns. All six cows showed irregular diurnal feed intake patterns for a lengthy period of time postpartum. Nevertheless, unsupplemented cows seemed to reach a repeated diurnal intake pattern by 20, 19, and 19 d postpartum ($\bar{\chi}$ = 19.7 d), whereas cows supplemented with YC seemed to achieve repeated diurnal intake patterns by 17, 15, and 10 d postpartum ($\bar{\chi}$ = 14.0 d).

Ruminal fermentation was not influenced by supplementation with YC, and because time of sampling relative to parturition was not significant for any variable measured, average values are shown in Table 8. Values for pH, ruminal liquid turnover rate, volatile fatty acid concentrations, and concentrations of soluble N components were normal for lactating dairy cows. In addition, no significant interactions of time of sample collection × treatment occurred. Ruminal contents of cows that were not supplemented with YC was sampled at an average of 10.3 d prepartum, as

Table 5. Postpartum[a] intake, BW, and BCS during wk 1 through 8 postpartum as influenced by prepartum and postpartum supplementation with yeast culture

	Treatment		Contrast[b]		
Item	Control	Yeast culture	Trt	Trt × time[c]	SEM
			P-value		
Primiparous cows					
Intake					
DM, kg/d	14.34	15.40	.17	.99	.74
% of BW	2.86	2.97	.34	.99	.11
OM, kg/d	13.35	14.32	.18	.99	.69
NDF, kg/d	4.24	4.24	.99	.99	.20
% of DMI	29.7	27.7	<.01	.41	.3
% of BW	.85	.82	.28	.95	.03
CP, kg/d	2.51	2.75	.12	.99	.14
% of DMI	17.53	17.87	.10	.78	.19
BW					
Average, kg	502	519	.45	.99	23
Change, kg/d	–.49	–.34	.51	.44	.23
BCS					
Average, units	3.27	3.22	.54	.99	.09
Change, units/wk	–.025	–.013	.18	.01	.009
Multiparous cows					
Intake					
DM, kg/d	19.45	20.76	.10	.99	.83
% of BW	3.11	3.27	.30	.99	.17
OM, kg/d	18.12	19.31	.11	.99	.77
NDF, kg/d	5.75	5.85	.70	.99	.26
% of DMI	29.6	28.1	<.01	<.01	.3
% of BW	.92	.92	.91	.99	.05
CP, kg/d	3.35	3.56	.12	.98	.14
% of DMI	17.25	17.18	.54	.22	.13
BW					
Average, kg	628	639	.61	.99	24
Change, kg/d	–.51	–.12	.19	.37	.31
BCS					
Average, units	3.15	3.20	.71	.99	.15
Change, units/wk	–.059	–.044	.49	.44	.023

[a]Excludes the day of calving.
[b]Time was significant ($P < .05$) for all parameters except NDF intake (% of DMI), CPI (kg/d and % of DMI), BW, and BCS for primiparous cows and BW and BCS for multiparous cows.
[c]Time is week postpartum.

Table 6. Milk production and composition during wk 1 through 8 postpartum as influenced by prepartum and postpartum supplementation with yeast culture

	Treatment		Contrast[a]		
Item	Control	Yeast culture	Trt	Trt × time[b]	SEM
			P-value		
Primiparous cows					
Production, kg/d					
Milk	25.36	27.81	.09	.99	1.37
Fat	.96	.99	.58	.99	.05
Protein	.79	.83	.37	.99	.04
Lactose	1.18	1.30	.12	.99	.07
Composition, %					
Fat	3.88	3.59	.18	.99	.21
Protein	3.16	3.00	.08	.99	.08
Lactose	4.63	4.66	.46	.99	.04
Multiparous cows					
Production, kg/d					
Milk	38.60	40.35	.28	.99	1.74
Fat	1.48	1.53	.54	.99	.10
Protein	1.16	1.22	.22	.99	.06
Lactose	1.73	1.82	.23	.99	.08
Composition, %					
Fat	3.88	3.82	.61	.98	.14
Protein	3.05	3.05	.98	.99	.09
Lactose	4.49	4.50	.90	.99	.07

[a]Time was significant ($P < .05$) for milk, protein, and lactose production for primiparous cows, as well as milk and lactose production, and milk fat and protein percentage for multiparous cows.
[b]Time is week postpartum.

well as at 20.0 and 41.0 d postpartum. In contrast, cows supplemented with YC were sampled at an average of 17.0 d prepartum, as well as at 20.3 and 41.3 d postpartum. No postpartum, and only one prepartum, sampling period occurred during a period of reduced feed intake.

