The Correct use of Pressed Beet pulp

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Preamble
This “Guide Technique” corresponds to an actualization of a first edition achieved by the IRBAB/KBIVB, in 1984, when the use of pressed beet pulp began to develop in Belgium. This second edition is also interested in the description of the correct use of pressed beet pulp, and recalls the essential rules of its production, its delivery and its conservation by ensilage at the farm. This edition also attempts to explain the occasional problems that occur during ensilage or unloading of the silo. As in its first edition, this Guide doesn't propose examples of feed rations where the pressed pulp is used according to such or such type of livestock or according to its age and performances. On the other hand, numerous Notes, regrouped in this Guide's second part, bring a complement of more precise information, according to the handled paragraphs. The most important elements of these descriptions (notes) are frequently repeated to inform, as well as possible the interested reader, who will browse only some of them.

Acknowledgments
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Warning
The information presented in this guide is given in good faith and can under no circumstances be used to settle causes. Because the causes of problematic situations are often complex, use and interpretation of this information is under the reader's only responsibility. The IRBAB/KBIVB and its staff cannot be held responsible for direct or indirect consequences of their use.
1. SUGAR BEET PULP

Because of its high feed value and its excellent appetite, sugar beet pulp is recognized as an excellent feed for livestock (Figure 1). It can be consumed in big quantities by the cattle, however without passing the rate of 1.5 kg DM/day generally and by 100 kg of living weight.

1.1. Description

Available in big quantities in sugar factories during the beet campaign, sugar beet pulp is an ideal feed for dairy livestock and meat cattle, but also for other farm animals (Note 1). It presents itself as fragments of fine slices of sugar beets (cossettes), exhausted by hot water and pressed. The exhausting of the cossettes corresponds to the diffusion process achieved in sugar factories to extract the accumulated sugar by the sugar beet in its root. After the diffusion, the cossettes exhausted in sugar (pulp), are pressed to produce the wet pulp (10 to 13% of DM) or the pressed pulp (22% of DM).

Figure 1: Sugar beet pulp is recognized as an excellent feed for livestock.

At the time of its production, pressed pulp is a fresh feed product, non sterilized, hot delivered, in bulk and in a relatively humid state (Figure 2). In the absence of particular precautions, it is quickly altered by outside elements (air, water, bacteria, moulds,…) and therefore perishable. The conservation of pressed pulp, on the other hand, is easy at the farm, even beyond the period of delivery and even until the next beet campaign, thanks to the technique of ensilage (Note 2).
In other European countries, the sugar beet pulp is incorporated in some culinary preparations (biscuit, butcher's shop) or used in non food applications (Note 3).

1.2. Process of production
After their washing in the factory, the sugar beets are cut in fine slices (cossettes) in a beet slicer. These cossettes are put to circulate in a cross-current of hot water during the diffusion stage (Notes 4 & 5).
At the exit of the diffusion, the cossettes contain practically no more sugar, but are stuffed again with water (somewhat sugary). They are pressed some more to extract the excess of water and to increase their dry matter content (Note 6).
Pressed to at least 22% DM, they form pressed sugar beet pulp, easily portable, which must be delivered at the farm in the best delays, with regard of several health rules and other quality standards (Notes 7 & 8).

1.3. Composition
Pressed sugar beet pulp has a relatively steady composition. This composition can vary however during the campaign of extraction, according to the degree of "maturation" of the sugar beets. It can also vary according to the geographical origin of the deliveries and according to the years (Note 9). The standard composition and the feed values of the pressed pulp are itemized in the tables 1a and 1b. It has a high content in cellulose (21%) and in other digestible carbohydrates (hemicellulose and pectin, respectively 27 and 23%). Its content in lignin is weak enough (< 4%), what confers a good digestibility of its organic matter (of the order of 87 to 90%) and a good energy value (superior to the one of a maize ensilage and close to the one of the fodder beet).
<table>
<thead>
<tr>
<th>Content in organic elements</th>
<th>in % of DM</th>
<th>in g/kg corrected to 88% DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw protein (nitrogen matter)</td>
<td>10</td>
<td>88.0</td>
</tr>
<tr>
<td>Raw ash</td>
<td>7.5</td>
<td>66.0</td>
</tr>
<tr>
<td>Fat content</td>
<td>1</td>
<td>9.7</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>81.3</td>
<td>716.3</td>
</tr>
<tr>
<td>total sugars</td>
<td>6.5</td>
<td>57.2</td>
</tr>
<tr>
<td>cellulose</td>
<td>21</td>
<td>187.4</td>
</tr>
<tr>
<td>hemicellulose</td>
<td>27</td>
<td>236.7</td>
</tr>
<tr>
<td>pectin</td>
<td>23</td>
<td>201.5</td>
</tr>
<tr>
<td>lignin</td>
<td>3.8</td>
<td>33.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content in mineral elements</th>
<th>in g/kg of DM</th>
<th>in g/kg corrected to 88% DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>1</td>
<td>8.8 (7 – 40)</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>0.1</td>
<td>0.9 (0.8 – 1.2)</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.5</td>
<td>4.4 (4 – 10)</td>
</tr>
<tr>
<td>Magnesium</td>
<td>0.25</td>
<td>2.2 (1.2 – 2.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average contents in mineral elements</th>
<th>in g/kg of DM</th>
<th>in g/kg corrected to 88% DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine</td>
<td>0.5</td>
<td>0.44</td>
</tr>
<tr>
<td>Sodium</td>
<td>1</td>
<td>0.88 (0.5 – 1.5)</td>
</tr>
<tr>
<td>Sulphate</td>
<td>4</td>
<td>3.52 (10)</td>
</tr>
<tr>
<td>Total nitrogen</td>
<td>16</td>
<td>14.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Content in heavy metals (in mg/kg corrected to 88% DM)</th>
<th>Average</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>&lt; 2</td>
<td>2</td>
</tr>
<tr>
<td>Lead</td>
<td>&lt; 5</td>
<td>5</td>
</tr>
<tr>
<td>Mercury</td>
<td>&lt; 0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Cadmium</td>
<td>&lt; 0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Fluorine</td>
<td>&lt; 10</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 1a: Indicative values of several components of pressed pulp (some extreme values are presented for some elements).

