

Ensiling PRESSED Beet Pulp

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PRESSED BEET PULP IS A BY-PRODUCT OF THE SUGAR INDUSTRY. It is an excellent feed for lactating dairy cows. Pressed pulp is very palatable, moderately high in energy, and high in digestible fiber. Fresh pressed pulp is normally available from October through February. Producers have the option of feeding fresh pressed pulp or feeding ensiled material. Ensiling pressed pulp enables dairy producers to maintain similar rations throughout the year.

Pressed beet pulp silage is a common feed ingredient on European livestock operations, yet ensiling pressed beet pulp for feed is a relatively new practice for US livestock operations. Research on proper ensiling techniques in North America is limited. Utilizing the extensive research database from European countries, Idaho researchers are developing guidelines for ensiling pressed pulp. In this bulletin, we summarize storage alternatives, guidelines for ensiling pressed beet pulp, tips for evaluating silage quality, and profile the North American experience with pressed beet pulp silage.

STORAGE STRUCTURES

European researchers and livestock producers have successfully ensiled pressed beet pulp in 700-liter (185 gallon) bags, silage bags, clamp silos (covered silage piles or stacks without concrete walls), and bunker silos. The system of choice varies due to the amount of silage stored, herd size, removal rate, available equipment, and available storage facilities. Producers in the United States are more familiar with ensiling feed in silage bags, covered stacks, and bunker silos. These options are more economically viable for larger livestock operations.



Timely delivery of fresh pressed pulp from the factory is critical to proper silage conservation.

Pressed beet pulp silage quality usually is excellent when stored in silage bags. Advantages include: rapid filling, adequate compaction by the bagging machine, rapid exclusion of oxygen from the silage mass, rapid post-fermentation cool down and limited dry matter losses. Disadvantages include: greater space requirements to ensile a given mass of silage, higher storage costs per ton of silage, higher labor requirements to remove silage during TMR (total mixed ration) preparation, possible mold formation near tears in silage bags, and management issues with plastic disposal.



Silage bagging systems offer excellent conservation conditions for pressed pulp silage.

Covered silage stacks are popular on European livestock operations. The key advantages for stack silage include: low investment cost in the storage facility, low storage costs per ton of silage, rapid removal of large quantities of silage for feeding, and enhanced flexibility at the farm level (the concrete pad can be used for other purposes besides storing silage). Disadvantages to stack silage include: higher dry matter losses, greater difficulty in achieving uniform compaction



Small stack silos are popular on northern European livestock operations.
Photo courtesy of IRBAB, Belgium.

relative to corn or hay silage, delayed cool down of the silage mass if stacked too high or too wide, and increased risk for poor silage quality if recommended practices are not followed.

Bunker silos are the predominant silage storage structure in both the United States and Europe. The key advantages include: moderate cost per ton of silage stored, ease of packing utilizing tractors, excellent silage quality if recommended ensiling practices are followed, and rapid removal of large quantities of silage for feeding. Key disadvantages include: greater investment costs than with stack silage, moderately high dry matter losses, difficulty in achieving uniform compaction compared with corn or hay silage, delayed cool down if silage mass is stacked too high or too wide, and increased risk for poor silage quality if recommended practices are not followed.

