Yeast Product Supplementation Influences Feeding Behavior and Measures of Immune Function in Transition Dairy Cows

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Summary
Yeast supplementation has been shown to increase feed intake and production in some studies with early lactation dairy cows, but the mechanisms underlying this effect remain unknown. The objective of this study was to assess the effects of supplementing a yeast product derived from *Saccharomyces cerevisiae* on production, feeding behavior, and immune function in cows during the transition to lactation. When fed for 3 weeks before calving through 6 weeks after calving, supplementation altered feeding behavior as well as responsiveness to vaccination and gut immunoglobulin secretion. Results suggest that yeast products can modulate several aspects of immune function and promote the consumption of smaller, more frequent meals.

Key words: transition dairy cow, yeast, nutrition, immunity

Introduction
The 2 weeks after calving remain the most challenging window of time during the dairy production cycle, often accounting for more than 50% of total disease in the lactating herd. The health challenges at this time include both metabolic and infectious diseases, resulting in a complex problem, often without any obvious cause. Our current understanding of transition cows suggests that rapid weight loss caused by low feed intake as well as poor immune function during this time combine to lead to these health problems.

Relatively strong evidence indicates that dietary yeast culture can increase DMI in early lactation, and more recent evidence suggests that this can happen through alterations in meal patterns. Furthermore, many studies in model organisms and young ruminants have suggested that yeast products can alter numerous functions of the immune system. In light of the immunosuppression that occurs during the transition period, there is great interest in the use of a yeast product to enhance immune function during this time when mammary and uterine infections are such a challenge. Our objective was to determine whether supplementing a yeast product derived from *Saccharomyces cerevisiae* altered production, feeding behavior, and measures of immune function in transition cows.

Experimental Procedures
Forty multiparous Holstein cows were blocked by expected calving date and randomly assigned within block to 1 of 4 treatments (10 cows per treatment) from 21 days before expected calving to 42 days postpartum. Rations were top-dressed with yeast culture plus enzymatically hydrolyzed yeast (YC-EHY; Celmanax, Vi-COR, Mason City, IA) at the rate of 0, 30, 60, or 90 g/day throughout the experiment. The basal diets fed pre-

partum and postpartum are detailed in Table 1. Dry matter and water intake, feeding behavior, and milk production were monitored daily throughout the study.

To evaluate humoral immune function, cows were challenged (subcutaneous injection) with 1 mg of ovalbumin (OVA; Sigma-Aldrich, St. Louis, MO) diluted in vaccine adjuvant (VET-SAP, Desert King International, San Diego, CA; 0.5 mg of adjuvant dissolved in 1 mL of saline) on days -21, -7, and 14. Blood samples were collected on days -21, 14, and 21 relative to calving from the coccygeal vessels 1 hour prior to feeding for determination of antibody titer against OVA. To evaluate mucosal immune function, fecal samples were collected on days 7 and 21 of lactation for analysis of immunoglobulin A (IgA) concentration.

To evaluate the efficiency of net energy utilization for milk production, energy supplied by the diet and body condition mobilization were estimated. Energy utilization efficiency was then quantified as milk energy output / (diet energy supply + energy from body condition mobilization).

One cow in the 0 g/day treatment group was removed from the study on day 30 postpartum due to difficulty standing up in the tie-stall. Data obtained from this cow prior to removal were included in all analyses. Feeding behavior variables were calculated from logged data that included the start and end weights as well as start and end times of meals, and meals were combined if the intermeal interval was less than 12 minutes. Data were analyzed using mixed models with repeated measures over time. Models included the fixed effects of treatment, time, and their interaction, and the random effect of cow. Contrast statements were used to assess the overall effect of YC-EHY (control vs. all YC-EHY treatments) as well as the linear and quadratic effects of dose. Significance was declared at $P \leq 0.05$ and tendencies at $0.05 < P \leq 0.10$.

