# Salt-based Edible Coverings for Hay Bales

L. L. Berger

Department of Animal Sciences, University of Illinois
1207 West Gregory Drive, Urbana, IL. 61801, U.S.A.

The purpose of this research is to develop a salt-based edible covering to protect and preserve large round hay bales. Fifty years ago it was common in the U.S. to apply 25 kg of salt per ton of fresh hay when stored in a barn to prevent mold growth and heating. Our research has focused on developing an edible covering that would preserve the hay, but also protect it by shedding water. A salt–based covering has several advantages. First, it would reduce spoilage that can be as high as 30% of the hay dry matter. Secondly, it will serve as a source of nutrients when consumed. Finally, it can reduce the use of coverings that are not biodegradable and have to be removed before feeding. The covering we have developed is 46% salt, 46% cornstarch, 4% potassium bitartrate and 4% soybean oil. An equal amount of boiling water is added and mixed until the starch is partially gelatinised, forming a mass with a play-dough consistency. This mixture is then applied to the hay bales in a 1-1.5 cm thick layer. In our initial development, various formulations were evaluated with a drip test. This test used a separatory funnel to apply one drop of water per second to a fixed point on the protected hay to determine how long it would take to erode the covering. Various formulations would last from 2 to 8 hours before the water would penetrate the hay. We found that applying a thin layer of paraffin with a paint roller to the salt-based covering rendered the covering impermeable to water. This process was then used to cover large round bales (500 kg) of alfalfa hay. The salt mixture was applied in early September and observed weekly through March. The covering completely protected the hay until mid-December when freeze-thaw cycles caused the covering to crack. In March, the protected hay had an 11.3% greater in situ digestibility than the unprotected hay (55.5% vs. 49.2%). Salt was removed from the diet of the cattle before feeding the covered bales. After an initial adjustment, the cattle would lick the salt-based covering as they consumed the hay. Approximately 20 different formulations have been tested in the laboratory to increase the durability of the salt-based covering. Adding 5% sucrose to the mixture shows promise to resisting cracking. This project is leading to the development of a new use for salt as part of a protective covering for hay, silage and agricultural byproducts.

The preservative properties of salt have been known for thousands of years. When lose hay was stored in barns it was a common practice to salt the hay. Approximately 25 kg of salt would be applied per ton of fresh hay to prevent mold growth and heating, which sometimes lead to spontaneous combustion. Since the late 1970's, the use of large round bales as a method of hay harvesting and preservation has become extremely popular in the U.S. Because it is highly mechanized, harvest and storage of large round bales only requires one person compared to two or more needed for harvesting and storage of small square bales. However, few producers weigh their hay at harvest and again at feeding, so they have little appreciation for storage losses.

Storage dry matter losses of unprotected large round bales varies from 3 to 40 percent (1,2,3). Weather conditions, length of storage, and method of storage have the greatest impact on dry matter losses. Dry matter losses are caused primarily by microorganisms in the hay, which metabolise soluble nutrients. These microorganisms have their greatest biological activity when the hay is moist and warm. In warm wet climates, dry matter losses of 3 percent per month have been reported (3).

When rain occurs on an exposed bale, much of the rain is absorbed in the outer layers of the bale. The moisture content of the outer 10 to 20 cm of hay is increased to between 25 and 40 percent (3,4). Large round bales can be wrapped in plastic, which

will reduce moisture penetration and storage losses to 35% of uncovered bales. However, the problems with plastic covers for individual bales are they cost $3-5 per bale, they must be removed from each bale before feeding or processing, and they are not biodegradable.

Due to mold and fungi growth on the outer 10-20 cm of hay, cattle are often reluctant to consume this portion of large round bales. Consequently, feeding losses as high as 34.3 percent of the unprotected large round bales has been reported (5). Other researchers (1) found that feeding losses of large round bales stored inside average 12.4 percent compared to 24.7 percent for uncovered bales stored outside.

When storage and feeding losses are combined, 15 to 50 percent of the harvested dry matter can be lost with large round bales. With hay valued at $50 to $100 per ton, U.S. farmers lose millions of dollars each year due to storage and feeding losses.

Hay based diets often require energy and mineral supplementation. In our laboratory, we have been investigating the potential of protecting hay while providing the supplemental nutrients, simultaneously. This has economic advantages because if the nutrients were going to be supplemented anyway, the hay protection value is achieved with only the costs of application. The covering we have developed is a mixture of 46 percent salt, 46 percent cornstarch, 4 percent potassium bitartrate and 4 percent soy oil. The dry ingredients are mixed prior to adding an equal amount of boiling water. The mixture is then agitated for at least five minutes to allow the starch to partially gelatinise before it is applied to the hay.

