Can yeast replace sodium bicarbonate in rations?

Today's dairy nutritionists typically supplement sodium bicarbonate and a yeast additive to high-producing dairy cows primarily to combat subclinical acidosis and to improve fiber digestion. New research shows that live yeast alone can result in higher mean daily rumen pH.

By **MARY BETH DE ONDARZA, TONY HALL** and **ERIC CHEVAUX***

SUPPLEMENTAL live yeast has been shown to positively affect the rumen microbial population and, in turn, dairy cattle performance.

An analysis of 14 research trials concluded that live yeast (*Saccharomyces cerevisiae* CNCM I-1077) increased 3.5% fat-corrected milk yield by 1 kg and improved feed efficiency from 1.70 to 1.75 (de Ondarza et al., 2010).

Live yeast can improve fiber digestion in the rumen. It has resulted in more rapid establishment of rumen cellulolytic bacteria, greater fiber-digesting enzyme activity and improved *in situ* dry matter degradation in lambs (Chaucheyras-Durand and Fonty, 2001 and 2002). Live yeast has increased cellulolytic bacteria populations as well asA growth of rumen protozoa in sheep (Chaucheyras-Durand and Fonty, 2001 and 2002; Mosoni et al., 2007).

Live yeast can reduce the risk of rumen acidosis. *In vitro* cell numbers of the lactic acid-producing bacteria *Streptococcus bovis* were reduced with live yeast (Chaucheyras-Durand et al., 2005). The growth of *Megasphaera elsdenii*, a lactate utilizer, has been found to increase with live yeast (Chaucheyras et al., 1996).

In one study, supplementation of live yeast to the diet of dairy cows increased rumen pH and decreased lactic acid concentration (Guedes et al., 2008). In two other studies, live yeast increased average rumen pH in dairy cows as well as reduced the amount of time the rumen pH was below 5.6 (Bach et al., 2007; Thrune et al., 2009).

Sodium bicarbonate has been supplemented to dairy cows for many years as a rumen buffer (Le Ruyet and Tucker, 1992). Russell and Chow (1993) also suggested that sodium bicarbonate increases the flow of undigested starch from the rumen and reduces propionate production.

Erdman (1988) concluded that the addition of sodium bicarbonate to low-forage diets increased rumen pH, the ratio of acetate to propionate and milk fat percentage.

More recently, research trials showed an extra increase in rumen pH as well as production benefits when live yeast was added to lower-forage dairy cow rations that already contained sodium bicarbonate (Bach et al., 2007; Thrune et al., 2009).

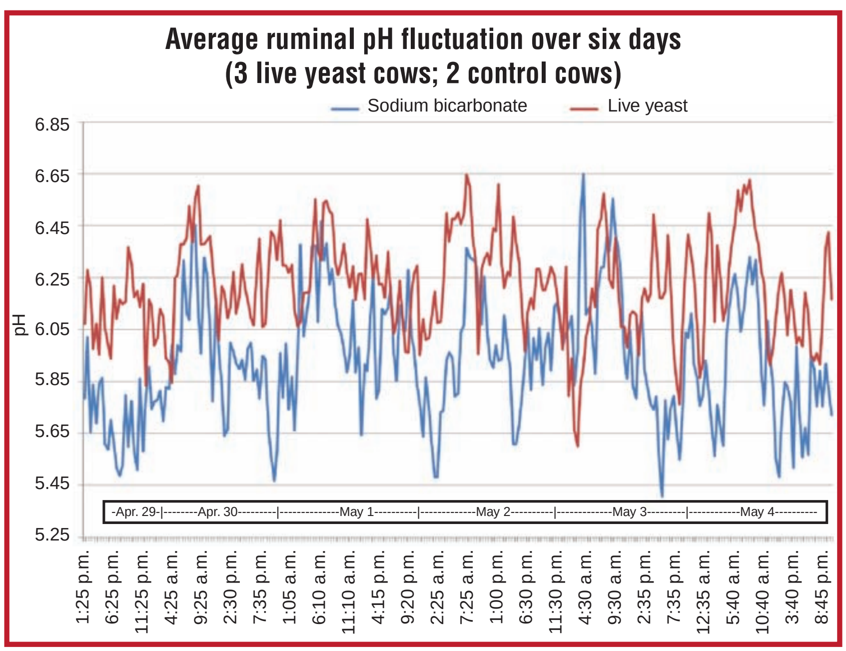
With improvements in forage fiber digestibility and increases in grain prices, ration forage content has increased on many dairies in recent years, making any enhancements in fiber digestibility even more critical. At the same time, live yeast has been proved to moderate rumen pH.

A recent study was conducted to determine the effect of supplementing 0.5 g live yeast (*S. cerevisiae* CNCM I-1077) versus 6 oz. per cow per day of sodium bicarbonate (170 g) in a 58% forage dry matter diet containing 25.6% forage neutral detergent fiber (NDF) on milk yield, milk components and rumen pH (de Ondarza et al., 2012).