Results

Pre- and postpartum DMI and water intake did not differ ($P > 0.10$) among treatments (Table 2). Quadratic dose effects ($P < 0.05$) were detected for prepartum feeding behavior, reflecting decreased meal size and increased meal frequency for cows that received 30 and 60 g/day of YC-EHY. Postpartum feeding behavior and milk yield were unaffected ($P > 0.10$) by treatments, but tendencies for increased ($P \leq 0.10$) percentages of milk fat, protein, and lactose were detected for cows receiving YC-EHY (Table 3). Furthermore, YC-EHY tended to increase the proportion of total energy supply secreted in milk nutrients ($P \leq 0.10$; Table 3).

Increasing YC-EHY dose linearly increased ($P < 0.01$) plasma anti-ovalbumin IgG levels following 3 ovalbumin challenges (Figure 1A), suggesting that treatments enhanced humoral immunity. Increasing YC-EHY dose also quadratically increased fecal IgA concentrations in early lactation ($P = 0.03$; Figure 1B), suggesting that 30 and 60 g/day doses enhanced mucosal immunity.

Discussion

These results provide some intriguing evidence that YC-EHY shifts meal patterns and results in cows eating smaller, more frequent meals. Although this was found to be significant only prepartum, numerical patterns during the postpartum period were similar. Smaller, more frequent meals may be beneficial from the standpoint of maintaining stable ruminal conditions, because very large meals provide a lot of fermentable substrate and can result in decreased ruminal pH, at least for a short period of time. We found no evidence, however, that YC-EHY increases DMI in the critical first 6 weeks after parturition.

By accounting for energy derived from release of stored tissue (i.e., body fat), we found that YC-EHY tended to improve efficiency of energy utilization for milk production. Substantial evidence in past studies indicates that yeast products can improve diet digestibility in ruminants. Although we did not directly measure this, the tendency for increased energy efficiency with YC-EHY in our study is consistent with an increase in diet digestibility.

We found that YC-EHY increased antibody production following vaccination against OVA and, at intermediate doses, increased gastrointestinal IgA release. Humoral immunity (antibody-based protection) is thought to be suppressed during the transition to lactation, so the ability of a feed additive to enhance this capacity is encouraging. Secretion of IgA by mucosal immune cells lining the gut is one key mechanism that helps prevent attachment of gut pathogens to the epithelium, thereby minimizing gastrointestinal disease. These findings are interesting, but whether or not a feed additive limits the risk of infection or speeds recovery from infection must be tested in disease challenge studies or large-scale studies capable of assessing health risks.

Conclusions

Feeding a yeast culture product with enzymatically hydrolyzed yeast did not affect milk production or DMI during the transition to lactation but modulated feeding behavior and several aspects of immunity. In the current study, a 60 g/day dose of YC-EHY resulted in favorable changes in feeding behavior, mucosal and humoral immunity, and supported the numerically greatest energy efficiency and milk yield postpartum. Future studies with larger numbers of animals may provide more insight into production implications of these biological responses.

Table 1. Ingredient and nutrient composition of diets

Item	Prepartum	Postpartum
Ingredient, % of DM		
Corn silage	29.5	15.9
Wet corn gluten feed	21.3	34.3
Alfalfa hay	-	14.2
Wheat straw	10.9	3.3
Prairie hay	16.8	-
Cottonseed	-	5.0
Ground corn	3.4	11.2
Dry-rolled sorghum grain	3.4	6.4
Mechanically extracted soybean meal	12.3	4.8
Molasses	1.2	1.2
Ca salts of long-chain fatty acids	-	0.8
Micronutrient premix	1.3	2.9
Nutrient, % of DM		
DM, % as-fed	45.4	51.1
CP	13.0	17.7
Starch	21.1	20.2
ADF	24.4	16.9
NDF	42.5	31.0
NFC	33.8	41.1
Ether extract	3.3	4.2
Ash	6.0	8.3

