The use of yeast in ruminant diets as a natural gut flora stabiliser

Yeasts are described as fungi that reproduce asexually by budding or fission. This means that growth results in groups of single cells. Saccharomyces cerevisiae is probably the most well-known and researched species of yeast and has many diverse functions in both human and animal diets. There has been much research into the benefits of dietary inclusion of S. cerevisiae for ruminant livestock and hindgut fermenters, such as the horse.

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Many different strains of this yeast exist, and all vary slightly in regards to their effects in the animal. Several strains have been the subject of ruminant research, including S. cerevisiae CBS 493.94.

As research into yeast supplementation has been extensive over the last few decades, this article focuses mainly on its effects in dairy cattle.

The ruminant digestive tract

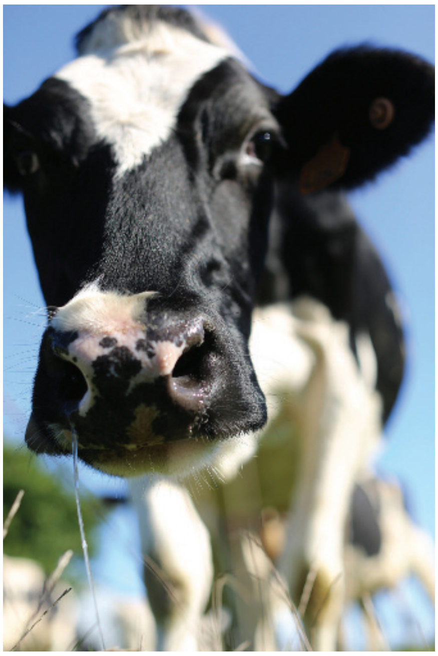
The ruminant digestive tract has evolved to make use of low-quality, fibrous feed material via microbial fermentation in the reticulo-rumen.

The ruminal microbial ecosystem generates sources of energy, nitrogen and other nutrients via the breakdown of dietary ingredients.

Volatile fatty acids (VFA) are the end product of the bacterial fermentation of carbohydrates and are absorbed across the rumen wall as the primary energy source for the ruminant.

It is well-established that diets high in soluble carbohydrates (starch and sugar) can lead to overproduction of VFA, particularly propionate and lactate, and, ultimately, to a drop in rumen pH and sub-acute acidosis (SARA) and/or acute acidosis.

Cellulolytic bacteria operate within a narrow pH range (above 6.0) and can only survive for a relatively short time below this range before their growth and activity is compromised. Thus, fibre digestion is inhibited if rumen pH remains low for long periods.



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If the situation is allowed to progress, acute acidosis will result in further compromise of cellulolytic and lactate-utilising bacterial growth, with a concomitant proliferation of lactate-producing bacteria.

This then deteriorates into a vicious cycle, with a continual decline in pH to the point of acute acidosis (pH <5.0) and subsequent animal death.

Yeast in rumen diets

Interest in yeast as part of ruminant diets has been cited as far back as 1925 but its mode of action was not fully understood. Over the last three decades, in-depth investigation has revealed that the main effects of yeast relate to alterations in microbial fermentation in the rumen.

Primarily, yeast, or rather, S. cerevisiae, stimulates the activity of cellulolytic bacteria, or those that utilise lactate, particularly Selenomonas ruminantium, as well as total anaerobic bacteria, helping to reduce the amount of time the rumen pH falls below 5.5.

The majority of beneficial bacteria in the rumen rely on a stable, anaerobic environment in order to function. Oxygen enters the rumen with feed particles and thus poses a consistent threat.

S. cerevisiae is known to scavenge (respire) oxygen entering the rumen, helping to promote an anaerobic environment and promoting anaerobic bacterial growth.

Additionally, stimulatory co-factors are thought to be involved in increasing bacterial growth, meaning that live yeast is likely to be more effective compared to 'dead' or inactivated yeast. Dawson et al. (1990) hypothesised that heat-labile compounds could also be exerting an effect on numbers of cellulolytic and/or total anaerobic bacteria.

Numerous beneficial effects have been reported on the inclusion of yeast in ruminant diets.

However, the response of animals to yeast inclusion is influenced by several factors, including diet, days in milk and yeast strain.

Stabilising the rumen

Yeast is purported to stabilise the rumen environment, with effects including higher rumen pH, increased numbers of cellulolytic bacteria and reduced lactate concentration.

Although it had no effect on rumen pH or cellulolytic bacteria, Erasmus et al. (1992) found yeast reduced peak rumen lactate concentration two to three hours post-prandium in fistulated dairy cows.

They also found a lower rumen ammonia concentration following yeast inclusion, which, they hypothesised, resulted from greater incorporation of nitrogen (N) into microbial protein. A study in dairy heifers also picked up reductions in rumen ammonia N concentration.

In this experiment, dairy heifers supplemented with a live yeast culture exhibited increased VFA production and a

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possible stimulation of N uptake by rumen bacteria.

Similarly, Al Ibrahim et al. (2010a) also noted a reduction in ammonia N concentration but with little effect on other rumen parameters.