Discussion

Yeast culture products have been shown to modify ruminal fermentation and stimulate bacterial growth (Wiedmeier et al., 1987; Harrison et al., 1988; Dawson et al., 1990; Erasmus et al., 1992). Such changes are often associated with increased digestibility of dietary fiber, which can lead to higher DMI or animal performance, or both. Results of a previous study (Robinson, 1997) were consistent with such an hypothesis, although those results did not demonstrate a less severe reduction in DMI in the immediate prepartum period when YC was supplemented to the diet.

Prepartum Performance (21 Through 2 Days Prepartum)

Overall performance of cows of both parities was not influenced by YC supplementation during this period. However, despite the similarity in performance, evaluated by DMI and body traits, it seems evident that the behavioral responses of the cows were not the same between treatments. For example, YC-supplemented cows of both parities seemed to select in favor of the protein-rich TMR ingredients, although no explanation can be advanced for this observation. However, diurnal DMI behavior patterns of the

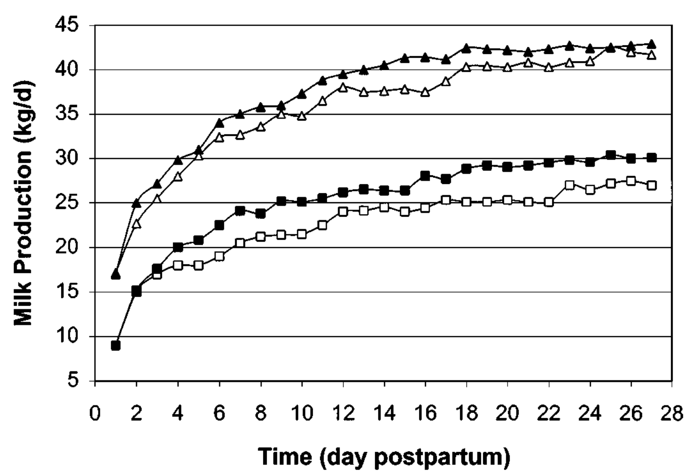

Figure 4. Milk production by day relative to parturition for primiparous and multiparous cows. Key: primiparous cows fed the control diet (□); primiparous cows fed the yeast culture diet (■); multiparous cows fed the control diet (△); multiparous cows fed the yeast culture diet (▲).

ruminally cannulated cows suggested that cows fed diets supplemented with YC maintained unaltered diurnal patterns closer to parturition than did unsupplemented cows; this may reflect an underlying trend toward a less severe modification in diurnal DMI patterns in the late prepartum period for cows supplemented with YC. Even though this observation is not supported by differences between treatments in concentrations of soluble ruminal metabolites and pH, the prepartum rumen sampling periods occurred prior to the first substantive alteration in the diurnal intake pattern for all cows examined.

Transition Performance (2 Days Prepartum Through 2 Days Postpartum)

This period was not assessed statistically. However, visual appraisal of among-day DMI patterns supports observations of Robinson (1997) that cows fed diets supplemented with YC maintained a higher DMI on the day of calving, although this was not sustained.

Postpartum Performance (2 Through 56 Days Postpartum)

Cows of both parities supplemented with YC had trends toward, or numerically higher, intakes of DM and its CP component, as well as output of milk and its components. In addition, losses of BW and BCS for cows supplemented with YC tended to be, or were numerically, lower. Finally, output of energy by cows of both parities supplemented with YC tended to be, or was numerically, higher. Overall, these results can be interpreted to suggest that overall postpartum performance of primiparous and multiparous cows supplemented with YC was modestly enhanced relative to that of cows fed the unsupplemented diets. Even though this conclusion may be disputed due to its weak statistical support, it is supported by numerical differences of similar magnitudes in these same response variables measured in a previous study, using only multiparous cows, that used a similar design and diets (Robinson, 1997). In addition, Wohlt et al. (1991) reported higher DMI and milk yield during the first 8 wk of lactation for primiparous cows supplemented with a YC.