RECOMMENDED ENSILING AND FEEDOUT PRACTICES

- 1) *Schedule delivery of adequate amounts of pressed beet pulp.* Successful ensiling depends on receiving pressed beet pulp in adequate quantities and in a timely fashion. European researchers strongly recommend ordering adequate amounts to fill bunkers, stack piles, or silage bags as quickly as possible, preferably in one day. Space deliveries of pressed pulp to allow adequate time for layering and compacting pressed pulp in a bunker silo.
- 2) *Ensile pressed pulp that is greater than 104°F and less than 24 hours old.* Successful ensiling at the farm occurs when the temperature of the pressed pulp is above 104°F (Fahrenheit) or 40°C (Celsius) and when pulp has sufficient quantities of sugar for a good silage fermentation to occur. Freshly pressed pulp at the factory has a pH of 5.5 to 6.0, sugar content of 4% to 6%, and a temperature of approximately 113°F to 131°F (45°C to 55°C). The temperature starts dropping and the fermentation process begins shortly after the pulp enters the stack at the factory. Lactic-acid-producing bacteria start multiplying in the stack and begin metabolizing the available sugar in the pressed pulp. Over time, the stacks at the sugar factory decrease in sugar content, decrease in pH, and have significant quantities of lactic acid and acetic acid due to fermentation. Aged stacks at the sugar factory are not likely to produce quality silage at the farm level because: 1) initial fermentation partially depletes sugar levels, 2) the presence of oxygen leads to undesirable secondary fermentations, 3) lactic acid fermentation must restart after loading and delivery to the farm, and 4) lactic acid production is minimal due to depleted sugar content.

3) *Measure the dry matter content of the pressed beet pulp at ensiling.* Dry matter and sugar content of pressed pulp vary due to beet condition and press operations at the sugar factory. Very small differences in dry matter content should occur between loads. Dry matter (DM) determinations can be made in 10 to 15 minutes using a microwave oven method or in 40 minutes using a Koster Moisture Tester™. High dry matter pulp (27% DM) has less sugar than low dry matter pulp (23% DM). Recent German research compared ensiling high versus low dry matter pressed pulp in silage bags. Low (23% DM) pulp silage had higher residual sugar and higher lactic acid, acetic acid, and ethanol concentrations than did high (27% DM) pulp silage. However, overall silage quality and aerobic stability measures were in the desired range for both silages when ensiled in silage bags. Similar results were observed in a Swiss study, comparing high versus low dry matter pulp ensiled in 700-liter bags. Achieving adequate compaction can be a problem with high dry matter pulp (>25% DM) and increases the risk for alcohol fermentation in the silage.



Dry matter content of pressed beet pulp can be determined quickly using a microwave oven.

4) *Ensile pressed pulp in a storage structure that allows rapid post-fermentation cooling.* The ensiled mass pH drops quickly after successful initiation of lactic acid production. Once the acidification is completed, rapid cooling of the mass is desired to prevent undesirable secondary fermentations and to prevent pectin breakdown due to thermal degradation and enzymatic activity. European researchers recommend a temperature drop of 1.8°F (1°C) per day. For proper cooling, European researchers recommend bunker silos not exceed 26 feet in width, 6.5 feet in height, and 250 tons in volume. Wider, taller, more voluminous bunkers pose a greater risk for undesirable secondary fermentations and pectin breakdown due to thermal degradation and enzymatic activity. Other factors that can influence cooling of the silage mass include: 1) using black rather

than white plastic to cover the bunker, 2) ensiling pressed pulp in bunkers below ground level, and 3) ensiling pulp next to a heated building or in side by side bunkers. Silage bags are well below European recommendations for maximum width and approach the maximum for height. Research studies have shown excellent cooling characteristics in pressed pulp ensiled in silage bags.

5) *Avoid dirt or manure contamination of pressed pulp.* Dirt contamination can inoculate the pressed pulp with clostridia bacteria that ferment sugars to undesirable butyric acid. Clostridia reside in all soil, so contamination presents a problem for all crops. Since beets are harvested with dirt on them, clostridia potentially pose a greater problem. Sweep bunker floors clean prior to ensiling pulp. Keep packing tractors in the silage bunker throughout the packing process. Clean delivery truck beds prior to hauling pressed pulp to the farm storage facility to help prevent clostridia bacteria contamination from dirt (especially important if delivering fresh beets to factory and back-hauling pressed pulp to farms).

