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Yeast Products for Growing and Lactating Ruminants: A Literature Summary of Impacts on Rumen Fermentation and Performance

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Yeast products are widely utilized as feed additives for ruminant animals in many parts of the world. There are a number of corporate groups that produce these products, which are marketed under a wide variety of trade names. While the number of yeast products that have undergone substantive evaluation in controlled research studies is somewhat limited, there is a widespread belief among dairy and beef producers, and ruminant nutritionists, that yeast products are beneficial by enhancing dry matter (DM) intake and overall animal performance. Since yeast products are generally modestly priced, economic barriers to their use are low.

Mechanisms have been proposed to explain why yeast products could stimulate DM intake and productivity in growing and lactating cattle. Perhaps the oldest hypothesis is that the yeasts are able to grow, at least for a short period of time, in the rumen thereby directly enhancing fiber digestion and/or producing nutrients that stimulate growth of rumen bacteria, which do the bulk of the fiber digestion. It has also been suggested that yeasts utilize nutrients, such as lactic acid which, if allowed to accumulate in the rumen, could suppress bacterial growth and/or suppress DM intake by driving rumen pH down. A more recently suggested possibility is that growth of yeast in the rumen utilizes the trace amounts of dissolved oxygen, particularly at the interface of the cellulolytic bacteria and fiber, thereby stimulating growth of rumen bacteria, to which oxygen is toxic. It seems clear that for these mechanisms to be operative, yeasts in the product have to be viable, in the sense of being able to grow for at least a short period of time in the rumen. Hence the origin of the debate between ‘live’ and ‘dead’ yeast products.

The alternate mechanism is that it is the yeast culture itself, which is created in the yeast fermentation process, which provides a mixture of micro-nutrients to stimulate bacterial growth in the rumen thereby facilitating increased fermentation of fiber and/or utilization of end-products of fiber fermentation to prevent their accumulation in the rumen. Supporters of this theory point to a limited research base showing that when cultures of live brewers or fermentation yeasts are fed to ruminants, there are few, if any, changes to rumen fermentation and/or animal performance. Indeed the view that live fermentation yeasts are ineffective is so widely held that little research has been completed in the area.

Table 1. Published studies with yeasts and yeast cultures.

	Species									Study Type .			
	Cattle					buffalo	sheep	goats					total
	calves	growing	lact	dry	bulls	growing		lact	*in vitro*	prod	met	both	studies
Saccharomyces cerevisiae yeasts													
Alltech Inc. (USA)													
1026	0	4	3	0	2	2	3	0	4	1	14	1	18
8217	0	0	0	0	0	0	0	1	0	1	0	0	1
8417	0	0	0	0	0	0	0	0	2	0	0	0	2
undefined	1	5	3	0	0	0	0	0	4	2	7	4	13
Chr. Hansen Co. (USA)													
Biomate Plus	0	0	4[1]	0	0	0	0	0	1	3	0	1	4
Undefined	0	0	0	0	0	0	0	0	1	0	0	0	1
Diamond V Mills, Inc. (USA)													
YC	0	0	2	0	0	0	1	0	0	2	1	0	3
XP	3	4	11	1	0	0	1	0	5	6	6	4	23
undefined	0	3	1	3	0	0	1	0	1	2	6	0	7
Dox-Al Inc. (Italy)													
Thepax Dry	0	0	1	0	0	0	0	0	0	0	0	1	1
Lesaffre Developments (France)													
Biosaf	0	0	2	0	0	0	1	0	1	1	3	0	4
PMX70SBK	0	0	0	0	0	0	0	0	1	0	0	0	1
Santel Sante Animal (France)													
Levucell 1077	0	0	1	0	0	0	1	2	2	1	5	0	8
Levucell 1096	0	0	0	0	0	0	3	0	1	0	4	0	4
Levucell undef	0	1	0	0	0	0	0	0	0	0	1	0	1
Undefined	0	0	2	0	0	0	1	0	2	2	0	0	4
Vi-Cor Co. (USA)													
A-Max	0	0	1	0	0	0	0	0	1	0	0	0	1
Western Yeast Co. (USA)													
Cell-con & 2x-2-2-5	0	0	1	0	0	0	0	0	0	1	0	0	1
Fermentation yeasts													
Emmet Grain Co. (USA)													
BY35	1	0	0	0	0	0	0	0	0	1	0	0	1
Fleischmann's Yeast, Inc. (USA)													
Yeast effluent	0	0	1	0	0	0	0	0	0	0	1	0	1
Undefined	0	0	0	0	0	0	0	0	2	0	1	0	4

Zea Gen Inc. (USA)													
Zea-Gen	0	0	0	1	0	0	0	0	0	1	0	0	1
Totals	5	15	31	5	2	2	13	2	23	24	47	9	98

The objective of this article is to summarize studies that have been published in the scientific literature that have examined the impact of specific commercial yeast products on rumen fermentation, fiber digestion and/or animal performance. The mechanisms by which yeast cultures could be efficacious will only be addressed indirectly.