Table 2. Feed and water intake and feeding behavior responses to yeast culture-enzymatically hydrolyzed yeast (YC-EHY) supplementation during the experimental period

	Treatment (YC-EHY dose/day)					*P*-value		
Item	0 g	30 g	60 g	90 g	SEM	YC-EHY vs. Con	Linear dose	Quadratic dose
Prepartum measures								
DMI, kg/day	12.1	11.9	12.6	12.1	0.51	0.86	0.77	0.76
Water intake, L/day	49.0	48.3	49.0	51.3	2.38	0.84	0.48	0.53
Meal frequency, per day	10.1	11.4	11.2	10.0	0.45	0.12	0.80	0.01
Intermeal interval, hours	2.08	1.87	1.94	2.08	0.08	0.18	0.86	0.02
Meal size, kg DM	1.23	1.06	1.16	1.24	0.06	0.27	0.68	0.04
Meal length, minutes	20.6	17.7	17.3	21.1	1.58	0.31	0.87	0.04
Postpartum measures								
DMI, kg/day	21.8	19.7	21.5	22.8	1.13	0.73	0.34	0.14
Water intake, L/day	105.6	96.1	105.6	105.2	5.15	0.59	0.72	0.40
Meal frequency, per day	12.8	13.1	13.5	12.2	0.62	0.85	0.62	0.19
Intermeal interval, hours	1.50	1.50	1.42	1.60	0.08	0.90	0.53	0.29
Meal size, kg DM	1.81	1.69	1.76	1.93	0.10	0.87	0.34	0.14
Meal length, minutes	26.4	25.0	25.3	26.7	1.11	0.56	0.80	0.19

Table 3. Milk production and composition responses to yeast culture-enzymatically hydrolyzed yeast (YC-EHY) supplementation during the experimental period

	Treatment (YC-EHY dose/day)					*P*-value		
Item	0 g	30 g	60 g	90 g	SEM	YC-EHY vs. Con	Linear dose	Quadratic dose
Milk yield, kg/day	45.3	42.6	47.8	46.7	2.53	0.90	0.39	0.72
Milk fat, %	4.11	4.38	4.33	4.17	0.13	0.20	0.80	0.09
Milk protein, %	2.99	2.89	3.04	3.12	0.07	0.76	0.08	0.17
Milk lactose, %	4.77	4.74	4.84	4.85	0.05	0.45	0.10	0.67
Milk urea nitrogen, mg/dL	13.3	14.1	13.4	13.9	0.63	0.44	0.65	0.81
Fat yield, kg/day	1.81	1.82	2.02	1.90	0.09	0.32	0.24	0.46
Protein yield, kg/day	1.34	1.21	1.42	1.42	0.08	0.86	0.17	0.42
Lactose yield, kg/day	2.16	2.03	2.32	2.26	0.13	0.78	0.30	0.79
Energy utilization efficiency[1], %	74.9	79.5	82.6	81.5	3.1	0.08	0.11	0.36

[1] Milk energy output divided by energy provided by feed and BCS mobilization.