<table>
<thead>
<tr>
<th>Feed value (average by kg DM)</th>
<th>VEM</th>
<th>VEVI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.040</td>
<td>1.114</td>
</tr>
<tr>
<td>G VRE (g/kg DM)</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>G DVE (g/kg DM)</td>
<td>101</td>
<td></td>
</tr>
<tr>
<td>G OEB (g/kg DM)</td>
<td>-68</td>
<td></td>
</tr>
</tbody>
</table>

Table 1b: Mean feed values of pressed pulp.

In relation to the other roughages, pressed pulp is rich enough in potassium, in sodium, in calcium and in magnesium. It is, on the other hand, very poor in phosphorus, in manganese, in zinc and in copper. It will be necessary to carefully complement these elements in the feed rations containing pressed pulp.

The calcium content of the pulp (8.8 g/kg DM) is higher than the one for roughages. It can vary according to the origin of the sugar beets (natural content of the soils in calcium), but
also according to the quantity of gypsum used in the sugar factory during the pressing (Note 6). This content can also vary during the campaign, between 5 to 30 g/kg DM.

The content in protein (10% DM) is weaker than the one of a maize ensilage. This insufficiency must be compensated in the ration, by the supply of proteineous nitrogen (soybean oilcake,…).

The pulp raw proteins have a digestibility of 75% and contain essential amino acids, particular lysine, methionine, cysteine and threonine. These proteins are not broken down to the level of the rumen. They are absorbed directly to the level of the intestine. On the other hand, pulp is poor in carotene and in vitamin A. One will be careful to incorporate it in the ration of feed and complements that will compensate these deficiencies. The clutter of the pulp in the rumen is lower compared to many other roughages. Pulp has a positive value on the physical structure however; it’s the equivalent of 30 to 40% of the value in physical structure of a grass ensilage.

1.4. Guarantee of the product to the delivery

In Belgium, the pressed pulp must have a content in dry matter of at least 22%, a content in raw ashes of 8% on the DM and a content in insoluble ashes to the hydrochloric acid (HCl) of maximum 3.5% on the DM (inter-professional specification). This content level in insoluble ashes reflects the intensity of the washing of the sugar beets done by the washing drums in the sugar factory. An effective washing reduces the risk of contamination of the pulp strongly (and of the diffusion in the sugar factory) by ominous bacteria (Bacillus, Clostridium,…).

The Belgian inter-professional agreements consider the pulp as pressed pulp (with expenses of surpressage) when its content in dry matter is greater than 22%. The expenses of surpressage are said" lessen" if the dry matter content consist between 21 and 22%. The pulp is considered as wet pulp if its dry matter content is lower than 21% (no pressing cost).

According to the factories, its sugar content varies between 4 and 6% (DM). The guaranteed minimum is 2.5% (Note 10).

The supply, from the sugar factory to the farm, will take place within 24 or at last 48 hours following its production.

The delivery planning, agreed between the sugar factory and the user, must perfectly be synchronized and must be respected by both sides, in an effort of good coordination. It must permit to finish a medium size pressed pulp silo quickly, in less then one day. In the same way, the time interval between the deliveries should correspond to the time necessary to ensile, without precipitations, every delivery. This will be in function of the delivered tonnage, and will take at least 15 minutes between each delivery.

The colour of the pulp at the delivery varies, in a normal way, from white to grey, according to the factories, to the diffusion type (depending on the hardness of the movements of the pulp in the diffuser, which encourages its oxidation by air and procures the pulp a more greyish colour) and of the treatment in diffusion (use of sulphur based technological auxiliaries, or substances which whiten the pulp). The colour doesn't have any impact on the fermentation abilities, or on the feed quality.

At the delivery, the pulp cannot contain any visible moulds, it should not release a typical acidic and acrid odour (acidity increased resulting of a microbiological contamination during the diffusion), nor should it be sticky (Note 17).

The cleanliness and the regular decontamination of the pressing facilities, the track areas of the pulp from and towards the pulp yard; the regular decontamination (brushings and regular treatments with propionic acid), the cleanliness and the management of the pulp yard; the storage time in the yard; it’s aspect and it’s temperature (> 45°C); cleaning and the cleanliness of the truck skips at the loading time; the covering of the loadings; a regular cadence of delivery are also, according to the factories, elements taken in consideration and controlled.
In that way, the factories are careful to evacuate the scrapings regularly from the yard, out of the pulp yard. Some even disinfect this space regularly (Figure 3). The best way to evacuate pulp from the factory, is by using the "first in/first out" technique, where different pulp heaps are achieved successively and evacuated (Figure 4). This good management limits the displacements of pulp heaps, ominous to the starting of the lactic fermentation in the factory (Note 8). The direct loading by waiting bunkers is a technique that avoids these problems.