The Published Information Base

The author was able to find a total of 98 published papers that originated largely from North America and Europe, with some papers from India, that were published in a wide variety of scientific journals (Table 1). The vast majority of these studies, 76, were with whole animals that included cattle (calves, growing animals, bulls, lactating cows, dry cows), growing buffaloes, sheep, lambs and lactating goats. There were also 22 *in vitro* studies. The corporate groups that sponsored the most research effort were Alltech Inc. (34), Diamond V Mills Inc. (33) and Sante Santel Animal (13). Virtually all of the studies (91) utilized strains of the yeast *Saccharomyces cerevisiae*, and some companies sponsored research with more than one strain of this yeast.

Articles appeared in numerous scientific journals with the Journal of Dairy Science (38%), Animal Feed Science and Technology (18%) and the Journal of Animal Science (12%) sharing 68% of total articles with the balance divided among 17 other journals. The author does not claim that this listing is inclusive of all research ever published with yeasts and yeast cultures relative to ruminant production. It is the information base that was available, and relevant, in the author's opinion.

Impact of Yeast Products on Ruminal Fermentation and Fiber Digestion

The only yeast product that has been sufficiently widely studied to create a data base of its effects on rumen fermentation and fiber digestion is the Alltech yeast product 'Yea-Sacc^{1026} (1026). Not all of the 15 studies reported data in all areas of rumen fermentation. The summarized data are in Table 2.

In the 21 experiments reported, the average change in rumen pH was only 1.6%, although 86% of experiments reported an increase (all increases reported here and throughout are numerical changes and ignore within experiment statistical analysis). While ammonia nitrogen concentrations increased an average of 3.2% over 18 experiments, only 40% of experiments actually showed an increase. Total rumen volatile fatty acid concentrations increased 5.4% and lactate concentrations decreased 8.1%, and 65% and 67% of individual experiments, respectively, showed these changes.

Table 2. Influence of Yea-Sacc[1026] on rumen fermentation and fiber digestion.

	Source		Diet[1]		Benefit	
	Papers	Experiments	C	YP	Overall %	% expts
Rumen fermentation parameters (mM/L)						
pH	13	21	6.36	6.46	+1.6	86
Ammonia N	11	18	18.2	18.8	+3.2	40
VFA	12	20	84.8	89.4	+5.4	65
Lactate	6	9	8.6	7.9	-8.1	67
Rumen Bacterial Counts ($x10^9$)						
Total	4	6	2.89	4.12	+42.4	100
Cellulolytic	5	7	2.02	2.42	+20.0	86
Non-cellulolytic	4	6	0.87	1.70	+95.0	100
Digestion of Neutral detergent fiber (%)						
In vitro (24 h)	2	5	43.2	42.7	-1.1	60
In sacco (24 h)	4	8	46.5	49.6	+6.6	75
In vivo	6	6	54.8	56.9	+3.9	83

[1] - 'C' is the control diet and 'YP' is the diet with added Yea-sacc[1026].

In contrast to these modest changes in parameters of rumen fermentation, 100% of six experiments reported an average 42% increase in total viable bacterial counts in the rumen and 86% of seven studies showed an average 20% increase in cellulolytic bacterial counts. An impressive average 95% increase in non-cellulolytic bacterial counts represented an increase in all experiments.

Digestion of fiber, as neutral detergent fiber (NDF), was measured either *in vitro* for 24 h (outside the animal in the laboratory), *in sacco* for 24 h (by putting feeds into the rumen of live animals in porous bags) or *in vivo* (by measuring digestion of NDF in the entire digestive tract of live animals). *In vitro* data showed little difference in fiber digestion, perhaps reflecting difficulties with this approach to evaluate the impact of products, such as yeast products, that take several days to have their full effects. In contrast, both the *in sacco* and *in vivo* fiber digestions were enhanced, by 6.6 and 3.9% respectively, and increases were reported in 75 and 83% of experiments respectively.

Impact of Yeast Products on Animal Growth and Feed Efficiency

The only product that has been sufficiently studied to create a data base of its effects on growth and feed efficiency is the Alltech product 'Yea-Sacc[1026]'. All of the 4 studies, and 8 experiments, reported data on all parameters, which are summarized in Table 2.

Dry matter intake was increased by an average of only 2.0%, but an increase occurred in 75% of experiments. Body weight gain increased by only slightly more, 3.7%, although an increase was reported in all experiments. Feed conversion efficiency increased a razor thin average of 1.8%, and only occurred in 60% of reported experiments.

Table 3. Influence of Yea-Sacc[1026] on DMI, BW gain and FCE.

	Source		Diet		Benefit	
	Papers	Experiments	C	YP[1]	Overall %	% expts
Dry matter intake (kg/d)	4	8	7.39	7.54	+2.0	75
Body weight gain (kg/d)	4	8	1.25	1.30	+3.7	100
Feed conversion efficiency (kg BW gain/kg DM intake)	4	5	0.175	0.179	+1.8	60

[1] - 'C' is the control diet and 'YP' is the diet with added Yea-sacc[1026].