If a trend to a modest postpartum improvement in performance of cows supplemented with YC is accepted, then a part of the reason may have been due to the observation that cows supplemented with YC had achieved repeated diurnal intake patterns 5.7 d earlier than cows not supplemented (i.e., 19.7 vs 14.0 d postpartum, respectively). However, it is clear that

Table 7. Postpartum energy status during wk 1 through 8 postpartum as influenced by prepartum and postpartum supplementation with yeast culture

Item	Treatment		Contrast[a]		SEM
	Control	Yeast culture	Trt	Trt × time[b]	
			P-value		
Primiparous cows					
Energy intake, Mcal/d					
Total[c]	24.66	26.33	—	—	—
Energy use, Mcal/d					
Milk	18.01	18.94	.24	.99	.76
Maintenance	8.48	8.70	.44	.99	.29
Body change	–2.33	–1.53	.49	.42	1.15
Total	24.81	26.92	.21	.74	1.60
Dietary energy density, Mcal/kg of DM					
Estimated[c]	1.72	1.71	—	—	—
Calculated[d]	1.64	1.65	.89	.72	.08
Multiparous cows					
Energy intake, Mcal/d					
Total[c]	33.45	35.50	—	—	—
Energy use, Mcal/d					
Milk	26.98	28.18	.36	.99	1.40
Maintenance	10.03	10.16	.61	.99	.29
Body change	–2.40	–.44	.19	.36	1.52
Total	35.25	38.97	.09	.64	2.19
Dietary energy density, Mcal/kg of DM					
Estimated[c]	1.72	1.71	—	—	—
Calculated[d]	1.72	1.82	.12	.12	.06

[a]Time was significant ($P < .05$) for all variables except maintenance energy for primiparous cows and milk and maintenance energy for multiparous cows.
[b]Time is week postpartum.
[c]Estimated from NRC (1989) values (also Tables 1, 2, and 3).
[d]Calculated from total energy output and DMI on an individual cow basis.

Table 8. Prepartum and postpartum[a] ruminal fermentation traits of multiparous cows as influenced by prepartum and postpartum supplementation with yeast culture

	Treatment		Contrast[a]		
Item	Control	Yeast culture	Trt	Trt × time[b]	SEM
pH	6.45	6.40	.67	.59	.08
LTO, %/h[c]	14.38	12.36	.45	.96	1.69
Soluble nitrogen, mg/L					
Ammonia	112.2	132.2	.44	.46	16.5
Residual	143.9	146.1	.90	.82	12.0
Total	256.1	278.3	.60	.74	27.3
VFA, mmol/L					
Acetate	64.9	65.7	.84	.90	2.6
Propionate	24.6	22.2	.49	.43	2.3
Isobutyrate	.8	.9	.90	.92	.1
Butyrate	11.3	12.8	.23	.47	.8
Isovalerate	1.6	1.7	.88	.81	.2
Valerate	1.5	1.4	.64	.94	.1

[a]Time of sample collection relative to parturition was not significant ($P > .05$) for any trait.
[b]Time is the collection period.
[c]Ruminal liquid turnover rate.

this cannot account for the entire difference because cows of both parities fed diets supplemented with YC showed numerical improvements in milk production within 48 h after calving, well before cows of either parity had achieved repeated diurnal intake patterns.

There is no evidence that supplementation with YC had a positive impact on ruminal fermentation in the postpartum period, because there were no differences between treatments in measured traits of ruminal fermentation. Nevertheless, there is evidence that an overall enhancement of postpartum performance of cows of both parities supplemented with YC occurred and that it may have been due to different mechanisms. In primiparous cows, the calculated NE_l density of the diet was the same for both treatments, suggesting that all of the increased numerical output of NE_l was the result of the numerically higher DMI. Conversely, in multiparous cows, the calculated NE_l density of the diet tended to increase in addition to the trend toward increased DMI. This suggests that approximately 55% of the tendency toward an increased NE_l output for multiparous cows supplemented with YC was due to the numerically increased energy density of the diet, and 45% was due to the trend for increased DMI.