Animals and experimental treatments. One hundred twenty multiparous cows were assigned to one of two treatments. Half of the cows received 0.5 g per cow per day of live yeast (10×10^9 colony-forming units per day; Levucell SC), and half of the cows received 6 oz. per cow per day of sodium bicarbonate.

Cow groups (live yeast versus sodium bicarbonate) were balanced for pre-trial lactation number (2.9 for the live yeast group and 3.2 for the sodium bicarbonate group), days in milk (195 days and 196 days for live yeast and sodium bicarbonate, respectively) and 3.5% fat-corrected milk yield (38.2 kg and 38.4 kg per day for live yeast and sodium bicarbonate, respectively).

The study was 11 weeks in length with six weeks of diet adaptation and five weeks of data collection. Cows were housed in a commercial free-stall barn in separate pens (live yeast versus sodium bicarbonate) in this side-by-side study.



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Measurements and analysis. Cows were milked three times per day, and daily milk production of individual cows was recorded. Milk was sampled (on one day, with all three milkings composited) on weeks 8, 9 and 10 of the study and analyzed for fat, true protein, somatic cell count and milk urea nitrogen (MUN).

Rumen pH was measured every five minutes using rumen bolus pH probes and receivers (Kahne Ltd.). Four cows in each treatment pen were given boluses for pH measurement during the last five weeks of the study.

Data were analyzed using JMP statistical software (SAS) to determine if milk yield, milk component percentages and yields and rumen pH were affected by treatment.

Results

Diet and intake. The basal ration consisted of corn silage, mixed alfalfa/grass silage, corn meal, whole cottonseed and a commercial grain blend (Table 1). Cows were fed a total mixed ration once per day and had *ad libitum* access to the ration and water. The ration was typical of high-production diets fed in the northeastern U.S.

Prior to beginning the study and during weeks 6 and 9 of the study, all forages were sampled and analyzed via chemical analysis.

Daily pen dry matter intakes were excellent throughout the study for both pens, with 26.1 ± 0.3 kg per cow per day consumed by the live yeast-supplemented cows compared to 26.3 ± 0.3 kg per cow per day consumed by the sodium bicarbonate-supplemented cows ($P < 0.05$).

Milk yield and milk components. Milk yield was 2.1 kg higher for cows fed live yeast: 41.9 kg and 39.8 kg per day for live yeast and sodium bicarbonate, respectively (Table 2). The lack of a statistically significant difference ($P = 0.09$) may have resulted from a relatively small number of animals per treatment, a range in days in milk within a treatment group or some subclinical mastitis issues that contributed to greater variation.

Any improvements in milk yield would most likely be attributed to a combination of increased fiber digestion (Chaucheyras-Durand and Fonty, 2001) and reduced subclinical rumen acidosis (Chaucheyras et al., 1996; Chaucheyras-Durand et al., 2005) with the live yeast treatment.

Milk fat percentage was not affected ($P = 0.79$) by treatment, with means of 3.62% for live yeast and 3.65% for sodium bicarbonate. Milk fat yield was unaffected ($P = 0.30$) by treatment, with means of 1.51 kg per day for live yeast and 1.46 kg per day for sodium bicarbonate.

Overall, 3.5% fat-corrected milk was not affected ($P = 0.18$) by treatment, with means of 42.6 kg per day for live yeast and 40.9 kg per day for sodium bicarbonate.

Milk true protein percentage was similar ($P = 0.34$) for all cows, with means of 2.98% for cows fed live yeast and 3.01% for cows fed sodium bicarbonate. Milk true protein yield tended ($P = 0.09$) to be higher for cows fed live yeast, with means of 1.24 kg and 1.18 kg per day for live yeast and sodium bicarbonate, respectively.

MUN was not affected ($P = 0.51$) by treatment, with means of 13.05 mg/dL for live yeast and 13.33 mg/dL for sodium bicarbonate.

Overall, somatic cell count (times 1,000) was lower ($P < 0.05$) for cows supplemented with live yeast (80.1) than for cows supplemented with sodium bicarbonate (245.5). Pre-trial somatic cell count was not a significant covariate in the analysis of milk yield or 3.5% fat-corrected milk. There is no apparent biological reason for this difference to be a result of study treatments or management.

Feed efficiency. Based on the pen intakes, cows supplemented with live yeast had a feed efficiency (kilograms of 3.5% fat-corrected milk per kilogram of dry matter intake) of 1.63, while cows supplemented with sodium bicarbonate had a feed efficiency of 1.56.

This difference could not be statistically analyzed because of the calculation from pen intakes rather than individual cow intakes, but it is similar to the difference reported by de Ondarza et al. (2010) of +0.05 with live yeast.