![Figure 3: The cleanliness of the yard is an important element during the loading of pressed pulp (Note 8).](image)

The pulp yard must be sufficiently spacious and free to avoid displacements of the loading contraptions on the pulp. The out-flow of rain waters must be reduced and no truck transporting (or messed up by) neither soil nor out-flow of mud must be admitted there. The driver of the loading vehicle must be careful during charging, with a minimum of losses, the pulp in the trucks. The vehicles must always position themselves on a delimited site for loading (Figure 2).
In every factory, a traceability system permits to follow every delivery and manages the complaints according to possible incidents observed during the pulp production process. Some factories insure daily, by laboratory tests, the fermentation faculty of the produced pulp. These various guarantees are described in a "descriptive product card", published by every feed producer for livestock and therefore available in every sugar factory.

1.5. GMP pulp
In order to answer to the increasing requirements of the agro-food industry and the feed producers for livestock, the production of sugar beet pressed pulp complies with the GMP production criteria ("Good Manufacturing Practices"), that means to comply with specific norms of surveillance and feed security (Note 11). These norms are inspired by those defined by the HACCP security criteria, applied for the food production intended for human consumption.

The GMP criteria are defined among others by the existence of a " descriptive product card ". This card recalls the legal requirements of the product, its inter-professional requirements and those specific to the factory. It presents the indicative composition, the transport and delivery guarantees, instructions for the conservation and the use of the pressed pulp.

The GMP criteria consist, among other things, of a detailed description of the production process and risk analysis. The risk analysis takes in account risks from physical, chemical and biologic origins, inventoried and put directly in relation with product quality and security, but also with its direct production environment. This risk analysis also includes control measures which the factory imposes itself and their frequency. Finally it also presents risk management procedures if danger would occur.

1.6. The use of pressed pulp in animal feed
The carbohydrates found in pressed pulp have a very high digestibility (between 87 and 90% DM), what confers to pulp a very good feed value.

On the other hand, its low protein content (10%) and its low structure requires an intake, in the ration, of a feed complement, which on one hand is rich in proteins and on the other hand is propertied of structure.

A contribution of fresh straw (long fibres) and a progressive adaptation of the feed rations (transition period of 10 days at least) are always counselled (Note 12). In the same way, it is always recommended to split up the distribution of the rations when important proportions of pressed pulp are used.

In beef breeding, the contribution of pulp should not pass 1.5 kg DM/100 kg of living weight, either 8 to 10 kg DM for an adult beef and 3.5 to 7.5 kg DM for a bull-calf.

In dairy breeding, this contribution must be limited to 3 to 5 kg DM/cow. The pressed pulp is well known for its lactogenic effect. Very numerous tests demonstrated an increase from 1 to 3 kg of milk/day/cow, according to its incorporation in the rations. The pulp, used in important quantities (6 kg DM/day/cow) also decreases the butyric rate (1 to 2 g/kg) and increases the protein rate of milk (0.5 to 3 g/kg). For cows at the end of pregnancy, it is recommended to limit the pulp consumption 3 to 4 weeks before the calving, to avoid that the excess of calcium doesn't provoke the milk fever.

The use of pressed pulp is not advised for young calves. Too big quantities will disturb the normal working of the belly, by an inflation of the pulp in the rumen.

The pressed pulp is an interesting feed for other farm animals (pigs, sheep, goats, horses,…). However, for these smaller animals or monogastrics, the quantities to use by individuals are more reduced. In these farms, the use of pressed pulp will be in function of the possibility to achieve a reduced size silo, so that the unloading speed of the silo will be sufficiently quick.

In pig breeding, pressed pulp, is used as a complement, it is suitable for sows in pregnancy as well as for heavy pigs. One can thus feed the pigs pulp at will, but no more than 4
kg/day/animal (either 1 kg DM/day/animal). Lot of experimentations demonstrated that the incorporation of pressed pulp (until 15 to 30%) in the pig ration reduced the total quantities of faeces meaningfully, but it reduced even more the quantities of the ammonium nitrogen present in the faeces.

The behaviour of the sows is also better when they are fed with the pulp. As these are quieter, following the prolonged digestion, the accidental bruising of piglets by the mother is less frequent and the litters are appreciably more important.

In sheep breeding, the distribution of pressed pulp for dairy ewes can go up to 1 or to 2 kg DM/day/ewe, but it must be complemented by a contribution of straw (0.5 kg/day), of concentrates (500 to 800 g/day) and of mineral complements and vitamins, on phosphorus basis.

It is not advised to feed pressed pulp to lambs under 2 months. Older lambs and fatting lambs can consume up to 3.5 to 4 kg/day of pressed pulp. In this case it is necessary to cover the nitrogen needs, to use a perfectly ensiled pulp and to place it in very clean feeding troughs.

In goat breeding, the pressed pulp can represent 30% of the total ingested DM. Goats can consume up to 4 kg/day, while providing a contribution of long fibres (straw), of nitrogenous matter, minerals and vitamins.

Apart from breeding, the use of pressed pulp is not generalized in horse feed. Their stomach being of reduced size (5 to 6 l), the pulp feed will be limited to 2 to 4 kg/day/animal for “heavy horses” or half-breed, without exceeding 40% of the ration of hay and straw.
2. CONSERVATION OF PRESSED PULP BY ENSILAGE

Pressed pulp is a fresh feed product, non-sterilized, delivered hot, in bulk and in relatively humid state. It is therefore a feed that is quickly alterable by outside elements (air, water, bacteria, moulds,…) and therefore perishable if some conditions are not respected to assure its conservation by ensilage.

