Animal Performance Benefits of Silage Inoculants

Kevin Panke-Buisse, U.S. Dairy Forage Research Center

Forages for ensiling are commonly inoculated with a mix of homofermentative Lactic Acid Bacteria (LAB) and heterofermentative LAB. These have long been used to, under ideal conditions, rapidly ferment water soluble carbohydrates (WSC) in forages primarily to lactic acid (homofermenters), and also some acetic acid (heterofermenters). The goal of inoculation is to ensure a lower pH and higher aerobic stability in the ensiled forage. These benefits have made bacterial inoculants the most common silage additive used by farmers.

Despite their wide use as an additive in the industry, these bacteria are highly successful in the environment and forages often have enough naturally-occurring LAB on their surface to create high-quality silage. This is especially true of corn, sorghum, and sugarcane silages. Current evidence suggests inoculation does not necessarily improve the quality of these silages, and I've spoken with some farmers who question the cost-benefit ratio of inoculation, particularly for silage corn. Consider the following:

- Laboratory studies often tightly monitor and control their ensiling conditions, with the goal of optimizing any parameters not being studied (i.e., best-case scenario comparisons). On farm, environmental conditions often differ and results tend to be more variable.
- Inoculation has a larger potential effect in sub-optimal conditions in which the native LAB population is often limited or spoilage organisms (i.e., Clostridia, yeasts, molds) are stronger competitors.
- Benefits of bacterial inoculants are not exclusive to forage preservation. There is consistent evidence suggesting inoculation of forages with LAB can increase animal performance.

Of the benefits bacterial inoculants bring to forage systems, the role inoculants play in increasing animal performance are the least understood. A 1997 Kung and Muck review summarized animal responses to silage additives. It showed, between 1990-1995, approximately half of the studies including microbially-inoculated silages, observed significant increases in gain and milk production *[Proc. Silage NRAES-99 (1997)]*. The average increase in milk yield for these studies was 1.37 kg/day. A recent meta-analysis of data from previously published studies revealed a significant and consistent effect of improved milk yield and numerical increases in milk fat and protein associated with bacterial inoculation of ensiled forages *[J. Dairy Sci. (2017) 100:4587-4603]*. These observations raise two important questions.

What is the mechanism driving this effect and can we harness it to improve dairy production efficiency? There are four main mechanisms that could potentially explain animal responses to silage inoculation. Each of these will be explored briefly in the context of current research.

- **Increased forage digestibility.** There is evidence long ensiling/storage times increase forage digestibility. Inoculation effect on improvement in dry matter (DM) digestibility was not significant. This does not mean inoculation has no effect whatsoever on DM digestibility; however, ensiling time was not accounted for, and DM digestibility had the smallest dataset of the forage parameters analyzed.
- **Increased DM or energy intake.** Inoculation has been shown in several studies to increase DM intake (DMI), but also to have no effect on DMI in others. The 2017 meta-analysis showed a strong trend of increased DMI, but also variability between datasets. This may indicate inoculation can drive DMI patterns, but effects depend on properties that are difficult to control or measure. This may be attributable to a reduction in spoilage organisms, or associated compounds like ammonia and butyrate that reduce intake.
- **Decreased proteolysis.** The breakdown of forage protein between cutting and feedout can cost farmers a significant proportion of their forage protein, particularly in leguminous forages. Enemies in this regard are plant proteases that remain active after cutting and secondary fermentation organisms (i.e., Clostridia), all of which break down protein during silage fermentation. These processes also produce byproducts reducing intake,

as mentioned previously. Plant proteolysis is limited by decreasing the amount of time the harvested forage is exposed to oxygen, while clostridial fermentation is inhibited by rapidly lowering the forage pH as much as possible. Inoculants can affect both of these by dominating the fermentation community and utilizing available WSC for organic acid production. In the meta-analysis, ammonia concentrations, an indicator of protein degradation, were greater in un-inoculated forages. In addition, farm-scale silages showed far more variable, and greater, ammonia concentrations when compared to laboratory-scale silages. This is likely due to variable weather conditions and longer times from cutting to ensiling at the farm scale.

- **Improved preservation of WSC.** Water soluble carbohydrates are easily lost from harvested forages due to leaching and as respired carbon dioxide. Similar to proteolysis, this is largely influenced by the time from field to silo. Following this trend, inoculated laboratory-scale silages had greater WSC levels, while inoculation at the farm had more variable effects on WSC levels.

When looking at these data, it is clear microbial inoculation has a pronounced positive effect on grass and legume silage fermentation, with increased lactic and acetic acid concentrations, improved DM preservation, decreased proteolysis, and improved aerobic stability. The same cannot be said for the effect of inoculation on corn, sorghum, and sugarcane silages. And yet, the observed increases in animal performance in response to silage inoculation are still present regardless of forage species.

If animal performance consistently increases in response to silage inoculation in the absence of changes in silage quality measurements, is there something we aren't measuring? Dry matter intake is most likely to affect animal performance even in the absence of observed differences in silage quality. However, there are likely values that can be measured that would provide more insight into the role of silage inoculants in animal performance. Specifically, investigations of the effects of inoculation on the formation of intake-reducing compounds (i.e., biogenic amines, butyric acid, ammonia) might provide targets to measure connecting silage inoculation and DMI. Further study of the mechanisms in the animal that lead to observed increases in milk protein, fat, and yield are warranted. Of particular interest is the rumen microbial community's response to inoculated forages, including biohydrogenation and microbial protein synthesis.

When it comes to a decision about whether to inoculate forages, current evidence is strongly in favor of inoculation for temperate and tropical grasses and legumes. With corn, sorghum, and sugarcane it is less clear. For the farmer looking at the cost-benefit ratio of inoculating these forages, it is important to account for the variability of on-farm conditions when assessing silage quality and potential animal performance benefits.