6) *Properly compact the pressed pulp in the storage structure.* Density of fresh pressed pulp ranges from 25 pounds per cubic foot to 35 pounds per cubic foot. For proper silage conservation, European researchers recommend a packed density of 50 pounds per cubic foot (wet basis). Bagging systems provide adequate compaction during the bag filling process. For bunker silos, European researchers recommend spreading out the pulp in 8- to 12-inch-thick flat layers and then compacting by tractor prior to adding the next layer. The thin layers allow steam removal during the packing process. An alternative method utilizes the progressive wedge technique in bunker silos. When using the progressive wedge method, producers continually pack pressed pulp on a 30 percent- to 40 percent-grade. Each load of pulp is spread out in 6- to 12-inch layers on the incline and compacted using a tractor. The University of Wisconsin has developed spreadsheets for predicting silage density before packing bunker silos and stack silos. Input variables include dimensions of the storage cross-section, silage delivery rate, packing tractor weight, number of packing tractors, layer thickness, and dry matter content. Producers can adjust variables under their control (fill rate, number of packing tractors, and layer thickness) to determine if the changes will result in adequate predicted density. The calculator was designed for estimating density of corn silage and hay crop silages but has not been tested with pressed beet pulp silage. A web address for downloading the density calculators follows at the end of this publication.



Add fresh pulp to the bunker in 6- to 12-inch layers, then use a tractor to pack thoroughly.



Covering the silage mass is essential to promote proper fermentation and to minimize mold development.

- 7) *Properly cover the bunker silo with white plastic.* Prior to covering, slightly crown the middle of the silage mass to allow rain and snowmelt to run off the stack or bunker. Covering the silage mass is essential for proper fermentation of the pressed pulp and to minimize mold development. When utilizing a three-sided bunker, lay covers in place along the end wall and along the sidewalls prior to filling. As the silo is filled, place the end cover over the mass and then lay the side covers over the end cover, overlap, and seal. White plastic covers are preferred because less heat accumulates under a white cover on warm, sunny days. It is best to wait at least 24 hours before sealing the top of the pulp mass to allow release of steam and water vapor. Covering too soon allows the water vapor to condense on the top layers. Condensation can create favorable conditions for mold development. Cover the silo immediately after ensiling if heavy rain or snowfall is predicted in the next 24 hours. Direct precipitation increases the risk of molding and undesirable fermentations in the top layer. Place tires on top of cover to hold the cover in place.
- 8) *Allow adequate curing time prior to feeding.* The standard European recommendation is to wait 4 weeks to 6 weeks prior to feeding. Recent research from Germany suggests silage bags can be opened as early as 14 days post ensiling. However, this practice greatly reduces aerobic stability of the silage mass relative to a standard storage period. To compensate, increase feedout rate to at least 3 feet of silage removal per day, regardless of bag size. Chemical additives (sodium benzoate and sodium propionate) are also strongly recommended when early feedout is planned from the storage structure.

9) *Remove at least the minimum amount of silage per day.* Standard European recommendations are to remove 4 inches to 6 inches per day during the winter months and 8 inches per day during the summer months. Remove silage uniformly along the entire silage face. Silage de-facers are an excellent tool for maintaining a uniform silage face. If using a bucket loader, be careful not to disturb the silage mass when removing silage. Cracks can form in the top of the silage mass due to ramming with the bucket loader. Extensive mold growth may occur in these cracks. The cracks also may initiate a secondary fermentation that can spoil the feed. Discard moldy silage.



Maintaining a uniform silage face is important to retain feed quality and to prevent heating of the pressed pulp at the feed bunker.

10) *Consider using silage additives.* European researchers have evaluated the benefits of adding inoculants, chemical additives, and molasses to pressed beet pulp silage. Silage quality and aerobic stability were not improved by adding inoculants with either single or multiple strains of lactic-acid-producing bacteria. Chemical additives tended to lower silage pH, increase lactic acid production, and improve aerobic stability compared with control pressed pulp silages. Successful chemical additives included either a mixture of sodium benzoate and sodium propionate or a mixture of sodium benzoate and propionic acid. Molasses typically is added only under unique situations, such as low sugar content (< 2.5% sugar, DM basis) in pressed pulp prior to ensiling. Sugar content is inversely related to dry matter content of the pressed pulp (27% DM pulp has less sugar than 23% DM pulp). Adding 2% to 3% molasses to pressed beet pulp increases sugar levels and improves silage fermentation (lower silage pH and increased lactic acid content). However, molasses addition may increase secondary fermentations in improperly ensiled pressed pulp. Silage additives (microbial or chemical) can be added to the pressed pulp at the sugar factory or at the farm. In the case of bunker or stack storages, it will be easier to achieve uniform additive application at the sugar factory than at the farm during ensiling. Bagging machines have applicators that properly distribute additives during the filling process. Contractors must be prepared to have the applicator installed on the bagging machine and to have sufficient quantities of additive available for application.



