J. Dairy Sci. 98:1–6
http://dx.doi.org/10.3168/jds.2015-9332

Short communication: Use of a mixture of sodium nitrite, sodium benzoate, and potassium sorbate in aerobically challenged silages

Martin Knicky and Rolf Spörndly[1]
Department of Animal Nutrition, Swedish University of Agricultural Sciences (SLU), SE-750 07, Uppsala, Sweden

ABSTRACT

Aerobic instability is still a common problem with many types of silages, particularly well-fermented silages. This study evaluated the effect of adding an additive mixture based on sodium nitrite, sodium benzoate, and potassium sorbate to a variety of crop materials on fermentation quality and aerobic stability of silages. Ensiling conditions were challenged by using a low packing density (104 ± 4.3 kg of dry matter/m^3) of forage and allowing air ingression into silos (at 14 and 7 d before the end of the storage, for 8 h per event). Additive-treated silages were found to have significantly lower pH and reduced formation of ammonia-N, 2.3-butanediol, and ethanol compared with untreated control silages. Yeast growth was significantly reduced by additive treatment in comparison with untreated control silage. Consequently, additive-treated silages were considerably more aerobically stable (6.7 d) than untreated control silages (0.5 d). Overall, adding 5 mL/kg of fresh crop of the additive based on sodium nitrite, sodium benzoate, and potassium sorbate reduced undesirable microorganisms in silages and thereby provided suitable ensiling conditions and prolonged aerobic stability, even under air-challenged laboratory ensiling conditions.

Key words: silage, additive, stability, yeast

Short Communication

A high degree of anaerobiosis is important for successful ensiling by lactic acid fermentation, which rapidly reduces the pH of the forage. Prolonged presence of oxygen may result in insufficient substrate for satisfactory lactate production due to extended respiratory activity of plants and prolonged activity of aerobic microorganisms, such as yeasts and molds. Insufficient elimination of these microorganisms during silage fermentation can result in unfavorable processes during the feed-out phase of the ensiling process (Jonsson and Pahlow, 1984), when exposure of silage to air is inevitable. Aerobic deterioration degrades the nutritional value and hygiene quality of silages (Woolford, 1990). These problems can be avoided or reduced by using selective additives that promote good fermentation, improve aerobic stability, and reduce hygiene risks.

The antimicrobial properties of sodium nitrite, sodium benzoate, and potassium sorbate have been described by Woolford (1975) and have been tested in variety of combinations to improve forage conservation (Lättemäe and Lingvall, 1996; Lingvall and Lättemäe, 1999; Knicky and Lingvall, 2004). The latest additive mixture, based on a combination of 50 g of sodium nitrite/kg, 200 g of sodium benzoate/kg, and 100 g of potassium benzoate/kg, is reported to have high efficiency for improving silage quality in both high- and low-DM silages (Knicky and Spörndly, 2009). Its efficiency in preventing the growth of undesirable microflora in silages has also been demonstrated for a large variety of crops (Knicky and Spörndly, 2011). However, these results have been obtained in routine ensiling conditions with properly consolidated contents and properly sealed silos. Unfortunately, these are not always the conditions under which silages are ensiled in practice. Punctures and other damage to the silo cover, as well as uneven forage consolidation in the silo, are common. Such ensiling conditions challenge a silage additive in fulfilling its intended purpose. Therefore, testing the efficiency of silage additives under difficult ensiling conditions, as recommended by Kwella et al. (1993), can provide a better picture of their potential. The objective of our study was to examine the efficiency of a silage additive mixture comprised of sodium benzoate, potassium sorbate, and sodium nitrite when applied to silages made from a wide range of different crops and under air-challenged ensiling conditions.

A total of 5 crops were used, all harvested in or near Uppsala (59°50′32″N, 17°40′23″E), Sweden. The harvesting conditions and botanical composition of these crops are presented in Table 1. The crops were selected from local farms, where they were cultivated according to normal agricultural practices in Sweden. For the leys, this involved approximately 90 and 60 kg of N/ha as a mineral fertilizer to the first and second cut,

Received January 10, 2015.
Accepted April 15, 2015.
[1]Corresponding author: rolf.sporndly@slu.se

Table 1. Composition and stage of development of harvested crops used for ensiling with and without an additive mixture of sodium benzoate, potassium sorbate, and sodium nitrite