Impact of Yeast Products on Dry Matter Intake and Milk Production

The three products that have been sufficiently studied to create a data base of effects on milk production and composition are the Alltech yeast product 'Yea-Sacc[1026]', the Diamond V Mills yeast culture product 'XP' (XP) and the Chr. Hansen yeast product 'Biomate Plus' (BP). All studies, and experiments, reported data on all parameters, which are summarized in Table 4. The 1026 and BP products are 'live' yeast products while the XP is 'dead' yeast culture product.

Dry matter intake was increased by an average of 2.1% for 1026, 1.4% for XP and 0.5% for BP and increases were observed in 60, 55 and 60% of studies respectively. Thus 1026 and XP were the most likely, and BP least likely, to stimulate DM intake. Increases in milk production were very consistent among products, at about 3.5%, and consistent increases were observed among products, with 80, 90 and 100% of experiments showing increases for 1026, XP and BP respectively.

Milk protein percentage was lower, by 1.3, 0.6, and 2.1% respectively for 1026, XP and BP, and the consistency of the decline was much greater for BP (i.e., 60, 60 and 100% of the time for 1026, XP and BP). Milk fat percentage showed small effects of the three products, and the consistency of the responses were less than 60% for 1026 and BP.

The impacts of the three products on diet energy density was calculated assuming the average cows in all studies weighed 600 kg and that they had no net body weight change (as this data was not consistently reported in the experiments). On this basis, changes in the calculated NE_l density of the diets were very modest, and consistency among experiments could not be assessed.

Overall Assessment

A substantial amount of controlled research is available on affects of yeasts and yeast cultures on rumen fermentation and performance of growing and lactating ruminants. However the bulk of this research is restricted to four corporate groups. In lactating cows, where data are available for three specific products (Yea-Sacc[1026], Diamond V XP, Chr. Hansen BP), the impact on performance is similar, but with subtle differences.

Table 4. Influence of Alltech Yea-Sacc[1026], Diamond V Mills 'XP' and Chr. Hansen (CH) Biomate Plus on dry matter intake, milk production, milk components and estimated diet energy density (net energy for lactation (NE_l)).

	Source		Diet		Benefit	
	Papers	Experiments	C	YP[1]	Overall %	% expts
Dry matter intake (kg/d)						
Alltech[1026]	3	5	19.1	19.5	+2.1	60
Diamond V XP	11	12	20.8	21.1	+1.7	63
CH Biomate Plus	4	5	22.0	22.1	+0.5	60
Milk Production (kg/d)						
Alltech[1026]	3	5	22.7	23.5	+3.5	80
Diamond V XP	11	12	35.6	36.6	+2.6	83
CH Biomate Plus	4	5	36.0	37.2	+3.4	100
Milk protein (%)						
Alltech[1026]	3	5	3.17	3.13	-1.3	60
Diamond V XP	11	12	3.12	3.10	-0.6	63
CH Biomate Plus	4	5	3.10	3.04	-2.1	100
Milk fat (%)						
Alltech[1026]	3	5	3.34	3.33	-0.3	40
Diamond V XP	11	12	3.64	3.72	+2.2	75
CH Biomate Plus	4	5	3.61	3.63	+0.6	40
Diet Energy Density (Mcal/kg DM)						
Alltech[1026]	3	5	1.30	1.32	+1.5	-
Diamond V XP	10	10	1.65	1.68	+1.8	-
CH Biomate Plus	4	5	1.60	1.63	+1.9	-

[1] - 'C' is the control diet and 'YP' is the diet with added the added yeast product.

While all three products result in an average milk yield increase of about 3.2%, none shows a consistent increase in DM intake. The decline in milk protein % occurs for all products, but its extent, and the reliability of a decline, is least for 1026 and XP.

The quantitative increases in DM intake with 1026 for beef (2.0%) and dairy (2.1%) cattle, increases in beef growth (3.7%) and dairy milk production (3.5%), as well as the small, but consistent, increases in beef efficiency (1.8%) and dairy diet energy density (1.5%) are remarkable in their similarity. This similarity between cattle classes is supportive of a consistent impact of yeast products regardless of the base diet.

The exact mechanism responsible for the benefits of these yeast and yeast culture products are not clear from the published data. Nevertheless, data support a stimulation of both rumen cellulolytic and non-cellulolytic bacterial counts for 1026, which is consistent with observed increases in fiber digestion and decreases in lactate

concentrations respectively. There can be interpreted as evidence to support a direct effect of growth of yeasts in the rumen. That there are little difference between the 'live' (i.e., 1026 and BP) yeast products and the 'dead' (XP) yeast culture product suggests that different mechanisms may be responsible for the benefits, particularly between the 'live' and dead' yeast products. Overall, the modest nature of the improvements in rumen fermentation efficiency (for 1026) are consistent with the modest improvements in productivity with these yeast products.

The yeast products Alltech 'Yea-sacc^{1026}', Diamond V Mills 'XP' and Chr. Hansen 'Biomate Plus' can be expected to consistently deliver a production improvement about 80 to 90% of the time with an average of about 3.5% in both beef and dairy animals, although the individual products appear to differ in how the improvement occurs and individual situations can be expected to vary. Efficacy of other yeast products cannot be determined due to a paucity of controlled research.

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