



Yeast in Dairy Cattle Diets

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Introduction

Yeast is a unicellular fungi that does not reproduce via asexual spore production (Phaff, 1966). The most commonly fed yeast in dairy diets is *Saccharomyces cerevisiae* (SC); a facultative anaerobic yeast often referred to as brewers or bakers yeast. The most common yeast products fed to ruminants are live cells or yeast culture mixtures. A yeast culture is a yeast-fermented product that contains live and dead yeast, the culture media the yeast cells were grown on, and the metabolic by-products produced by the yeast during fermentation. The process involves inoculation of a culture media (generally liquid and cereal grain raw ingredients) with live yeast cells, fermentation of the media, and drying of the fermented media. Live cell yeast products consist solely of live dried yeasts that are mixed with a carrier for feeding.

Yeast is supplemented in dairy diets to improve animal performance and is considered a 'natural' alternative to using antibiotics. When fed to lactating dairy cows, improved milk production is the most consistent benefit reported, however increased dry matter intake (DMI) and milk fat percentage have been shown. Supplementing calves with yeast has been found to improve body weight gain and health. How yeast directly improves animal health and performance is not known although a variety of mechanisms have been suggested. These include changes in the rumen microbial population, rumen fermentation, intestinal nutrient flow, and diet digestibility.

Dairy cattle research on feeding yeast has shown inconsistent responses. One explanation for this inconsistency is the wide variation in conditions across studies. This includes differences

in inclusion level, type of diet fed, feed intake and the use of additional feed additives along with animal factors such as age, physiological stage, health and stress status; all of which may affect DFM efficacy (Wagner et al., 1990).

Literature

Fungal DFMs have been extensively reviewed by Newbold et al., 1996; Yoon and Stern, 1995; Jouany, 1994 and Martin and Nisbet 1992. Therefore, this paper will primarily focus on subsequent research studies. The effect of yeast supplementation on production parameters are summarized in Tables 1 to 3. Changes in production or health parameters presented in the tables are significant at $P < 0.05$.

Lactating Dairy Cows

Kung et al. (1997) supplemented mid-lactation cows with SC culture for 77 days and early lactation cows for 28 days. Supplementation with SC did not alter cow performance when fed to mid-lactation cows, but increased 3.5% FCM yield in early lactation cows when fed at 10 g/d compared to control cows (39.3 vs. 36.4 kg/d). Shaver and Garrett (1997) evaluated the effect of supplementing SC culture to mid-lactation cows in 11 high producing Wisconsin commercial dairy herds. Yeast increased ($P < 0.05$) milk yield 0.9 kg/d and milk protein yield (1.17 vs. 1.14 kg/d). Milk fat was decreased 0.1 percentage unit with no difference in milk fat yield. Lehloenya et al. (2005) fed a control (C), yeast (Y) or yeast plus *Propionibacteria* (Y+P) supplemented diet to 31 cows from 2 weeks prepartum to 210 DIM (DIM). Yeast was fed at 56.0 g/d and

Table 1. The effect of yeast culture (YC) or live yeast (LY) supplementation on the dry matter intake (DMI), milk yield and milk fat percentage of lactating dairy cows.

Study	DMI, kg/d ¹	Milk (kg/d) ¹	Fat (%) ¹
Bruno et al., 2005 – (YC)		+ 1.20	-0.10
Lehloenya et al., 2005 ² – (YC)			—
Schingoethe et al., 2004 – (YC)			
Kung et al., 1997 – (YC)		+2.90	
Shaver and Garrett, 1997 – (YC)		+ 0.90	-0.10

¹Response change from control when significantly different from control.
²Supplemented with yeast culture in addition to *Propionibacteria freudenreichi*.

Table 2. The effect of yeast culture (YC) or live yeast (LY) supplementation on the dry matter intake (DMI), milk yield and milk fat percentage of transition cows.

Study	DMI, kg/d ¹	Milk (kg/d) ¹	Fat (%) ¹
Nocek et al., 2006 ² – (LY)	+2.70	+2.30	-0.32
Kim et al., 2005 – (YC) ³	+ 5.94 (1 st 2 DIM)		0.14
Erasmus et al., 2005 – (YC)			
Vogel et al., 2005 – (YC)			
Wang et al., 2001 – (YC)			
Dann et al., 2000 ⁴ – (YC)	+2.10 prepartum +1.80 postpartum ³		
Block et al., 2000 ⁵ – (LY)	+ 1.9 postpartum	+1.0	
Soder and Holden., 1999 – (YC)			
Robinson and Garrett., 1999 – (YC)			
Robinson, 1997 – (YC)			

¹Response change from control when significantly different from control.
²Supplemented with live yeast in addition to *Enterococcus faecium*
³Increased DMI postpartum only the day of calving and 1 day post calving
⁴Increased DMI postpartum only for the first 21 DIM
⁵Supplemented with live yeast in addition to *Lactobacillus plantarum* and *E. faecium*

Table 3. The effect of yeast culture (YC) or live yeast (LY) supplementation on the dry matter intake (DMI), average daily gain (ADG), feed efficiency (FE) and health of calves.

