Covering Bunker Silos

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Introduction

Bunker silos and drive-over piles offer several advantages for large dairy farms. Low initial cost, low maintenance, high storage capacity, and rapid filling are common advantages over upright silos or silo bags. However, proper management of these structures is key to optimizing forage preservation and animal productivity.

Covering the bunker or drive-over pile shortly after filling the silo is an essential step to proper preservation. Bolsen et al. (1993) reported that dry matter losses in the top 1 to 3 ft can exceed 50% when the silo is not properly covered. Plastic film and tires are the most common method of covering most large silos. However, this method has several disadvantages. First, several people are required to cover most large silos with plastic and tires. Labor is also required to remove the plastic and tires. Secondly, proper disposal of the plastic is a real concern in many states. Split tires are often required because whole tires make an excellent breeding ground for mosquitoes, thus increasing the risk of West Niles virus. Finally, deer, raccoons, and vermin can tear the plastic, allowing air to penetrate increasing localized spoilage. Holthaus et al. (1995) reported that organic matter losses in the top 18 inches of silos covered with plastic and tires averaged approximately 25%.

Because of these challenges, there are producers who have decided not to cover their silos. Kansas State researchers have estimated that the value of the silage lost from not covering bunker silos in the High Plains regions was between 5 and 10 million dollars per year. There are many factors that can affect the return on investment for plastic and tires. Bolsen (1997) estimated that the value of the lost silage averaged about four times the cost of the plastic and tires, and labor to apply and remove both.

Some producers are tempted to feed the spoiled silage, with the assumption that it will be diluted to the point of not affecting the animals. However, feeding silage contaminated with mycotoxins can cause reduced milk production, missed breeding cycles, abortions, increased veterinary fees, and require the feeding of additives to bind the mycotoxins. The exact cost of feeding mycotoxin-contaminated silage is difficult to determine, but Thomas et al. (1998) estimated that it cost the Vermont dairy industry between 4.5 and 9 million dollars per year. Kansas State data showed that feeding a 75:25 normal:spoiled corn silage mixture reduced organic matter, crude protein, NDF, and ADF digestibilities by 5.0, 4.1, 7.2, and 9.9 percentage units, respectively (Bolsen, 2004). These researchers reported that feeding 25% spoiled silage partially or totally destroyed the mat phase in the rumen.

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Previous Edible Coverings

Because of the challenges associated with using plastic and tires, there have been several attempts to develop an edible covering for bunker silos. Bolton and Holmes (2004) summarized the data evaluating alternative covers for bunker silos. These include lime, earth, a roof, candy, molasses and molasses-based products (Cargill Liqui-Seal)™, small grains, sod, Nutri-Shield™, sawdust, chopped straw, and composted manure solids. Savoie et al. (2003) evaluated apple pulp and peanut butter as alternative covers for laboratory silos. The bottom line is that of all the alternative coverings tested, none were as effective as the conventional plastic covering.

Criteria of a Plastic Replacement

The following criteria have been used in developing our alternative bunker cover: 1) provide effective protection, 2) be edible, 3) provide essential nutrients, 4) be palatable, 5) easy to apply, and 6) cost effective. For an alternative covering to be successful, it must be equal or superior to plastic in its ability to protect the silage and minimize surface spoilage. The product should be edible or significant cost will be incurred in the removal and disposal of an inedible covering. If the product provides essential nutrients, then a portion of the cost is offset by its feeding value. The product must be palatable so that when included in the total mixed ration **(TMR)** intake is not impaired. Ease of application is critical to acceptance by the end user. Finally, the total benefits must be greater than the cost.

The original idea for this product resulted from my wife who made home-made play dough for our kids. After observing the physical properties and ingredient composition, the first series of experiments were to evaluate its potential to protect large hay bales. We found that it shed water well and was consumed by the cattle when salt was removed from their diet. This lead to a series of experiments with bunker silos.