The lack of effect in the Al Ibrahim et al. (2010) study is likely to be related to the performance of the control group, making it more difficult to find a difference between supplemented and un-supplemented animals.

In contrast, Bach et al. (2007) noted an increase in average rumen pH across time in dairy cows when yeast was added to the diet. These authors used a pH meter resident in the rumen for a period of two weeks, and they stated that a beneficial effect of yeast could potentially be seen as early as one week after supplementation.

Erasmus et al. (2005) commented that yeast increased propionate production but elicited only a modest effect on biological efficiency.

Apart from dairy cows, Kumar et al. (1997) did note a significant improvement in rumen parameters in buffalo calves fed a high-forage diet.

Rumen pH and cellulolytic bacterial count were increased and rumen ammonia N decreased relative to control animals.

Again, beneficial effects were seen after only one week of supplementation. It is interesting to note that these positive effects were seen on a high-forage diet, when other studies highlight a greater response in more starch- or concentrate-based diets. In a study investigating the effect of yeast on bulls fed a barley beef diet, both total VFA and acetate production was increased without any effect on propionate or the acetate:propionate ratio.

This, together with the improved dry matter intake (DMI), suggests an increase in fermentation rather than a shift in fermentation patterns. The increased DMI did not translate to increased performance.

Similarly, Williams et al. (1991) noted a reduction in lactate concentration together with a concomitant increase in pH when yeast was added to the diet of steers.

In a linked experiment, they also noted increased DMI and subsequent milk yield in Friesian dairy cows, whereby yeast effects were more noticeable at higher levels of concentrate in the diet, supporting evidence for dietary influence over yeast effects. Overall, the majority of yeasts are accepted as gut flora stabilisers.

Yeast benefits

In a recent meta-analysis of the effects of live yeasts in ruminants, Desnoyers et al. (2009) noted that across 157 experiments, yeast inclusion increased ruminal pH, VFA production and organic matter digestibility (OMD), while reducing lactate concentration.

It was highlighted that dietary composition played an important role in the magnitude of the effects. This is in agreement with Robinson and Erasmus (2009), who noted that higher dietary neutral detergent fibre (NDF) and acid detergent fibre (ADF) resulted in a lesser response to yeast supplementation.

Increases in milk production have often been numerical, rather than statistical. Kalmus et al. (2009) demonstrated a 5.8% numerical increase in milk yield, similar to the 6%, non-significant increase noted by Erasmus et al. (1992).

Milk composition has been shown to be affected by yeast supplementation. Significant increases in milk fat and/or milk protein have been demonstrated in several dairy studies as well as numerical increase.

Benefits appear to be more obvious during early lactation, when negative energy balance (NEB) is an issue. Al Ibrahim et al. (2010a) noted little effect of yeast supplementation in early lactation Holstein Friesians on milk performance parameters, including milk yield and composition as well as DMI.

Despite this, there was a numerical increase in milk yield, which would have been of importance from a financial aspect. In the Desnoyers et al. (2009) meta-analysis, a 1.2 g/kg body weight (BW) increase in milk yield and a 0.05% increase in milk fat was found.

Performance in terms of product output is not the only potential use for yeast cultures. Al Ibrahim et al. (2010b) noted that, although there was no effect on NEB in dairy cows post-partum, yeast supplementation improved serum insulin, the peak in oestradiol prior to ovulation and the size of the first ovulatory follicle post-partum. The authors suggest further investigation into these effects.

Additionally, Yuan et al. (2015b) evaluated the effect of an enzymatically hydrolysed yeast on immunity in transition cows.

They noted an improved humoral immunity in conjunction with a modulatory effect on uterine and mammary gland health. While response to yeast appears varied and inconsistent in the literature, overall, there are trends of improvement as described above.

However, not all yeasts are the same and not all commercially available products are comparable 'gram for gram'. Commercially, there are numerous yeast products, such as Yea-Sacc (Alltech Inc), available for use in ruminant livestock and other species. All are based on different strains. Probably the major distinction between them is whether the yeast is alive or dead.

Registration depends on demonstration of both safety and efficacy of the product in various ruminant species and types (for example, dairy vs. fattening animals vs. calves).

As dosage for live yeasts can often be reported as colony-forming units (CFU)/kg dry matter (DM) or as CFU/d, each different commercially available product will have its own minimum effective dose that is not directly comparable with other, similar products.

This is an important factor to consider when comparing yeast studies, as levels used for one yeast may not be sufficient to elicit responses from another yeast.

Conclusion

In conclusion, yeast cultures of S. cerevisiae have been used both commercially and experimentally in ruminant diets for several decades. There are many different strains, all of which differ in regard to their effects in the animal and their minimum effective doses.

The likely mode of action is concerned with oxygen scavenging to promote an anaerobic, more stable environment for ruminal bacteria. However, it is also likely that stimulatory compounds are generated by the activity of the yeast.

Key effects appear to be an improvement in rumen fermentation with a decrease in lactate, reducing the risk of acidosis. Improved DMI has been related to improved performance, albeit numerical, in many studies. Though care needs to be taken when interpreting results from different strains of yeast, the use of yeast in ruminant diets appears to have a place as a natural gut flora stabiliser. ■

References are available from the author on request.