Study	DMI ¹	ADG, kg/d ¹	FE ^{1,2}	Health ¹
Galvão et al., 2005 – (LY)		+0.09		+
Dobicki et al., 2005 – (LY)		+0.03	+0.44	+
Lesmeister et al., 2004 – (YC)		+0.12		
Wagner et al., 1990 – (YC)				
Seymour et al., 1995 – (YC)				

¹Response change from control when significantly different from control.
²Feed efficiency = kg gain per kg of feed

Propionibacteria at 6×10^{11} cfu/d. Milk fat percentage was significantly greater for cows fed the control treatment compared to Y or Y + P fed cows.

At a recent dairy conference in China, Cronjé (2006) discussed the role of yeast in heat stress of dairy cattle. The generally held theory is the decline in milk yield observed during and following heat stress in lactating dairy cows is due to a reduction in feed intake; a method to decrease the animal's heat load by lowering the metabolic heat production associated with the digestion and utilization of nutrients. However, current research does not fully support this hypothesis. As an alternative theory, Dr. Cronjé suggests structural damage of the rumen wall causes reduced feed intake which leads to decreased milk yield. More specifically, during heat stress blood flow to the rumen is reduced. This damages rumen cells, allows endotoxins to enter the bloodstream, and results in the release of inflammatory cytokines which negatively affect appetite and immune function. One method to limit the negative effects of heat stress is to decrease rumen cell damage prior to heat stress. In particular, decreasing damage caused by an acidic rumen pH may be useful. Supplementing dairy cows with yeast may decrease rumen cell damage caused by an acidic rumen pH as yeast has been shown to increase the rumen population of lactate utilizing bacteria (Callaway and Martin, 1997) which increases lactate utilization and rumen pH.

Supplementing lactating dairy cows during heat stress has not consistently improved animal performance. Bruno et al. (2005) supplemented heat stressed early lactation cows with 30 g/d SC culture for 120 days. Average daily temperature was 87.1°F with 86% humidity. Supplementation with SC culture increased milk yield 1.2 kg/d (43.3 vs 42.1 kg/d) and protein yield 0.03 kg/d. Milk fat percentage was decreased with the feeding of SC (3.49 vs. 3.59%). Schingoethe et al. (2004) supplemented mid-lactation Holstein cows with 60g/d SC culture for 84 days during heat stress. Daytime high temperatures averaged 91.4°F and ranged from 82.4 to 102.2°F. The addition of SC culture did not improve DMI, milk production or components.

Transition Cows – Performance

Kim et al. (2005) fed Holstein cows SC culture approximately 4 week prior to calving through 41 DIM. Treatments did not affect DMI prepartum

but the day of calving and one day following calving cows receiving SC had significantly higher DMI as compared to control cows. There was no effect of SC supplementation on milk yield or components. A more sustained DMI response was reported when Jersey cows were supplemented with 60 g/d of SC culture 21 days prepartum through 140 days postpartum (Dann et al., 2000). Dry matter intake was significantly higher for cows receiving SC culture the week prior to calving (9.8 vs. 7.7 kg/d) and the first 21 DIM (12.0 vs. 10.2 kg/d). Cows receiving SC culture also peaked in milk 14 days earlier than control cows (43 vs. 57 DIM) but there was no difference in milk yield or components through 150 DIM.

Nocek et al. (2006) assigned 44 cows to a control or SC and *Enterococcus faecium* supplemented diet from 21 days prepartum through 70 DIM. Supplementation with SC and *E. faecium* increased ($P < 0.05$) in situ corn silage and haylage DM digestibilities averaging 77.9% vs. 71.4% for corn silage and 59.1% vs. 54.3% for haylage at 72 hours. Dry matter intake tended ($P = 0.10$) to increase prior to calving (11.3 vs. 10.3 kg/d) and significantly increased postpartum (22.7 vs. 20 kg/d) for DFM supplemented as compared to control cows. Milk yield was also significantly greater for cows receiving the DFM compared to the control diet (39.2 vs. 36.9 kg/d). There was no difference in milk component yield; however, DFM supplementation significantly decreased milk fat percentage compared to control cows (4.76 vs. 4.44). Block et al., (2000) supplemented 64 cows with a control or a live SC plus *Lactobacillus plantarum* and *E. faecium* diet from 21 days prepartum through 70 DIM. There was no difference in cow performance prepartum. Postpartum DMI (20.5 vs. 18.6 kg/d), milk yield (35.9 vs. 34.9 kg/d), and milk protein concentration (3.5 vs. 3.4%) were significantly greater for cows fed the SC as compared to the control diet.

Robinson and Garrett (1999) supplemented Holstein cows with SC yeast culture 23 days prepartum through 56 days postpartum. No significant effect on prepartum DMI was observed. Postpartum there was a trend for increased DMI in multiparous cows and increased milk yield in primiparous cows. Vogel et al. (2005) also reported a similar cow response to SC culture supplementation 21 days prepartum to 75 days postpartum. There was no effect on DMI pre or postpartum but a trend ($P = 0.08$) for increased

milk yield for cows receiving SC culture as compared to control cows (32.5 vs. 28.2 kg/d).