The ensilage of pressed pulp allows a natural and spontaneous process of fermentation, the lactic fermentation, to take place within the ensiled mass. When the pressed pulp has been colonized completely by the lactic fermentation, it can be conserved for months with a minimum of losses in feeding substances, by respecting some rules of unloading.

Pulp of good quality at the delivery and correctly ensiled doesn't produce effluents or unpleasant odours.

To ensile pressed pulp in homogeneous, steady and anaerobic conditions, necessary for the development of lactic bacteria, one needs to respect the 10 following rules:

- 1. ensile pressed pulp of good quality (Note 13),
- 2. respect the dimensions of the silo (Note 14)…,
- 3. … do not surpass an ensilage of 2 meters height (Notes 15 to 18),
- 4. organize well the ensiling operations in order to work quickly (Note 19),
- 5. ensile the pulp on an adequate and clean place (Note 20),
- 6. work with strictly clean machines (Note 21),
- 7. spread and pack homogeneously and sufficiently (Notes 22 to 24),
- 8. equalize the last layer (Note 25),
- 9. close the silo correctly (Note 26),
- 10. ballast the top of the silo uniformly (Note 27).

A quality ensilage is mostly obtained in adapted facilities of the bunker silo type. Such silos have a hard floor-covering (concrete, stone,…), rigid lateral walls (concrete plates,…) or are reinforced (straw bales,…), providing conditions to get a homogeneous and sufficient compression of the whole ensiled mass (Figure 5).
Figure 5: Homogeneous pressing of each spread layer is an important element for a successfully ensilage of pressed pulp (note 22).

Figure 6: An ensilage in a plastic tube, done by contractors, offers excellent conservation conditions for pressed pulp (Note 28).

The technique of ensiling in plastic tubes, done by contractors, combines these conditions (Figure 6). It offers excellent conservation conditions for a pulp of good quality (Note 28).
Less expensive is the technique of ensiling in a clamp silo (no lateral walls), which must be done with bigger care (Figure 7), to get a homogeneous and sufficient compression of the whole ensiled mass (Note 29).

![Figure 7: Ensilage in a clamp silo must be done with bigger care, to get a homogeneous and sufficient compression of the whole ensiled mass (Note 29).](image)

To reach a sufficient preservation level, a pressed pulp silo must contain, at the opening time, different measurable values (table 2). A slight loss of the dry matter rate can be observed at this moment. It results mostly from evaporation losses of volatile compounds produced by various fermentations (Note 30).

<table>
<thead>
<tr>
<th>dry matter determined at the delivery point</th>
<th>pH</th>
<th>density (kg/m³)</th>
<th>Content in (g/kg DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.6 ± 0.2</td>
<td>&gt; 800</td>
<td>lactic acid &gt; 30</td>
</tr>
</tbody>
</table>

Table 2: Measurable values necessary to get a satisfactory conservation level in a pressed pulp silo.
To maintain the conservation conditions at the unloading time, it is necessary to watch carefully, to …

- … maintain the silo closed at least during 30 days before its use,
- … advance at least 1 m/week during the unloading, especially in summer,
- … avoid shaking the silo by a brutal unloading, that would encourage the apparition of cracks, quickly colonized by moulds,
- … fold the top tarpaulin correctly, while rolling them toward the rear of the silo and while perfectly maintaining them against the surface of the silo, by means of sufficient ballast and to avoid all introduction of air in this interstice (Figure 8),
- … evacuate water, soil and stains and eliminate (as far as possible) the mouldy pulp parts in order to prevent contamination of the surrounding area,
- … treat surfaces that might run a risk to be colonized by moulds with a diluted solution of propionic acid (1.5 l to 25% / m²) to slow down their development.

![Figure 8](image)

**Figure 8**: During unloading, the top tarpaulins must be folded correctly and need to be sufficiently ballasted to avoid all introduction of air, favourable to the development of moulds.
3. MOULDS OBSERVED DURING UNLOADING

Moulds of varied colours are sometimes observed on the surface or inside a pressed pulp silo. Mould development occurs when:

- the pulp quality has been altered at its production time by damaging conditions for its conservation (acidity and/or too elevated temperature before and/or during the diffusion process, microbial contaminations, deterioration of the pectin...) (Notes 4, 10, 17),
- the development of the lactic bacteria has been inhibited by an accidental over dosage of technological auxiliaries in the sugar factory (insufficient lactic fermentation) (Note 5),
- the dry matter content is non compliant and the quality of the pulp at the delivery is insufficient to allow a satisfactory compression (insufficient lactic fermentation) (Note 6),
- the pulp has been ensiled too cold, following a prolonged storage or following an excess of manipulations and displacements (insufficient lactic fermentation) (Note 8),
- small balls of compacted pulp, messed-up pulp or soil are found in pulp, before pressing, loading, delivery, discharge or during ensilage (contact with contaminant) (Notes 8, 20 and 21),
- the pulp content of soluble sugars after pressing is lower than 2.5% DM (insufficient lactic fermentation) (Note 10),
- the advancement speed during the unloading is insufficient (contact with air) (Note 14),
- cracks appear (contact with air) caused by pulp blocks slips (fat pulp, Notes 17 and 18) or by strong jolts at the time of unloading,
- some air pockets have been formed, caused by a heterogeneous or insufficient compression or by insufficiently airtight closing of the silo (contact with air) (Notes 22 to 26),
- some air pockets formed themselves following the condensation of the excess of water steam at the time of ensilage (hypothesis presented to the Note 26).

