MAKING ROUND BALE SILAGE – LESSONS LEARNED FROM AN ON-FARM SURVEY OF BALEAGE IN KENTUCKY

Henning, J.*; Lehmkuhler, J.*; Sears, B.*; Belton, C.*
Berg, L.*; Sorrell, D.*; Wilhoit, A.*
*University of Kentucky Cooperative Extension

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Abstract
The ability to make silage in round bale packages allows producers to avoid rain damage and produce high quality stored forage. The proliferation of bale wrappers (both individual and inline types) has made this technology more available to producers. Although the process for making baleage is well documented, producers have experienced poor fermentation and in some cases botulism toxicity from baleage. The parameters of good silage are well known and include pH below 5.0 and lactic acid concentrations above 3% on a DM basis. However, tests of farmer- produced baleage reveals that often these target values are not achieved. To better understand the fermentation characteristics of Kentucky baleage, a survey was conducted of round bale silage samples from several Kentucky counties in 2017, 2018 and 2019. Moisture content (MC) at baling was the greatest determinant of fermentation success as measured by pH and lactic acid concentration. Moisture contents were highly variable, with more outside the recommended range of MC (40 to 60%) than within. Farmer practices including wilting time and equipment used were recorded for the 2019 samples. All the well-accepted practices for making baleage were confirmed in this survey (cutting on time, wilting to proper MC, dense bales, achieving and maintaining anaerobic storage conditions). Baleage samples exceeding 65% MC had elevated butyric acid concentrations, indicating secondary fermentation by clostridial bacteria.

Introduction
Baleage is the process of making silage in bales of wilted forage which is wrapped in plastic to create an anaerobic environment. Baleage allows more timely harvest of forage crops, producing consistently higher quality stored feed than haying which requires longer periods of good curing weather. Key to this process is wilting the forage sufficiently to achieve the recommended moisture content (MC) leading to adequate fermentation within the wrapped bales. Good fermentation depends on achieving anaerobic conditions and rapid fermentation of available soluble carbohydrates to quickly lower bale pH by the production of lactic and acetic acid. The accumulating acids lower the pH, ideally to pH 5.0 or below (slightly higher in legumes). This acidity prevents spoilage during storage and when re-exposed to air at feeding. Well-fermented baleage is generally accepted to have more than 3.0% lactic acid and less than 0.1% butyric acid (dry matter basis).

The recommended practices for making good baleage are generally consistent across all regions of the US. Forage should be cut at an early stage of maturity, wilted to between 40 and 60% MC and preferably in the upper half of this range (50 to 60% MC). Forage should be baled into dense, uniform bales and wrapped with six layers of UV-resistant, stretch wrap plastic within 24 hours of baling. Although research has shown that four layers is adequate for ensiling in round bales, six layers gives an added level of safety and protection against punctures from forage stems and from exterior damage (Hancock and Collins 2006). The ensiling process will take four to six weeks.

As simple as this process sounds, baleage can and does go bad - that is fail to ferment properly. With baleage ensiled too dry, fermentation is incomplete and good storage relies on achieving and maintaining anaerobic conditions (Shinners et al. 2009). In the case of high moisture baleage (70% and above) and especially when forages are mature (lack sufficient fermentable carbohydrate (CHO), bales do not generate sufficient lactic acid to prevent a detrimental secondary fermentation by Clostridium bacteria. These bacteria metabolize available carbohydrates (including lactic acid) and protein and generally produce butyric acid, acetic acid, ammonia and sometimes other toxins (botulinum toxin for example) depending on the species of Clostridium present. Easily the most problematic of these bacterial types is *Clostridium botulinum*, the species responsible for the production of the botulism toxin.

Methods

A survey of Kentucky baleage was begun in 2017 to determine the fermentation characteristics in various lots of baleage. Samples were collected on selected lots of baleage in Kentucky and analyzed for forage quality, pH and fermentation profiles in a commercial, certified laboratory. In 2019, additional data was collected on general production practices, such as equipment type and the interval between cutting and baling. All lots were allowed to ferment for at least four weeks before sampling. Fermentation results were similar for 2017, 2018 and 2019, so only 2019 data is presented.

Most producers had some type of silage baler or baler adapted to handle silage. All used wheel rakes, but mowers were a mix of conditioning and non-conditioning types. Wilting time was difficult to summarize but varied from hours to a day or more depending on conditions. All producers were using at least four layers of plastic, and at most six or more. All of the high butyric samples were small grains and were high in moisture. None of the producers used any form of silage or baleage inoculant.

