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SALT MAY IMPROVE CORN AND SORGHUM SILAGE FERMENTATION

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INTRODUCTION

Silage is widely used in dairy cow rations and is also used to some extent in beef cattle rations. Good quality silage is very palatable to cattle and little wastage occurs during feeding. Production of good quality silage involves fermentation of high moisture forage by anaerobic lactic acid bacteria, and inhibition of growth of aerobic microorganisms that result in spoilage of silage.

Salt has been used for centuries to preserve foods by inhibiting the growth of harmful bacteria (Cai et al., 1997). Many aerobic bacteria, that require oxygen for their growth, are inhibited by salt. However, some strains of lactic acid bacteria can tolerate fairly high concentrations of salt. Some research has indicated that adding salt to forage material at the time of ensiling improves silage fermentation.

SILAGE FERMENTATION

Silage is produced by controlled fermentation of high moisture forage by anaerobic microorganisms that grow in the absence of oxygen. Producing good quality silage is dependent on: 1) rapid removal of oxygen from the silo, 2) an adequate amount of soluble carbohydrates to produce lactic acid, 3) the correct moisture level, and 4) lactic acid producing bacteria dominating the silage fermentation.

Oxygen is present when forage is blown into the silo. During the early stage of silage fermentation, aerobic bacteria, yeast, and molds grow rapidly, and ferment water soluble carbohydrates to carbon dioxide and water until oxygen is depleted from the silo. Prolonged exposure to oxygen during the fermentation process is associated with poor palatability, and reduced dry matter and energy content of silage.

Aerobic organisms are replaced by anaerobic bacteria once oxygen is depleted from the silo. Anaerobic bacteria convert soluble carbohydrates to organic acids, such as acetic, butyric, and lactic acid, causing a reduction in pH of the silage. A rapid decrease in pH helps inhibit the growth of anaerobic bacteria, such as clostridia, that are associated with reduced silage quality. When silage pH drops to approximately 5, the anaerobic fermentation is dominated by lactic acid producing bacteria. As the pH of silage is reduced to 4.5 or lower, further microbial activity is inhibited by the low acidity. At this point the silage is stable and can be stored for a considerable period of time.

Lactic acid is the primary acid found in good quality silage. Conversion of soluble carbohydrates in forages to lactic acid results in the lowest losses of dry matter and energy during silage fermentation. Silage high in lactic acid is also highly palatable to cattle. A good quality silage has little or no butyric acid. Silage high in butyric acid results from fermentation by clostridia bacteria, and has a lower energy value and reduced palatability.

SALT AND SILAGE FERMENTATION

Cai et al. (1997) evaluated the effects of salt and two strains of salt-tolerant lactic acid bacteria on fermentation characteristics of sorghum silage. Chopped sorghum forage was packed into plastic bags and treated with: 1) no additive (control), 2) 40 grams of salt/kg of fresh forage, 3) *Lactobacillus casei*, 4) *Lactobacillus plantarium*, 5) salt plus *Lactobacillus casei*, and 6) salt plus *Lactobacillus plantarium*. Various strains of *Lactobacillus* organisms are commonly used in silage inoculants to enhance lactic acid fermentation. Salt was distributed throughout the silage in this study. Silage characteristics were measured at 2, 5, 8, and 15 days after ensiling.

Treating silage with salt or salt-tolerant lactic acid bacteria increased the number of lactic acid bacteria at 2, 5, and 8 days after ensiling (Cai et al., 1997). Silage pH was lower in treated compared with control silage by day 8, and remained lower through day 60 after ensiling. Adding lactic acid bacteria to silage was more effective than salt in enhancing lactic acid bacteria counts, and lowing pH early in the ensiling process. However, treatment of silage with salt was more effective than the addition of lactic acid bacteria in reducing aerobic bacteria, and butyric acid-producing bacteria after ensiling. By day 5 following ensiling no butyric acid -producing bacteria were detected in sorghum silage treated with salt. Treating sorghum with salt at ensiling increased the dry matter (31.7 vs. 30.3%), and lactic acid content (41.5 vs. 25.4 grams/kg dry matter) compared with control silage when the chemical composition of silage was determined at 60 days after ensiling. No butyric or propionic acid was detected in salt-treated silage while control silage contained 13.1 and 5.0 grams/kg dry matter of butyric and propionic acid, respectively. In this study adding salt alone was as effective in enhancing silage fermentation as adding a combination of salt and lactic acid bacteria at ensiling.

A study at the University of New Hampshire indicated that salt addition to the top layer of corn forage ensiled in a bunker silo would reduce spoilage of top layer silage (McLaughlin et al., 2002). Bunker silos are an economically attractive means of storing ensiled forage. However, with bunker silos, oxygen exposure to the top layer of silage results in considerable damage to silage. Even when covered with plastic after packing of silage, approximately 10% of dry matter is lost in the top 25 cm of bunker silos (Bolsen, 1997). In the New Hampshire study corn forage was packed with a tractor in bunker silos. Silos were divided across the top into 121-m^2 sections, and salt was applied at the top of alternating sections at a rate of 22.5 kg of salt per 121-m^2. A silage inoculant containing *Lactobacillus plantarium* and *Enterococcus faecum* was applied to control and salt-treated silage. The silos were then covered with black plastic and secured with tires to minimize exposure to oxygen. The top 15 cm of silage was sampled for analysis at four weeks after ensiling.

The top layer of corn silage treated with salt tended to have a higher dry matter content (28.9 vs. 25.2%), and lower pH (4.51 vs. 4.87) compared with control silage (McLaughlin et al., 2002). Counts of total aerobes and clostridia bacteria were also lower in salt-treated silage. There was also a tendency for silage treated with salt to have lower mold and yeast counts. d Zearalenone, a mycotoxin produced from molds, was twice as high (315 vs. 155 mg/kg) in control silage compared with salt-treated silage. Mycotoxins in silage can affect animal health and productivity, especially in high producing dairy cows. The lower level of Zearalenone in salt-treated silage is consistent with less mold growth and improved silage fermentation. McLaughlin et al. (2002)

concluded that adding salt to the top layer of corn silage appeared to be a cost-effective method of reducing spoilage.

Salt addition to grass and legume forage has generally not improved silage fermentation. Salt addition to mixed grass and alfalfa forage increased final pH relative to control silage (Archibald, 1946). Wilson (1948) ensiled different forage species with salt at levels varying from 0 to 5%. He observed no benefit from adding salt in terms of pH decline or seepage losses. Shockey and Borger (1991) inoculated alfalfa silage with *Clostridium butyricum* and evaluated if addition of 4 grams of salt per kg of fresh forage would inhibit growth of *Clostridium*. Salt did inhibit growth of *Clostridium butyricum* in this study. However, the level of salt used in this study apparently also inhibited growth of lactic acid bacteria, and resulted in a silage that was not well-preserved.

SUMMARY

Good quality silage is produced by fermentation of high moisture forage by the proper types of microorganisms. Salt is known to inhibit the growth of certain bacteria that result in poor silage fermentation. Lactic acid bacteria are very important in silage fermentation, and many strains of lactic acid bacteria can tolerate fairly high salt concentrations. Limited research has indicated that adding salt to forage at the time of ensiling may improve fermentation of corn and sorghum silage. Mixing salt with sorghum forage at ensiling increased the number of lactic acid bacteria, and reduced silage pH. These changes indicate that adding 40 grams of salt per kg of fresh sorghum improved silage fermentation. Adding salt to the top layer of corn forage ensiled in bunker silos has reduced spoilage of top layer silage.

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