Ruminal pH profile. Live yeast had a significant positive effect on most rumen pH parameters (Table 3 and Figure). Mean daily pH was higher ($P < 0.0001$) for cows fed live yeast: 6.22 for live yeast versus

1. Diet composition and nutrient analysis (% of dry matter, unless specified)

Composition		Nutrient analysis	
Regular corn silage	14.71	Crude protein (CP)	17.74
Brown mid-rib corn silage	17.71	Soluble CP, % of CP	35.27
Mixed alfalfa/grass silage	22.55	RUP, % of CP	37.80
Straw	3.35	Methionine (% of metabolizable protein)	2.16
Fine-ground corn	16.81	Lysine (% of metabolizable protein)	6.84
Dried bakery product	2.65	Net energy of lactation, Mcal/kg	1.76
Whole cottonseed	4.31	Acid detergent fiber	19.75
Soybean meal-48	5.18	NDF	32.73
Canola meal	5.40	Forage NDF	25.66
Bypass protein source	1.94	Lignin	3.11
Blood meal	1.30	Non-fiber carbohydrates	39.82
Rumen-protected methionine	0.04	Sugar	3.59
Urea	0.19	Starch	27.35
Rumen-protected fat	1.12	Ether extract	5.34
Tallow	0.17	Calcium	0.98
Limestone	1.18	Phosphorus	0.36
Salt	0.38	Magnesium	0.30
Magnesium oxide	0.15	Potassium	1.45
Trace minerals/vitamins	0.41	Sulfur	0.23
Live yeast product plus carrier (LY only)	0.32	Selenium, ppm	0.30
Sodium bicarbonate (SB only)	0.64	Monensin, mg/kg	15.42

2. Production and component least-square means by treatment

	----Live yeast----		-Sodium bicarbonate-		
	Mean	Std. error	Mean	Std. error	P-value
Milk, kg/day	41.91	0.86	39.83	0.86	0.09
3.5% fat-corrected milk, kg/day	42.58	0.89	40.89	0.90	0.18
Fat, %	3.62	0.07	3.65	0.07	0.79
Fat, kg/day	1.51	0.04	1.46	0.04	0.30
Protein, %	2.98	0.02	3.01	0.02	0.34
Protein, kg/day	1.24	0.02	1.18	0.02	0.09
MUN, mg/dL	13.05	0.30	13.33	0.31	0.51
Somatic cell count x 1,000	80.09	49.16	245.48	49.06	0.02

3. Ruminal pH profile of cows by treatment

	----Live yeast----		-Sodium bicarbonate-		
	Mean	Std. error	Mean	Std. error	P-value
Mean daily pH	6.22	0.01	6.03	0.01	<0.0001
Minimum daily pH	5.54	0.01	5.34	0.01	<0.0001
Maximum daily pH	6.98	0.02	6.81	0.02	<0.0001
Daily pH range	1.44	0.03	1.46	0.03	0.58
Ruminal pH < 5.8					
Duration of day, min./day	141	15	378	14	<0.0001
Area, pH x min./day	19.5	4.4	80.1	4.2	<0.0001

6.03 for sodium bicarbonate.

Minimum daily pH was higher (P < 0.0001) for cows fed live yeast at 5.54 compared to 5.34 for sodium bicarbonate. Maximum daily pH was higher (P < 0.0001) for cows fed live yeast versus sodium bicarbonate: 6.98 versus 6.81.

The duration of the day when rumen pH was less than 5.8 (Dohme et al., 2008) was reduced (P < 0.0001) for cows fed live yeast: 141 minutes versus 378 minutes per day for live yeast and sodium bicarbonate, respectively. The area under the pH 5.8 curve (pH x time) was less (P < 0.0001) for cows fed live yeast at 19.5 compared to 80.1 for sodium bicarbonate.

These improvements in rumen pH with live yeast are similar to those seen in previous studies (Thrune et al., 2009; Bach et al., 2007) confirming that live yeast reduces the risk of subacute rumen acidosis. The range in daily pH was not affected by treatment (1.44 versus 1.46 for live yeast and sodium bicarbonate, respectively; P = 0.58).

However, Marden et al. (2008) did not see a pH effect between live yeast and sodium bicarbonate, but the redox potential was lowered with the live yeast, and NDF digestion was increased, suggesting that the live yeast played a role in the fibrolytic flora enhancement as opposed to a more exogenous buffer action for sodium bicarbonate.

Overall, these findings support the positive action live yeast seems to have on fibrous diet optimization for dairy cows.

Implications

Today's dairy nutritionists typically supplement sodium bicarbonate and a yeast additive to high-producing dairy cow diets primarily to combat subclinical acidosis and to improve fiber digestion.

This research shows that the tested live yeast strain alone resulted in higher mean daily rumen pH and fewer minutes per day with a rumen pH of less than 5.8. Milk yield tended to be 2 kg higher (P < 0.10) with live yeast.

This research suggests that sodium bicarbonate supplementation may be unnecessary when the tested live yeast is supplemented at a rate of 0.5 g per cow per day.

It is recommended that this study be repeated with larger, more homogenous groups of high-producing dairy cows.

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