Properly ensiled pulp appears white to light gray in color.

SILAGE EVALUATION

Several measures are available for assessing silage quality post ensiling. These measures are described below.

Color. The color of fresh pulp ranges from white to a light gray and varies depending upon the extraction process used at the factory. Properly ensiled pulp also appears white to light gray. Pulp that has undergone pectin degradation has a yellowish cast,

but the color soon disappears after exposure to oxygen. Pectin degradation is more likely to occur near the middle and bottom of the silage mass due to slower heat dissipation in these areas.

Odor. Properly ensiled pressed pulp has a mild, pleasant odor. Silage that has undergone secondary fermentation will have a vinegary smell due to acetic acid formation. A strong rancid odor indicates butyric acid fermentation. A sweet odor may indicate a high ethanol production in the pressed pulp. A moldy, musty smell can occur if the silage is fed out too slowly. Under certain situations, the bottom layer of pulp (2 inches to 4 inches) in a bunker cools down too quickly before the next layer is added. This bottom layer undergoes abnormal butyric acid fermentation, tends to be yellow in color, has an acrid smell, and is less palatable to cattle.

Texture. Normal ensiled pulp will be firm and rubbery in texture. It maintains its shape upon compression. Abnormal pulp silage that has undergone secondary fermentations or pectin degradation feels “tacky” or “smearly” and loses its shape upon compression.

Rigidity. The pectin in the pressed pulp can become degraded during the ensiling process due to prolonged high temperatures and enzymatic activity. Pressed pulp silage exhibiting degraded pectin has reduced structure and will not maintain a desirable silage face. Loss of structure occurs in the bottom 3 feet of the silage mass (the area that is slowest to cool down). Due to structure loss, the bottom pulp is not able to support the weight of the upper silage mass. It folds over and falls in front of the silage face. In extreme cases, the silage mass collapses in the middle and literally flows out of the bunker face.

Density. For proper silage conservation, European researchers recommend a packed density of 50 lb per cubic foot (wet basis) or greater. Due to less compaction, density will be lower in the top layer of the bunker than in the bottom layers. Belgian researchers recently evaluated densities of on-farm storages (see Table 1). Observed densities were **below** 50 lb per cubic foot in 11 of 11 stack silos, and in 10 of 22 bunker silos. All three plastic bag silos exceeded minimum recommended levels. These data reflect the difficulty in obtaining uniform and desired compaction rates in stack and bunker silos. The “Storage Density Calculator” spreadsheet (developed at the University of Wisconsin) can be used to estimate silage density achieved in the storage. The producer uses a TMR wagon scale to measure the weight of feed removed from the storage over a period of time. After measuring the volume removed, the producer can use the spreadsheet to determine average wet density. A web address for downloading the “Storage Density Calculator” spreadsheet is listed at the end of this publication.

Fermentation profile. Fermentation analysis can be obtained from a feed testing laboratory and is an excellent tool for evaluating success in ensiling pressed beet pulp. To obtain proper conservation of pressed pulp, European researchers recommend a silage pH below 3.8, lactic acid concentration of 3% or higher (DM basis), acetic acid concentration below 1.5% (DM



If the bottom silage layer cools too quickly, it undergoes abnormal fermentation, turns yellow in color, and has an acrid smell.

Photo courtesy of IRBAB, Belgium.



When pectin becomes degraded, pulp at the bottom of the silo is not able to support the weight of silage above it.