The place and the distribution of moulds in the silo can sometimes permit to assign the origin of it, while knowing that their presence can result from one or several of the quoted phenomena. The causes for problematic situations are therefore often complex (Figure 9). The likeliest origins are summarized in table 3, according to the place of moulds in the silo. It is necessary to note however that the moulds identification will bring few precisions concerning their origin. This type of analysis seldom reveals the origin of the possible causes. The identification of moulds can possibly determine if they present a risk for the livestock health. In this case, one must consider that the diagnosis is related only to the moulds present in the pulp sample. Since several moulds can be simultaneously present in a silo and because the identification is limited to the analysed pulp sample (in some cases only a few milligram of mouldy pulp), the only guideline to be respected is the systematic destroying of all mouldy zones. A visible, non toxic mould for cattle can co-exist together with another mould, which was not traced, but which could be toxic.

During unloading, out of precaution, an application of propionic acid (25%) can be carried out, at those places where moulds could develop themselves. Agricultural salt, applied on the top surface of the silo before closing, also limit the development of moulds in the superficial layers (Note 25).
Figure 9: Several phenomena can be at the origin of the development of moulds, encouraged by a bad conservation of the pressed pulp. In this silo we observe the following:
- sagging due to the presence of fat pulp at the bottom of the silo (too voluminous silo, height > 2 m, width > 8 m), parts which are quickly colonized by moulds (Notes 17 and 18),
- sagging which are encouraged by the slant of different layers of pulp spread in an oblique way at the bottom of the silo, at the time of ensilage (Note 22),
- a fine zone of moulds developing themselves under the surface of the silo as a result of condensation of excess water steam at the time of ensilage (Note 26).
### Place and distribution of small balls or scattered zones in the mass of the silo

- dry matter or insufficient pulp quality, or even damaged, at the delivery, not allowing a sufficient and regular compression or an optimal conservation
- lactic fermentation either blocked insufficiently (pH > 4.00; content in lactic acid <30 g/kg DM)
- pulps, too cold delivered or ensiled
- insufficient cleanliness of the loading area of the sugar factory, the trucks of delivery, the place and surroundings of the silo at the farm, of the machines (tractor, frontal shipper, boots,…) used to spread and to pack the pulp
- impurities present in the pulp (soil, compacted pulp and soiled, straw,…) too much time for the confection of the silo
- vestigial air pockets due to an insufficient or irregular compression (density < 800 kg/m³)

#### Notes

4, 5, 6, 10, 13, 17, 23, 24

5, 10, 23, 24

19

22

### Likely origins

- too much time for the confection of the silo
- insufficient cleanliness of the loading area of the sugar factory, the trucks of delivery, the place and surroundings of the silo at the farm, of the machines (tractor, frontal shipper, boots,…) used to spread and to pack the pulp
- impurities present in the pulp (soil, compacted pulp and soiled, straw,…) too much time for the confection of the silo
- vestigial air pockets due to an insufficient or irregular compression (density < 800 kg/m³)

#### Notes

4, 5, 6, 10, 13, 17, 23, 24

5, 10, 23, 24

19

22

### at the progression front in general

- insufficient progression speed
- too elevated temperature and humidity at the level of the progression front

#### Notes

14

14

### solely just under the tarpaulin

- insufficient progression speed
- irregular surface on top of the silo
- holes and rips in the tarpaulins, infiltration of water,
- air infiltration under the tarpaulin because it was insufficiently aggravated after opening
- insufficient or irregular ballast (tires,…) permitting the formation of air pockets under the tarpaulin

#### Notes

14

14

14

22

25

26

27

### at the top layer in general

- insufficient progression speed
- insufficient or irregular compression of the last layers (frequent in clamp silos)
- rehydration of the top layer by heavy rains, in the absence of fast closing of the silo

#### Notes

22, 25, 29

26

### on the sides, at the top corners, along the walls

- air pockets due to an insufficient or irregular compression (density < 800 kg/m³)
- irregular surface at the top of the silo
- holes and rips in the tarpaulins, infiltration of water,
- insufficient or irregular ballast (tires,…) permitting the formation of air pockets under the tarpaulin

#### Notes

22

26

26

26

27

### as a fine zone, situated 20-30 cm under the surface of the silo

- insufficient progression speed
- condensation of water steam still present in the pulp at the time of the closing of the silo

#### Notes

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### in cracks situated at the front of the progression front

- insufficient progression speed
- insufficient or irregular compression (density < 800 kg/m³)
- silo prepared by skipping one loading against the other and while packing all summarily with a machine equipped with a frontal shovel and without spreading the pulp
- fat pulp presence at the bottom of the silo, causing slips of pulp blocks,
- too brutal unloading, provoking some cracks

#### Notes

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17, 18, 22

### in cracks situated behind the progression front with slips of pulp blocks

- insufficient progression speed
- fat pulp presence at the bottom of the silo, causing slips of pulp blocks,
- insufficient progression speed
- too voluminous silo (height > 2 m and width > 8 m)
- too slow cooling of the silo (< 1°C/day)
- fat pulp presence at the bottom of the silo, causing slips of pulp blocks,
- local warming-up of the silo following secondary fermentations
- pulpsilo prepared too quickly on / under a maize silo
- silo prepared by skipping one loading against the other and while packing all summarily with a machine equipped with a frontal shovel and without spreading the pulp