Implications

Prepartum and postpartum supplementation with a *Saccharomyces cerevisiae* yeast culture does not modify ruminal fermentation, decrease the extent of the prepartum decline in dry matter intake, or enhance prepartum performance of dairy cattle. Yeast culture supplementation may result in a modest overall improvement in postpartum productive performance of dairy cows, but the data do not support its mediation via enhanced ruminal fermentation. However, a diet supplemented with yeast culture may produce modest increases in postpartum energy output due to increases in dry matter intake in both primiparous and multiparous cows, in addition to enhanced energy density of the diet in multiparous cows.

Literature Cited

Bertics, S. J., R. R. Grummer, C. Cadorniga-Valino, and E. E. Stoddard. 1992. Effect of prepartum dry matter intake in liver triglyceride concentration and early lactation. J. Dairy Sci. 75: 1914–1922.

Chilliard, Y., M. Cissé, R. Lefaivre, and B. Rémond. 1991. Body composition of dairy cows according to lactation stage, somatotropin treatment, and concentrate supplementation. J. Dairy Sci. 74:3103–3116.

Dawson, K. A., K. E. Newman, and J. A. Boling. 1990. Effects of microbial supplements containing yeast and lactobacilli on roughage-fed ruminal microbial activities. J. Anim. Sci. 68: 3392–3398.

Edmonson, A. J., I. J. Lean, L. D. Weaver, T. Farver, and G. Webster. 1989. A body condition scoring chart for Holstein dairy cows. J. Dairy Sci. 72:68–78.

Erasmus, L. J., P. M. Botha, and A. Kistner. 1992. Effect of yeast culture supplement on production, rumen fermentation, and duodenal nitrogen flow in dairy cows. J. Dairy Sci. 75: 3056–3065.

Harrison, G. A., R. W. Hemken, K. A. Dawson, R. J. Harmon, and K. B. Barker. 1988. Influence of addition of yeast culture supplement to diets of lactating cows on ruminal fermentation and microbial populations. J. Dairy Sci. 71:2967–2975.

McCoy, G. C., J. K. Drackley, M. F. Hutjens, and J. E. Garrett. 1997. Effect of yeast culture (*Saccharomyces cerevisiae*) on prepartum intake and postpartum intake and milk production of Jersey cows. J. Dairy Sci. 80(Suppl. 1):662.

NRC. 1989. Nutrient Requirements of Dairy Cattle (6th Rev. Ed.). National Academy of Science, Washington, DC.

Robinson, P. H. 1997. Effect of yeast culture (*Saccharomyces cerevisiae*) on adaptation of cows to diets postpartum. J. Dairy Sci. 80:1119–1125.

Robinson, P. H., and R. E. McQueen. 1992. Influence of rumen fermentable neutral detergent fiber levels on feed intake and milk production of dairy cows. J. Dairy Sci. 75:520–532.

Robinson, P. H., and R. E. McQueen. 1994. Influence of supplemental protein source and feeding frequency on rumen fermentation and performance in dairy cows. J. Dairy Sci. 77:1340–1353.

Robinson, P. H., and C. J. Sniffen. 1985. Forestomach and whole tract digestibility for lactating dairy cows as influenced by feeding frequency. J. Dairy Sci. 68:757–767.

Sanchez, W. K., G. D. Poppy, M. A. Guy, and J. E. Garrett. 1997. Influence of yeast on lactational performance and blood mineral concentrations of high producing dairy cows on a commercial dairy. J. Dairy Sci. 80(Suppl. 1):210.

Tyrrell, H. F. and J. T. Reid. 1965. Prediction of the energy values of cow's milk. J. Dairy Sci. 48:1215–1223.

Van Saun, R. J., S. C. Idleman, and C. J. Sniffen. 1993. Effect of undegradable protein amount fed prepartum on postpartum production in first lactation Holstein cows. J. Dairy Sci. 76: 236–244.

Wiedmeier, R. D., M. J. Arambel, and J. L. Walters. 1987. Effect of yeast culture and *Aspergillus oryzae* fermentation extract on ruminal characteristics and nutrient digestibility. J. Dairy Sci. 70:2063–2068.

Wohlt, J. E., A. D. Finkelstein, and C. H. Chung. 1991. Yeast culture to improve intake, nutrient digestibility, and performance by dairy cattle during early lactation. J. Dairy Sci. 74:1395–1400.