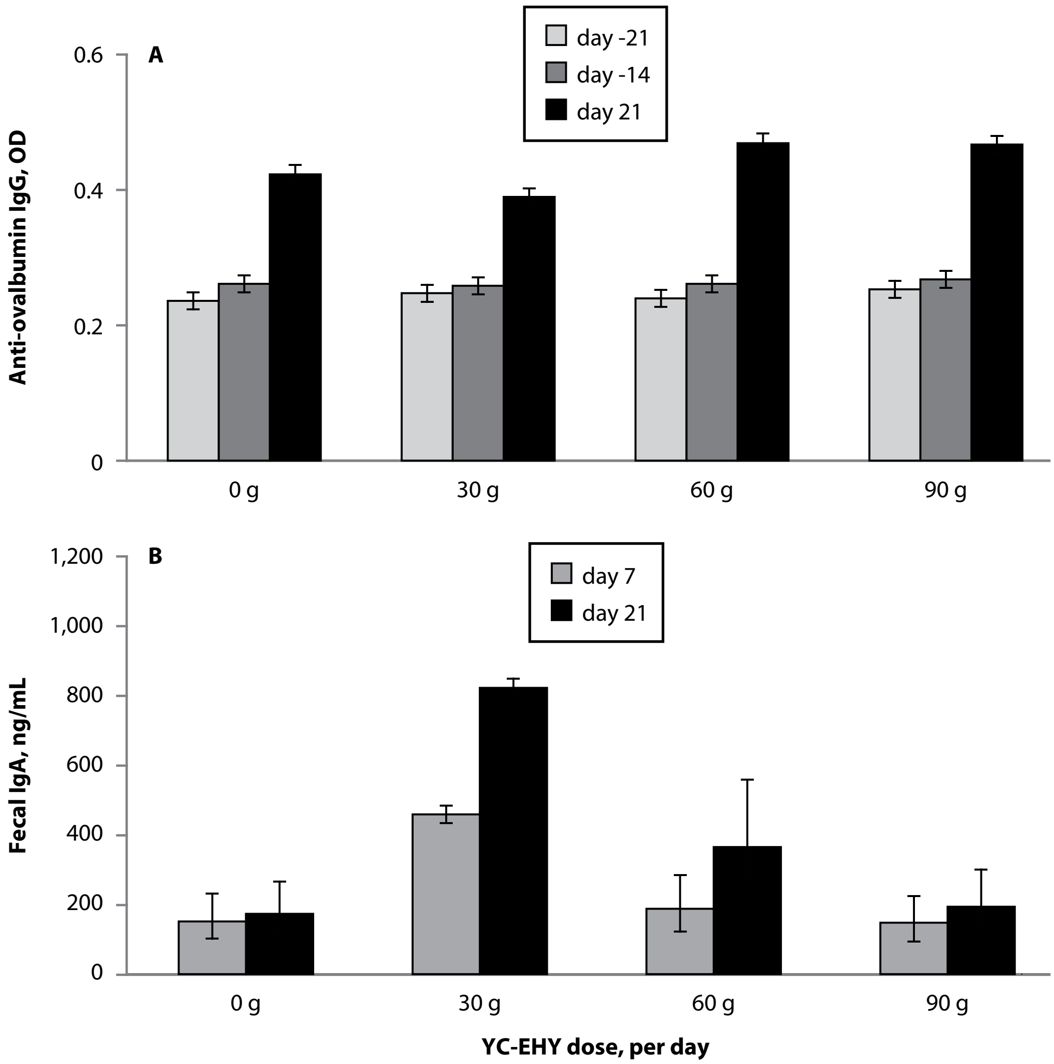

Figure 1. Antibody responses to yeast culture with enzymatically hydrolyzed yeast (YC-EHY) supplemented to dairy cows at 0, 30, 60, or 90 g/day from 21 days before expected parturition to 42 days after parturition. (A) Plasma concentrations of anti-ovalbumin IgG collected on days -21, -14, and 21 relative to calving. Cows were challenged on days -21, -7, and 14 with ovalbumin. There was a tendency for linear dose effect ($P = 0.06$) and a day effect ($P < 0.01$) but no yeast product vs. control ($P = 0.41$) or quadratic dose ($P = 0.50$) effects. A treatment × day ($P < 0.01$) effect was detected, reflecting that yeast product linearly increased ($P < 0.01$) anti-ovalbumin IgG on day 21. (B) Concentrations of IgA in fecal samples collected on days 7 and 21 relative to calving. There was a significant quadratic dose effect ($P = 0.03$), but no yeast product vs. control ($P = 0.16$), linear dose ($P = 0.73$), day ($P = 0.61$), or treatment × day ($P = 0.42$) effects.