Wohlt et al. (1998) fed cows SC at 0 or 10 g/d beginning 30 days prepartum through 28 days postpartum. On day 29, cows within each treatment group were reassigned to SC treatment levels of 0, 10, or 20 g/d through 126 DIM. There was no effect of SC on DMI prepartum with cows averaging 11.2 kg/d across treatments. From calving through 28 DIM, there was no effect of SC on DMI or milk production. Cows increasing from 10 g/d to 20 g/d at 29 DIM, consumed more DMI week 5 to 18 compared to cows decreased in amounts of SC from 10 g/d to 0 g/d (25.2 vs. 23.2 kg/d) and week 5 to 11 compared to cows whose SC supplementation was maintained (25.8 vs. 24.5 kg/d). Similarly, from week 5 to 11 cows fed increased levels of SC had increased 3.5% fat corrected milk compared to cows with maintained or decreased SC supplementation levels (43.4, 39.0, 38.1 kg/d), respectively.

In contrast, research has also shown no effect of yeast supplementation on prepartum or postpartum cow performance. Wang et al. (2001) fed SC culture at 60 g/d starting 21 days prepartum through 140 DIM. There was no effect of SC culture on DMI or milk production through 140 DIM. Robinson (1997) fed SC culture at 57 g/d starting 23 days prepartum to 56 days postpartum without any affect on cow performance pre or postpartum. Soder and Holden (1999) fed SC culture, alone or with enzymes, and found no effect on pre or postpartum DMI, milk yield or composition when offered at 15 to 20 g/d from 28 days prepartum to 92 days postpartum. Erasmus et al. (2005) fed approximately 51 g/d SC culture 21 days prepartum through 56 days postpartum and reported no difference in average postpartum DMI, milk production or composition when offered to Holstein cows with or without monensin.

Dry and Transition Cows – Health and Metabolic Effects

Yeast supplementation prepartum has improved feed intake during the transition period (Kim et al., 2005; Dann et al., 2000); an important factor in decreasing the metabolic stress of calving (Hayirli et al., 2002). Therefore, the possibility of yeast supplementation to decrease the incidence of metabolic diseases postpartum is likely, although studies have not been conducted with enough animals to directly assess this.

The effect of yeast on rumen fermentation has been modest. Enjalbert et al. (1999) fed SC culture to dry cows for 32 days. Supplementation with SC increased rumen total volatile fatty acid concentrations prefeeding (83.7 vs. 68.8 mmol/l) and 1 hr after feeding (93.3 vs. 78.2 mmol/l). Prior to feeding, cows supplemented with SC had higher rumen propionate concentrations and tended ($P < 0.10$) to have a decreased acetate:propionate ratio compared to control fed cows (3.00 vs. 3.49). *Saccharomyces cerevisiae* culture had no effect on rumen pH, however ammonia-N was lower 3 hrs post-feeding for treated as compared to control cows (103.1 vs. 148.5 mg/l). Supplementation with yeast products prepartum through early lactation has resulted in no modification of pre or postpartum rumen pH, ammonia-N or VFA concentrations (Robinson and Garrett, 1999; Varel et al, 1994) although postpartum increases in rumen pH (Nocek et al., 2003), a tendency for increased propionate concentration and decreased acetate:propionate ratio has been reported (Erasmus et al., 2005).

Calf Performance and Health

The effect of supplementing calves with yeast has been researched to a lesser extent than lactating or transition cows. Dobicki et al. (2005) supplemented calves with SC at 20 or 40 g/kg feed. Calves receiving SC had increased average daily gain (0.15 kg/d vs. 0.12 kg/d) and feed efficiency (2.94 vs. 2.50 kg gain/kg feed) as compared to the control calves. They also reported an improvement in health and immune status as measured by decreased blood cholesterol, increased leukocyte and erythrocyte counts and increased hemoglobin levels. Galvão et al. (2005) fed live SC to calves with low IgG concentrations indicating a failure of passive transfer. *Saccharomyces cerevisiae* treatments were: 0 (control), .5 g in grain/d for 84 days, 0.5 g in milk/d for 42 days or 0.5 g in grain/d for 84 days in addition to 0.5 g in milk/d for 42 days. Pre-weaning, calves receiving SC only in grain or milk had decreased days with diarrhea while post-weaning, calves receiving SC in grain or the combination of SC in grain and milk had decreased days with diarrhea ($P < 0.05$). Lianjiang et al., (2006) reported SC culture supplementation significantly decreased plasma endotoxin concentrations and increased immune system function in calves with diarrhea.

Lesmeister et al. (2004) supplemented calves with SC culture at 0, 10 or 20 g/kg calf starter for 42 days. At the end of the study, calves receiving SC culture at 20 g/kg calf starter were 5.1 kg heavier than control calves. There was no difference in

feed efficiency across treatments and no effect on calf health. Wagner et al. (1990) reported no effect of yeast culture on calf performance and Seymour et al. (1995) reported no effect of live yeast on calf performance or health.

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