Photo courtesy of IRBAB, Belgium.

basis) and butyric acid concentration below 0.2% (DM basis). Belgian researchers recently evaluated fermentation profiles of on-farm storages (see Table 1). The pH of pressed pulp silage averaged **above** 3.8 in 5 of 11 stack silos, in 6 of 22 bunker silos, but in none of three silage bags. Lactic acid concentration averaged **below** 3.0% (dry matter basis) in 10 of 11 stack silos, in 13 of 22 bunker silos, but in none of three silage bags. These data reflect the challenge for obtaining desirable fermentation profiles in stack and bunker silos.

TABLE 1. Survey of pressed beet pulp silages on Belgian farms (six samples collected at each silo).

Structure	number of storages	wet density (lb/ft ³)	pH	lactic acid (%DM)
Bag silo	3	51.5 to 54.6	3.55 to 3.65	2.8 to 3.5
Bunker silo	22	42.1 to 57.7	3.45 to 4.05	0.8 to 4.8
Stack silo	11	39.3 to 48.7	3.65 to 4.15	0.8 to 3.0
Goal for proper conservation		>50	≤3.8	>3.0

Source: Legrand, 2005. IRBAB Technical Guide.

Molds. A variety of mold species have been observed on improperly ensiled pulp. Molds range in color from aquamarine, green, red, yellow, and orange to gray. High mycotoxin concentrations are a potential issue when aquamarine or green color molds are present. Extensive mold formation can occur due to improper compaction, improper sealing, prolonged high temperatures in the silage mass, formation of cracks in the silage mass due to the loss of rigidity from degraded pectin, or rough handling by means of a loader tractor. If molds are suspected, have the silage tested at a laboratory for potential mycotoxin identification and concentrations.

Yeast. Yeast concentration directly influences the aerobic stability of pressed pulp. Pressed pulp showing high yeast concentration will start heating and spoiling after exposure to air. Properly ensiled pressed pulp will have a very low concentration of yeast when the silo is opened. Poor aerobic stability can occur if feedout rate from the storage structure is too low or if the storage structure is opened too early. Using a chemical additive (sodium benzoate and sodium propionate) at ensiling lowers silage pH, eliminates yeast, and significantly improves aerobic stability from less than 3 days to more than 5 days.

NORTH AMERICAN EXPERIENCE WITH PRESSED BEET PULP SILAGE

Fresh pressed beet pulp has been a staple feed used by livestock producers for many years. Pressed beet pulp has been ensiled in Michigan for nearly 10 years. Producer demand has been strong and increasing over the years. In 2005, approximately 185,000 tons of pressed beet pulp were sold, and about half was ensiled on Michigan livestock operations. Bunker silos are the predominant storage structure, followed by silage bags. Operations using pulp ranged from average to large dairy operations (>1,000 dairy cows). Bunker silos in Michigan are significantly wider and taller than those built to European recommendations. Unfortunately, silage fermentation analysis data were not routinely collected by Michigan livestock producers. We, therefore, cannot ascertain silage quality relative to European standards. Symptoms of pectin degradation were evident in some storage structures. Producers reported difficulties in maintaining the silage face due to extensive crumbling along the face. Some issues with mold

also were reported. However, cow acceptance of pressed pulp silage has been very good. Herd performance has been excellent. Producers have been highly pleased with the quality of pressed beet pulp silage from plastic bag silos. They did express concerns regarding higher storage costs per ton and greater labor required when feeding large quantities of silage on a daily basis.

In Idaho, the Amalgamated Sugar Company, LLC, is conducting research on ensiling pressed beet pulp in large bunker silos. These storage structures are significantly wider (100 feet versus 26 feet) and taller (10 feet versus 6.5 feet) than European recommendations for bunker width and height. Preliminary Idaho data suggest pressed pulp can be successfully ensiled in these larger structures. Additional research is currently in progress.