In laboratory experiments, flakes of alfalfa hay from small square bales (35 X 45 cm) were coated with a 1.0 cm layer of the mixture. The covering dried and hardened in 2 to 3 days at room temperature. The ability of the covering to shed water was tested by placing the hay at a 45-degree angle, 25 cm below a separatory funnel. Water was dripped from the funnel at the rate of one drop per second on a single location. Water that ran off was caught in an aluminium pan. Initially, nearly all the water ran off, but eventually the dripping water would form a crater in the covering. This observation suggested that with extended periods of rainfall, the covering might absorb enough moisture that water could penetrate the bale.

In order to correct this problem, the covering was applied as described above and then a thin layer of paraffin was sprayed on the covering. The smooth surface provided by the salt-starch mixture was easily coated with paraffin. The ability of the paraffin coated covering to shed water was tested using the drip test. Under laboratory conditions, the paraffin coated covering shed 100 percent of the water.

To test this concept under practical conditions, nine large round bales (500 kg) were divided into three groups of three bales. The three treatments were untreated control, and the salt-starch mixture applied at a thickness of 1.0 or 2.0 cm. Fifty kg batches of the salt-starch covering were mixed in a mortar mixer. Dry ingredients were mixed for approximately two minutes before boiling water was added. The entire mass was then mixed for approximately five minutes. A cement trowel was used to apply the covering to obtain the desired thickness on the bale. The web-like structure of the hay provided a suitable matrix for the covering to adhere to. Even on the vertical portion of the bale, the covering stayed attached to the bale as long as the hay was tightly wrapped. After 72 hours of curing, paraffin wax was applied. The wax was melted and then applied with a paint roller at the rate of 4 kg of wax per bale. These treatments were applied in early September and the bales were evaluated weekly through March.

The covering completely protected the hay until mid-December. During this time, we had repeated freeze-thaw cycles where it would get below freezing at night and then warm up during the day. Cracks began to appear on the south side of the bale first. This is due to the fact that the sun would warm up that side of the bale in the afternoons and then it would cool down at night. Although the east side of the bales eventually developed cracks also,

they did not appear until early January. Although the coverings continued to shed rain, water would run into the cracks and penetrate the bale. This moisture would hydrate the salt-starch covering so that it became soft. On the more vertical surfaces of the bale, some of the covering sloughed off because it became saturated with water and would not cling to the hay. By mid-March, the covering on the lower third of the bales were completely removed.

Prior to feeding, a hay core sampler was used to sample the outer 15 cm of the bales where the protection was intact. Samples from the unprotected bales were also obtained. All samples were ground and digestibility measured using the in situ Dacron bag technique. The protected hay had an 11.3 percent greater digestibility than the unprotected hay (55.5% vs. 49.2 %). These data showed that protecting the hay with this technique has the potential of reducing weather damage and increasing the digestibility of the hay.

Another major issued addressed by this trial is whether the cattle would consume the salt-starch covering. Salt was removed from the diet of the cattle before feeding the treated bales. After an initial adjustment, the cattle would lick the salt based covering as they consumed the hay.

Approximately 20 different formulations have been tested in the laboratory to increase the durability of the salt-starch mixture. Flakes of alfalfa hay from small square bales (35 X 45 cm) were coated with a 1.0 cm layer of the different formulations. After the covering had hardened for three days at room temperature, the covered hay was frozen over night at –20 °C and then heated to 55 °C the following morning. This cycle continued for 10 days to see which formulations were most resistant to cracking. Adding 5 percent bentonite and 5 percent sucrose to the basic mixture are currently being evaluated in the field. This research has to potential to result in a new use for salt as part of a protective covering for hay, silages, and agricultural byproducts.

**REFERENCES**


1. R.L. Belyea, F.A. Martz and S. Bell , J. Dairy Sci. 68 (1985) 3371.
2. M.R. Brasche and J.R. Russell, J. Animal Sci. 66 (1988) 3218.
3. T.M. Harriagan and C.A. Rotz, Paper 921572 (1992) Am. Soc. Agric. Eng. St. Joseph, Michigan.
4. J.R. Russell and D.R. Buxton, Anim. Feed Sci. Technol. 13 (1985) 69.
5. V.L. Lechtenberg. Proc. of Forage and Grassland Conf. 1978. p. 85.