Initial Bunker Silo Experiments

The objective of the first experiment was to determine whether the starch-salt matrix could serve as an edible covering for bunker silos that would simultaneously reduce spoilage and serve as a nutrient source. Whole plant corn silage (40% DM) was chopped and packed into six side-by-side mini-bunkers (12 ft long x 6 ft wide X 6 ft deep). Equal amounts (3,455 lb of DM) of chopped whole-plant corn were weighed into each bunker, leveled, and packed with a small tractor. The three treatments were uncovered, covered with six-mil plastic, or covered with the starch-salt matrix. The starch-salt matrix was mixed in a motar mixer with boiling water added to gelatinize the starch. The matrix was applied by hand to achieve a 0.5-0.75 inch thick layer using a cement trowel. After 3 days of curing, paraffin wax was melted and a thin layer applied with a paint roller. The forage was allowed to ensile for 92 days. Hand separation was used to sort the spoiled and good silage prior to feeding. A wooden frame (1 ft by 5 ft) was used to measure the spoilage under a fixed area. The measurements were made at 3 locations on each silo. Surface spoilage under the frame averaged 31.5, 36.0, and 2.6 lb of DM ($P < 0.05$) for the uncovered, plastic, and starch-salt covering, respectively. Forty-eight Angus heifers were allotted by weight to 12 pens. Two pens of heifers were randomly assigned to each mini-bunker. Silage DM fed was 1549, 1951, and 2684 lb ($P < 0.05$) for the uncovered, plastic, and starch-salt covering, respectively. These are relatively low recovery rates because of the small size silos with a large surface area to volume ratio. In addition, the forage at harvest was drier than optimum for bunker silos. Animal days per bunker were 140, 152, and 212, respectively ($P < 0.05$). During the feeding study, the starch-salt matrix was removed from the silage prior to feeding. For the last 6-days, heifers fed the starch-salt matrix silage were fed the covering at the rate of 2.0 lb/day (as-fed). After collecting the orts, it was determined that heifers consumed approximately 91% of the covering offered.

The ash content of the pre-ensiled forage was 5.8%, and for the spoilage from uncovered, plastic, and starch-salt matrix treatments, if averaged, 11.4, 8.7, and 18.3% ($P < 0.05$), respectively. These data suggest that a portion of the salt diffused into the silage immediately under the covering. Cai et al. (1997) showed that some strains of lactic acid bacteria are salt tolerant. A combination of the air-tight covering and preservative effects of the salt helped to minimize surface spoilage. Also, the salt containing silage did not inhibit intake when it was mixed with the normal silage below it.

This initial research showed promise, but there were several significant huddles to overcome. First, this product required boiling water to gelatinize the starch, a costly and awkward requirement on a large scale. Secondly, wheat flour was used as the starch source. A cheaper more easily obtained source of starch was needed. Finally, a more practical means of application was needed.

Several of these issues were addressed in the laboratory involving the testing of approximately 40 different formulations. All of the modifications still allowed us to meet the original criteria. We found that finely ground wheat could replace the flour. By adding additional feed-grade ingredients, we could eliminate the boiling water and still achieve a starch-salt matrix that was adhesive and flexible. Achieving a product that was able to be sprayed on and not crack upon drying required additional reformulations.

Alternative Application Methodology

The goal of this research was to develop a commercially feasible application method to cover bunker silos with an edible covering. The previous formulation had a bread-dough consistency and had to be modified so that it could be sprayed. After evaluating several pieces of equipment, a commercial CEJCO concrete pump (Model CSS 2489; Carl E. Johnson, Inc., 2171 Tucker Industrial Road, Tucker, GA 30084) with a vertical shaft mixer and screw pump was used. A 50 ft x 3 inch diameter hose was used to apply the product. On the end of the hose, a spray nozzle was connected to a 110 CFM Ingersoll-Rand industrial air compressor (Ingersoll-Rand, P.O. Box 0445, 155 Chestnut Ridge Rd., Montvale, NJ 07645) for atomizing the product as it was applied. Approximately 700 lb of dry ingredients were added to the mixing chamber and water was added to bring the final product to approximately 30% moisture. This unit was chosen because it could be powered by the hydraulic system of a farm tractor. This approach was used to cover mini-bunkers and small drive-over piles. The wax was applied as described above. When the silos were opened, surface spoilage was similar to what had been observed in the original experiment.