#### Notes

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16, 17

17, 18, 22

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17, 18

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### in contact zones with a forage ensiled in the same silo

- rehydration of the contact zone between the two food and contamination coming from this other forage
- the progression speed is a major element in the development of moulds. Try to respect the dimensions of your silo according to the quantities of pulp that you will use (Note 14)
- the yellowish coloured pulp formation, fat to touch and apparently similar to wet pulp, generally situated at the bottom of the silo, is not provoked by moulds, but by bad ensilage conditions (Notes 15 to 17)

#### Notes

25, 26, 29

### Table 3: Most probable origin for mould development according to their place in a pressed pulp silo.
3.1. Identification of moulds

A limited number of moulds are found in pressed and ensiled pulp (Figure 10). These are mainly aerobes species (Cladosporium, Epicoccum,...) or tolerant to the anaerobia (Aspergillus, Byssochlamys, Geotrichum, Monascus, Neurospora, Mucor, Penicillium, Trichoderma,...). Some species (Aspergillus, Byssochlamys, Penicillium,...) can produce mycotoxins, dangerous for the cattle. Even in the absence of mycotoxins, the ingestion of too big quantities of moulds can disrupt the good working of the rumen. A too big dysfunction of the rumen flora can sometimes be fatal for the livestock.

![Moulds](image)

Figure 10: Moulds of varied colour are sometimes observed on the surface or inside a silo of pressed pulp. The most frequent are: a) Penicillium sp. b) Aspergillus sp. c) Monascus sp. d) Neurospora sp.

However, some rumen dysfunctions (acidosis, enterotoxémie,...) are not always due to the presence of moulds (Note 12). Some butyric bacteria can also be at the origin of badly kept ensilage. These ensilages have a too elevated content in butyric acid (> 2 g/kg MS) and are less well appreciated by livestock (Note 17).
3.1.1. *Penicillium* sp.
These moulds (*P. roqueforti*) are very frequently present in and on the surface of deficient silos. They look like a coloration of a clear aquamarine and greenish dust (Figure 10a.). These species are tolerant to a reduced anaerobia. Different species can produce different mycotoxins (penicillic acid, patulin, roquefortin, fumiclavain, ochratoxin…), in laboratory conditions or by strong contaminations. In too high doses, these mycotoxins are associated with restless behaviour and provoke sometimes abortions among livestock. These moulds are often present in grass and maize silages, where the risk of mycotoxin production is almost impossible (according to the present literature).

3.1.2. *Aspergillus* sp.
These moulds (*A. flavus, A. fumigatus, A. glaucus*) are frequently present in and to the surface of deficient silos. They look like a coloration of a slightly darker aquamarine and greenish dust (Figure 10b.) comparable to *Penicillium*. These species are tolerant to the anaerobia. Different species produce different mycotoxins (aflatoxins, ochratoxin, fumitoxin,…) which are associated with restless behaviour, abortions and irregular breathing among livestock. By the mycotoxins that they produce (aflatoxins, ochratoxin,…), these moulds, also present in other ensiled forages, are especially harmful for the livestock. These moulds can only be distinguished from *Penicillium* by a microscopic examination.

3.1.3. *Monascus* sp.
These moulds (*M. ruber, M. purpureus*) are frequently present in pressed pulp. The pulp then shows a characteristic, bright red colour (Figure 10c.). These moulds are not toxic and would even stimulate the appetite in a small degree. *Monascus* is sometimes used as a pigment in the food industry.

3.1.4. *Neurospora* sp.
This mould (*N. sitophila*) is frequently present in pressed pulp. *Neurospora* sp. produces a very colourful mould, differing from yellow ochre to ochreous - orangey (Figure 10d.). They are not dangerous for livestock.

3.1.5 *Byssochlamys nivea*
This mould is sometimes present in pressed pulp. It produces a rather dense, white felting. When present in large quantities, it can produce a mycotoxin (patulin) which can cause a dysfunction of the rumen flora. This mycotoxin is normally not sufficiently present in contaminated silos to affect livestock seriously.

3.1.6 *Trichoderma* sp
It is an occasional mould, of a bright white colour. Some species can produce some mycotoxins in laboratory conditions, but they are not considered dangerous in silos.

3.1.7 *Geotrichums candidum*
*Geotrichum* candidum is a yeast (and no a mould) which frequently develops on ensiled pulp and forms a white powder. It has a bitter taste and spreads a rancid odour. The contaminated pulp is less tasty and will sometimes be refused by the cattle.
3.1.8 Other moulds
The species Absidia, Acremonium, Alternaria, Cladosporium, Epicoccum and Mucor are less frequent and without particular effect on livestock.

3.1.9 Fusarium sp.
A group of particularly dangerous moulds (Fusarium sp.) can be isolated in the mixed ensilages of maize and pulp, but very rarely in silos of pressed pulp only. This mould consists of numerous species (F. culmorum, F. oxysporum, F. moniliforme, F. cerealis,...) that are very often present in maize and grass silos. They are field originating moulds which are very characteristic in cereal crops. In these crops they are often present at the harvest. They produce many mycotoxins which can be retrieved in the silos. These mycotoxins (vomitoxin, zearalenon...) are very detrimental for the cattle. They can be retrieved sometimes in very high concentrations (> 10,000 ppb for the vomitoxin (déoxynivalénol - DON); > 3,000 ppb for the zearalenon - ZEA) in contaminated maize silos.