Crop	Cut/ DM, g/kg[1]	Weather[2]	Type of crop	Maturity of main crop
I	First cut/340	Mostly cloudy, 69% RH, 8°C	Whole crop maize (100%)	Hard dough stage
II	Third cut/130	Partly cloudy, 86% RH, 16°C	Red clover (60%), timothy and meadow fescue	Vegetative-pre-bud, No heads visible
III	Third cut/180	Partly cloudy, 86% RH, 16°C	Red clover (30%), timothy and meadow fescue (67%), weeds	Vegetative-pre-bud, Vegetative
IV	Third cut/170	Partly cloudy, 87% RH, 14°C	Red clover (14%), timothy and meadow fescue (80%), weeds	Vegetative-pre-bud, Vegetative
V	Third cut/260	Partly cloudy, 87% RH, 14°C	Timothy and meadow fescue (85%), red clover	Vegetative, Vegetative-pre-bud

[1]DM at harvest.

[2]Average daily relative humidity (RH) and temperature.

respectively, and farmyard manure once a year in the autumn. For whole-crop maize, approximately 90 kg of N/ha and 30 kg of P/ha as a mineral fertilizer were applied at sowing, whereas farmyard manure was applied in the previous autumn. Samples from all crops except maize were collected manually using a scythe and chopped in a stationary cutter head to approximately 5 cm in particle length. The maize crop (I) was harvested using a Claas-Jaguar precision harvester (≈1 cm chop length; Claas, Malmo, Sweden). Crops II, III, IV, and V were field-wilted for 2 to 4 h before chopping. After chopping, the forages were mixed and divided into 2 fractions of 3 kg of fresh matter (**FM**) each.

One forage fraction was treated with the silage additive, a water solution containing 200 g of sodium benzoate/kg, 100 g of potassium sorbate/kg, and 50 g of sodium nitrite/kg, at a rate of 5 mL of additive/kg of FM. The silage additive was applied to the forage in plastic bags using a manual spray bottle and then the contents of the bag were mixed thoroughly. The second forage fraction was left untreated and served as a control. Forage from each fraction was then ensiled in 3 laboratory silos (≈510 g of FM per silo) with 1.7 L of volume and a fermentation lock fitted on the lid. Water was added to the fermentation lock to achieve airtight sealing immediately after filling the silos. The lid and lower part of the silos were equipped with air inlets with rubber stoppers to allow controlled air ingression by removing and replacing the rubber stoppers. This was performed twice during the storage period, 14 and 7 d before the end, for 8 h each time. The silos were stored at room temperature (20–24°C) for 49 d.

Two samples of chopped fresh crop (before additive application) were collected from each crop. The number of lactic acid bacteria, yeasts, and molds was used to describe the microbiological composition of the fresh crops. The spread-plate methods using Slanetz-Bartley agar (Merck KGaA, Darmstadt, Germany) and the pour-plate method using Rogosa agar (Merck KGaA) were used to determine lactic acid bacteria (Pahlow, 1990). Serial dilutions of silage samples were cultured aerobically at 25°C on malt extract agar supplemented with 0.12 *M* lactic acid (50 mL/L) to determine yeast and mold counts. Chemical analyses comprised determination of DM, ash, CP, and water-soluble carbohydrate (**WSC**) concentration, as well as the buffering capacity of the harvested crops. The concentration of DM was analyzed in 2 steps. First, fresh samples weighing approximately 150 g were dried for 18 h in a ventilated oven at 65°C and milled through a 1.0-mm sieve. Final DM concentration was achieved by drying the milled sample at 103°C for 5 h. Concentration of ash was determined by combusting at 550°C for 3 h in a muffle furnace. The concentration of WSC was analyzed using an extract derived from dried silage samples (≈2.5 g), which were diluted with 250 mL of distilled water, boiled for 10 min, and drained through H-602 filter paper (Whatman GmbH, Dassel, Germany). Concentration of WSC was determined using enzyme-based acid hydrolysis (Larsson and Bengtsson, 1983). Concentration of CP was analyzed using the Kjeldahl technique with Cu as a catalyst (Bremner and Breitenbeck, 1983). Buffering capacity was determined according to the methods of McDonald and Henderson (1962).

The silos were weighed at the time of filling (d 0) and again at d 3, 10, 28, 42, and at the end of storage to determine weight losses. The weight losses were calculated by assuming the lost weight to be CO_2 leaving the silo via the fermentation locks. It was further assumed that for each mole of CO_2, 1 mol of H_2O was produced. Hence, for each gram of weight decrease due to CO_2, 0.44 g of the DM in the silo was transferred into water. Therefore, the DM loss was calculated as the decrease in weight of the silo multiplied by a factor of 1.44, expressed as grams per kilogram of DM. On the last day of storage period, the silo contents were emptied into