Results and Discussion

Baleage moisture content ranged from 22 to 79%, with more samples above 60% MC (18) than below 40% (12) (Figure 1). More samples were outside of the recommended MC range (40 to 60%) than within (30 vs 27). Moisture content at baling was the major factor impacting lactic acid and butyric acid production (Figures 2 and 3). Only when MC approached 60% did samples in this survey achieve 3% lactic acid and a pH of 5.0, generally accepted threshold values for good fermentation. Fermentation characteristics remained good for most samples at MC between 60 and 70, but the results became less predictable. Above 70% MC, butyric acid production was common. Lactic acid values generally declined at MC above 70%, presumably due to its metabolism by Clostridium bacteria.

Moisture levels in Kentucky baleage in 2019 were highly variable (Figure 1). Moisture content at baling was related to the production of lactic acid and lowering bale pH. Lactic acid values tended to rise with MC up to 60 to 65%, and then decline. In these samples, baleage needed to be 55% MC or above to consistently produce adequate lactic acid. All samples at or below 60% MC had acceptable butyric acid levels but one (<0.1%). These results are consistent with other reports of limited fermentation in baleage, especially at less than optimum MC (Muck 2006).

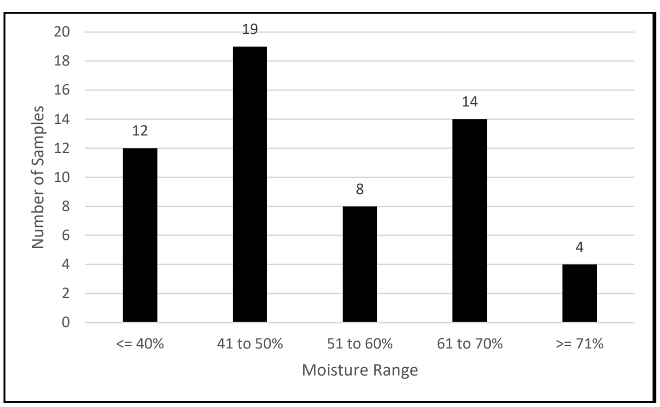

Figure 1. Distribution of moisture content among 57 samples of Kentucky baleage in 2019.

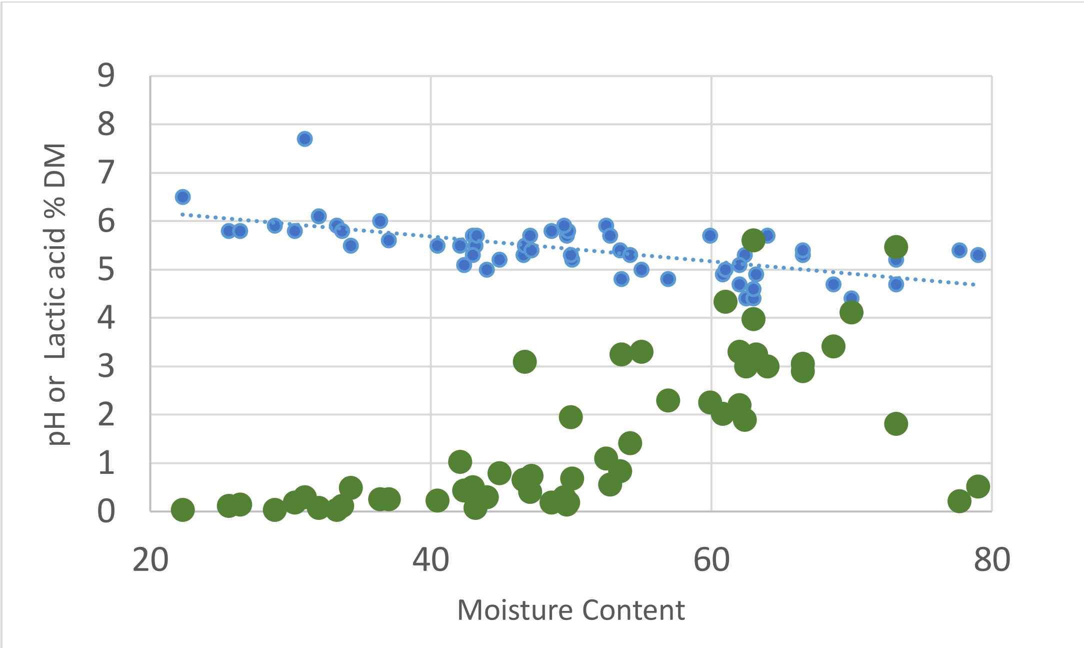

Figure 2. The effect of moisture content on lactic acid (large circles) and pH (small circles) of 2019 Kentucky baleage.