Pigs are in general very sensitive for mycotoxins. They refuse feed that is contaminated with vomitoxin as from a value of 1,000 ppb. Abortions are observed among sows with feed of which the content in zearalenon is of 50 ppb.
The Fusarium sp. Mould type are not observed in silos where only sugar beet pulp has been ensiled.

3.1.10. Butyric bacteria
Butyric bacteria belong mainly to the Clostridium group,… They are present in the soil, in organic matter in decomposition, etc…

Their development in pulp takes place, in absence of air, by temperatures included between 10 and 50°C and with a pH between 4.6 and 5.5. The pulp production process at the sugar factory reduces very strongly the natural contamination in butyric spores (less than 10² spores/g DM).

Storage conditions, transport, ensilage and unloading of the pulp, cleanliness of the stables influence the butyric spore content. A too important presence in food or in the immediate environment of the dairy livestock can drag overtaking of thresholds in butyric spores in milk.

Pulp deliveries intended to be ensiled must be ensiled directly.

In a pulp silo air is the ally of moulds;
one must put everything in work to avoid it's presence in the silo.

To the eye, it is impossible to discern if a mould is harmful for livestock.

The order is to eliminate all zones of mouldy pulp systematically.

It is an absolute rule, never to feed any cattle with mouldy pulp.

The most fragile animals (bull-calves, store stock, young calves and pregnancy cows) are the most sensitive ones. For them, mouldy feed can be fatal.
Note 01 Sugar beet pressed pulp and animal production

In Belgium, sugar beet pulp belongs to the beet growers. If one considers that 1 ha of sugar beet produces more than 65 t of roots, it means that, simultaneously with the production of raw sugar (> 10 t/ha), the beet grower produces, on the same area and without direct supplementary costs, a high quality cattle forage. Indeed, 1 hectare of sugar beet also produces more than 33 t of wet pulp (> 10% DM), or more than 13.5 t of pressed pulp (22% DM) or more than 3.3 t of dried pulp (± 90% DM). When a beet grower uses the pulp of sugar beet to feed his livestock, his beet area also allows him to produce, according to his type of livestock, more than 10,000 litres of milk or more than 900 kg of meat per hectare.

The first valorisation tests of pressed pulp by ensilage were done in 1977 by the sugar factories, in collaboration with the IRBAB/KBIVB and other research institutions. The development of pressed pulp was accompanied by the reduction of the quantities of pulp to dry, and therefore with the energy costs reduction in drying plants.

Belgium produces currently more than 240,000 t of wet pulp, more than 1,200,000 t of pressed pulp and more than 35,000 t of dried pulp, either a total of about 330,000 t of dry matter of pulp per year. The present tendency is to increase the part produced under the form of pressed pulp. Almost all the pulp is valorised at the exploitations having beef livestock and which are generally situated in the sugar beet crop area, or nearby.

Note 02 Conservation of the pulp at the farm

In cattle feeding, pressed pulp can be used immediately and without particular conservation measures (homogeneous compression, elimination of air, covering, etc.), but its conservation time "fresh" or "in the open air" is then relatively short (2 to 3 days, but hardly more then 4 to 5 days, according to the outside temperature). After this period the pulp stored "outdoors" becomes very rapidly colonised by detrimental fermentations and moulds. In this case it can no longer be used as livestock feed.

On the other hand, the ensilage technique at the farm, if correctly applied, creates conditions necessary to the natural and spontaneous lactic fermentation process. This fermentation only takes place in absence of air (anaerobic conditions), and by sufficiently compressing the pulp. The lactic fermentation, completely achieved throughout the total mass of the silo, entails an acidification of the pulp. This acidification will allow the pulp to keep its feeding qualities, with minimum losses (of substances). A complete lactic fermentation, without air infiltration, prevents the development of moulds which can arise within the silo.

Note 03 Alternative use of the sugar beet pulp

In some European countries, sugar beet pulp is an interesting source for dietary fibres for human nutrition or for pet feed.

In non-food sector, sugar beet pulp can be used as a fermentation substrate or serves the industrial methane production, as primary fuel or as element absorbing heavy metals and other pollutants in water purification stations. It is also used as alternative component for paper pulp, for the confection of composite isolating panels, of acoustic screens or cellular concretes. It can also act as absorbing element in disposable diapers for babies or in litters for pets. The use of pulp as substrate for the industrial fermentation by bacteria or fungi permits the production of various natural molecules: enzymes, proteins, sugars, until natural aromas of vanilla, etc. The pulp hydrolysis provides numerous molecules for industrial use. Galacturonic acid and its polymers, derived from pectin of the sugar beet pulp, are used for the manufacture of detergents or ecological surfactants. A derivative of its fermentation, the lactic acid, can act as element for the production of entirely biodegradable plastics.