Protective Coatings for the Edible Covering

The objective of this research was to develop a protective covering for the edible starch-salt matrix that was easier to apply than the paraffin wax. A control 6-mil black plastic covered with 2 to 3 inches of soil was compared to the starch-salt matrix coated with a sprayable wax emulsion, molten paraffin applied with a paint roller, or wax paper. The wax paper is made by Georgia-Pacific Paper Company (Clatskanine, OR) and is food grade so that it can be fed to animals. The sprayable wax emulsion has the advantage of eliminating the need for equipment and fuel to melt the paraffin wax. The wax paper could be applied directly behind the spraying apparatus and bound to the starch-salt matrix by running small press wheels on top of the paper. The wax paper has the potential advantage of holding the starch-salt matrix in place on steep slopes of bunkers or drive-over piles.

Eight 7 ft wide X 24 ft long by 4 ft deep mini-bunker silos were filled with 21,330 lb of chopped whole corn plant (39.1% DM). The silos were sealed on September 11, 2003 and opened after 117 days of ensiling. The silage was packed with a tricycle International Harvestor **(IH)** farm tractor. Less weight on the rear wheels resulted in less compaction next to the walls and more spoilage along the walls. Spoiled and good silage were hand separated. The DM fed for the plastic control, sprayable wax, paraffin wax, and wax paper treatments were: 4759, 4378, 5861, and 5493 lb, respectively. Less DM was fed from the sprayable wax silos than the plastic controls ($P < 0.05$). The DM fed from the paraffin and wax paper treatments was 23 and 15% greater, respectively, than what was fed from the plastic control silos. Again, low DM recoveries are due to the high surface to volume ratio for these silos.

Current research is aimed at the development of a low-profile vehicle that could drive over the piles and apply the starch-salt matrix in swaths. A feeder hose would be hooked to the unit from a screw-type concrete pump. Research is being done to determine if the dry ingredients and water could be mixed in a typical feed mixing unit and unloaded into the screw pump powered by its own hydraulic pump.

Summary

There are three reasons why the starch-salt matrix sealed with wax is superior to plastic in reducing surface spoilage. First, the starch-salt matrix forms an air-tight seal. The starch-salt matrix doesn't just lay on top of the forage like plastic, rather it bonds to the forage particles without air-layer interface. In addition, the salt diffuses into the top 10 to 15 inches of silage and acts as a preservative to prevent mold growth. These qualities allow the starch-salt matrix to meet our first criteria of providing effective protection.

All the ingredients in the formulation are Generally Recognized as Safe **(GRAS)** and feed grade, making it totally safe to feed. The ingredients in the starch-salt matrix also provide essential nutrients that would normally be added to the diet. The covering will blend with the other ingredients in a diet in a normal feed mixer. At subzero temperature, there may be a few clods that don't immediately breakdown. But when combined with the "warmer" ingredients, they will break apart and not be easily sorted by the cattle. We have fed the covering at 2.5% of the diet (DM basis) and not observed any reduction in intake. Seldom will the covering be at a higher proportion of the diet because we are only applying it at 0.5 to 0.75 inches. If the silage is over three feet deep, the covering will be less than 2.5% of the mixture. In addition, usually the silage does not make up the total diet.

Ease of application is the focus of much of our current research. We see this being done on a custom basis where the same equipment can be used on numerous silos per year. The dry ingredients would be delivered in bulk and loaded into a feed mixing truck. Water would be added to achieve the desired consistency and then unloaded into a screw pump that would deliver the mixture to the spraying machine.

Obviously, the technology will only be adopted if it is cost effective. We are optimistic because most of the cost of the original ingredients will be recovered when they are fed. Thus, application cost is the main item that needs to be paid for by the reduced spoilage and avoidance of plastic disposal and tire handling problems. Although there are significant application issues that need to be solved, we have made real progress in addressing these issues and are optimistic that this product has a future in helping large dairy farms and feedlots manage their silage more effectively.

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