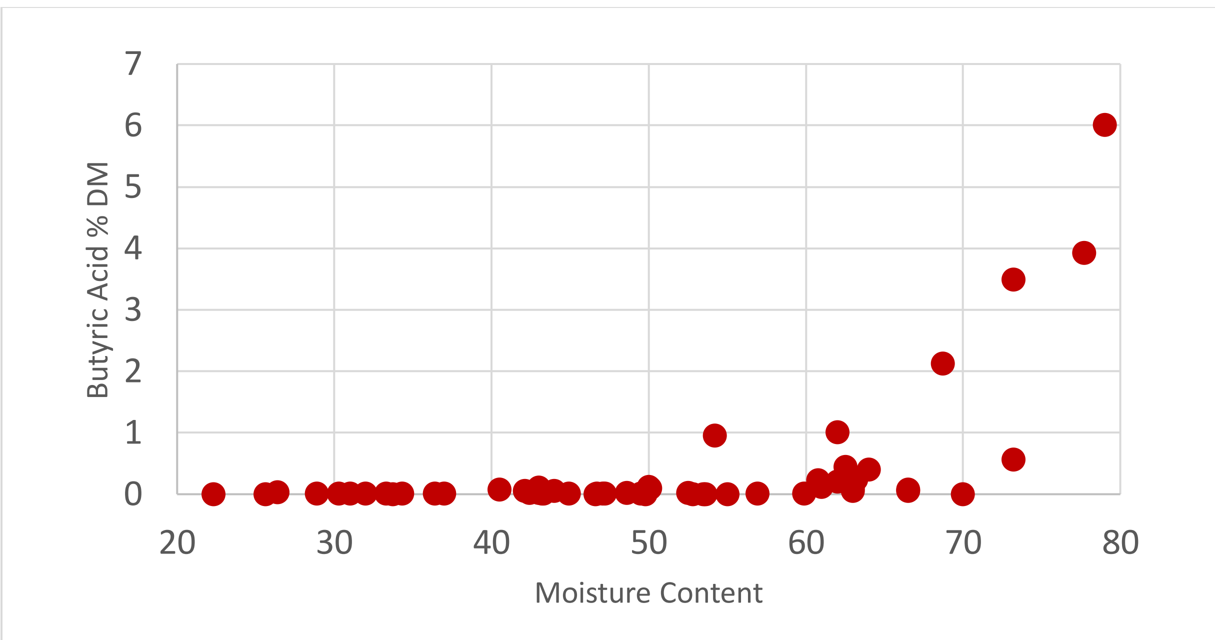

Figure 3. The effect of moisture content on butyric acid content in 2019 Kentucky baleage.

Fermentation reports showing low lactic acid and pH >5.0 cause concern with producers and uncertainty among extension and industry consultants regarding interpretation. (Shinners et al. 2009) found that baleage at or below 60% MC and with less than target lactic acid numbers should be stable in storage and feeding, if anaerobic conditions are maintained until feeding and bales are consumed within one week. Therefore, baleage with lower MC and lactic acid should be stable in storage so long as plastic integrity is maintained. These bales will not be very stable after exposure to air and should be fed quickly.

Baleage with MC between 60 and 70% produced high quantities of lactic acid (1.9 to 5.8% DM basis) but also above optimal butyric acid (>0.1%) in 10 of 14 samples. Above 70% MC, all samples had problematic levels of butyric acid. Further, butyric acid was present (0.23 to 6.0%) in every lot of small grain baleage above 60% MC. Type of crop/season of production should also be considered when determining risk; small grain baleage is produced in early spring when lactic acid bacteria numbers and lower temperatures likely limit beneficial fermentation. Poor curing conditions and wet soils make it difficult to wilt forage to the desired moisture levels. Some producers in this Kentucky database wilted small grain forage for 72 hours and still did not achieve moisture contents below 70%. Baleage inoculants would likely improve fermentation in spring produced baleage but was not used on any lots tested in any year.

Ash is the mineral content of forage and should be between six and eight percent of DM unless soil contamination has occurred. Elevated ash levels (above 10 to 11% DM basis) are a concern since dirt is the primary way that Clostridium bacteria are introduced into baleage. Ash content ranged from 7 to 15% in the 2019 samples. There was no clear relationship between elevated ash content and high butyric acid. However, there was evidence that the ash effect on clostridial fermentation might be seasonal. In two samples with ash levels above 14%, small grain baleage had greater butyric acid than sorghum-sudangrass baleage produced later that season from the same field (0.44 vs 0.01% DM basis). High ash content alone is not predictive of clostridial fermentation but should be considered as a risk factor.

Conclusions

All the well-accepted practices for making baleage were confirmed in this survey (cutting on time, wilting to proper MC, dense bales, achieving and maintaining anaerobic storage conditions). Baleage testing for quality and fermentation is highly recommended. Normal forage testing will not measure actual botulism toxin formation, but it will reveal risk factors that make it more likely. These risk factors are high MC (above 65%), pH > 5.0, ash content > 15% and high butyric acid production. To be clear, the presence of butyric acid above 0.1% is not proof of botulism or even a perfect predictor of poor performance. But high levels of butyric acid should be considered as increasing the risk of feeding problems, including the possibility of botulism. With a comprehensive forage test that includes a fermentation profile and measurement of the ash content, feeding problems due to poor fermentation become preventable or at least more predictable.

References

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