Idaho researchers recently evaluated fermentation profiles of pressed beet pulp silage from on-farm storages (see Table 2). The pH of pressed pulp silage averaged **above** 3.8 in none of five silage bags (9 sampling events), and the bunker silo had 2 of 18 samples **above** 3.8 (3.84 and 4.14). Lactic acid concentrations averaged **below** 3.0% (DM basis) in 1 of 9 sampling events in the bagged silage and in 3 of 18 sampling events in the bunker silo. Acetic acid concentrations were **above** 1.5% in 4 of 9 sampling events with the bagged silage, and in 18 of 18 sampling events in the bunker silo. Quality of the silages was very good, having minimal or no production of propionic acid and butyric acid in the pressed pulp silage. Fermentation profiles of Idaho pressed pulp silages appear to be similar to the profiles of European silages. Acetic acid levels in Idaho silages were higher than recommended for proper conservation by European researchers. Pulp temperature at ensiling (not measured during 2005–2006 seasons) may provide a possible explanation. Pulp below 104°F at ensiling provides a more favorable environment for acetic acid fermentation than for lactic acid fermentation. The impact of elevated acetic acid concentration on pulp feed value is unclear at this time

After the second year of the project, several factors were identified that can impact the storability of the pressed pulp and the quality of the ensiled forage.

TABLE 2. Survey of pressed pulp silages on Idaho farms (2006 data).

Structure	Number of silos	pH	Lactic acid (%DM)	Acetic acid (%DM)
Bagged silage ¹	5	3.3–3.5	2.5–4.8	0.6–2.6
Bunker silo ²	1	3.3–4.1	0.9–5.9	2.4–4.6

¹ Five silage bags were sampled monthly from 1/13/06 through 9/15/06.

² The bunker silo measured 100 feet wide by 400 feet long by 10 feet high (containing 6450 tons). The bunker silo was sampled weekly from 3/31/06 through 8/17/06.



Idaho researchers are studying large bunkers. This bunker in southern Idaho measures 100 feet wide by 400 feet long by 10 feet high. It contains 6450 tons of pressed pulp.

- To obtain optimum feed quality, recommended dry matter content of pressed pulp should be between 24% and 26% at ensiling. Increased moisture can adversely impact on the fermentation process.
- If the pulp is ensiled in a pit or bunker, do not allow the height of the bunker to exceed 10 feet. Pulp does not pack in the same manner as corn silage.
- Utilize a three-sided bunker for pressed pulp. This helps to maintain pit stability.
- When shipping pressed pulp for ensiling, have the factory send only fresh pulp to the farm, ideally less than 8 hours old.
- When scheduling pressed pulp delivery, take care to allow adequate time for packing the material. Packing the pulp is essential to eliminating air from the silage mass. This may require additional tractors for the packing portion of the process.
- Properly covering the silage mass is essential to the proper fermentation of the pressed pulp. The most common method includes covering the pit with plastic and utilizing either full casing or sidewall disc tires for weight on the surface of the bunker.
- When utilizing a three-sided bunker, lay the cover in place at the end of the silo prior to filling. As the silo is filled, lay the end cover over the mass; overlap and seal the side covers. If possible, make sure the side covers extend over the

side walls of the bunker to minimize infiltration of precipitation or air to the silage mass.

At this time, strong evidence supports success by ensiling pressed beet pulp in plastic bag silos and in narrow (26 feet), short (6.5 feet), small volume (250 ton) bunker silos. The Michigan experience and the recent Idaho experience suggest success is possible in taller, wider, more voluminous bunkers. It is not clear why larger silos appear to work in Michigan and Idaho but not in Europe. Nor is it clear how pressed beet pulp in Idaho compares with pressed beet pulp in Michigan or Europe. Further study is needed before we can recommend ensiling pressed pulp in wide, tall, and long bunkers. The risk of poor quality silage is great due to prolonged high temperatures within the silage mass and possible secondary fermentations.

ACKNOWLEDGMENTS

The authors are grateful for permission to use photographs supplied by the Institut Royal Belge pour l'Amélioration de la Betterave (IRBAB, Belgium).

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Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Charlotte V. Eberlein, Director of University of Idaho Extension, University of Idaho, Moscow, Idaho 83844. The University provides equal opportunity in education and employment on the basis of race, color, national origin, religion, sex, sexual orientation, age, disability, or status as a disabled veteran or Vietnam-era veteran, as required by state and federal laws.