Note 04 Diffusion in the sugar factory

The diffusion of sugar out of the cossettes is an essential step for the sugar factory. It must be done from perfectly washed sugar beets. It must be mastered permanently to assure stability and optimal regularity and free from all inopportunite microbiological infections. This step takes from 45 minutes to 2 hours, according to the diffusion type (horizontal or vertical). During this stage, and according to the diffusion type, the temperature of the water in contact with the cossettes is of about 65° to 70°C and with a maximum of 75°C. Higher temperatures (70 to 75°C) permit to limit the thermophile bacterial
infections in the diffusion. At the exit of the presses, the pulp temperature decreases to 60°C. According to the configuration of the factory, the cossettes can be preheated a short time (pre scalding) in the extraction juice, with as purpose to alter somewhat more the structure of the cell membranes. This change facilitates a much better diffusion of sugar out of the sugar beet cells. The scalding himself happens via juice/cossettes exchangers that brings the temperature of the cossettes to a temperature equivalent to that one at the entry in diffusion, either via more important heating (85°C or more), but that deteriorates the cell membranes much more. Too high temperatures, too acidic pH (pH <5.0), irregular debits or accidentally prolonged stays at these stages (heating, diffusion) harm the working order of the sugar factory and the pulp quality. According to these cases, too big quantities of pectin fragments (constituent of the sugar beet cell wall, Figure 11) and other cellular colloids are made free in the extraction juice, what disrupts the ulterior steps in the sugar factory. The sugar beet pulp quality will be much more weakened, to the level of its pectin, by too prolonged stays and/or by too high temperatures and by too acidic levels of pH during these processing operations (Notes 10 & 17).

Figure 11: Pectin is an element that contributes to the cell wall rigidity. It corresponds to a network of flexible fibres that are interlaced in a network of more rigid fibres of cellulose and hemicellulose which constitute the cell wall.

Note 05 Controlling infections in diffusion
Technological auxiliaries (antifoam products, pH regulators, dispersing products, disinfectants), registered for the food industry, are used during the diffusion to control the development of microbiological infections in the raw juice. Indeed, the high diffusion temperatures of the thermophile bacteria of the Bacillus group (B. stearothermophilus, B. subtilis, B. pumilus, B. cereus…) or of the Clostridium group (especially Cl. thermosaccharolyticum and Cl. thermohydrosulfuricum) present in the dirt soil of the sugar beets, or present in the washing water, in the press waters or in the extra water, can develop themselves in an inopportune way in the sugary and hot juice. Then these bacteria produce lactic acid or other organic acids in excess (butyric acid, etc…) from the sucrose. By the losses in sugar that they cause, these infections harm the sugar factory process.
By the standard doses of use (10 to 30 g/t of sugar beet according to the used technological auxiliary), these disinfectants don't limit the lactic bacterial inoculum drastically, thereafter necessary to the lactic fermentation of the ensiled pulp.
Other processes, such as cleaning of the devices with a hot high pressure steam (> 75°C), the sterilization of the press waters by pasteurization to 90°C, the supplying debit in cossettes, the diffusion temperature (<75°C), the time of scalding, the pH stabilization (between 5.5 and 6.0),… also permit to limit the development of particularly undesirable infections in the diffusion.
Note 06 Pressing of the pulp
To facilitate the pressing of the exhausted cossettes (= pulp), most factories use an pressing adjuvant. Gypsum (under natural form or in a reconstituted and purified form of calcium sulphate, according to the food quality rules) is the main auxiliary used in Belgium. This auxiliary reinforces the pulp fibres (by linking the pectin components of the cell membranes mutually with calcium ions). This is destined to facilitate the evacuation of water out of the cossettes, at the time of the pressing, which reduces the energy consumption at this stage. To the standard doses of use (200 to 800 g/t of sugar beet), the calcium sulphate doesn't have any effect on the fermentation, nor on the quality of the pressed pulp. The calcium chloride of aluminium sulphate is sometimes used as a pressing adjuvant in other countries. They are not used in Belgium. Some sugar factories in Belgium don't use any pressing auxiliary.
A too strong deterioration of the cell membrane structure of the cossettes (= pectin deterioration) during the diffusion, or obsolete press devices increase the difficulties of water elimination during pressing. This can lead to an exuberant use of gypsum. The excess of calcium, besides its repercussion on the increase of the mineral matter content in the pulp, can also have, by a buffer impact, a slightly unfavourable effect on the beginning of the lactic fermentation. Too much calcium would also indirectly promote undesirable butter acid fermentations.
On the other hand, a too strong pressing of the pulp (> 25 to 30% of DM) can reduce its content in sugar and compromise its faculty to ferment if this one becomes too weak (< 2.5% DM) (Note 10). The organic acids and the lactic acid in particular, produced between some limits by the bacterial activity in diffusion, permit an easier pressing of the pulp. The control of these infections is essential because a too elevated acidity in diffusion could exceed an alteration threshold of the pulp.

Note 07 Pressed pulp and bacterial inoculum
Currently in Belgium, no complementary supply of substances rich in soluble sugars (molasses, sugar beet fragments, ...) and therefore favourable to a faster development of the lactic fermentation of the ensiled pulp, are used in the sugar factories. The use of bacterial inoculums (as proposed for the grass or maize silages) doesn't appear justified for the pressed pulp ensilage. The quantity of even present soluble sugars in the pulp (4 to 6% DM) and the lactic bacteria (minimum $10^2$ to $10^3$ unit/g at the press exit time) are sufficient, in normal production and ensilage conditions, to initiate the lactic fermentation (Note 10). In the same order, the use of ensilage products of the "conservator" type doesn't bring a noticeable improvement to the conservation level of the pressed pulp.

Note 08 Storage of the pressed pulp at the sugar factory
As in a vinegar factory or in a brewery, the atmosphere reigning in a sugar factory is spontaneously enriched with bacteria specific to the process. In the sugar factories, the specific production facilities of the pulp become spontaneously richer in mesophile lactic bacteria (Lactobacillus sp.) present in the air or in the dirt soil delivered with the sugar beets. These bacteria are (still) present in the pulp, after the diffusion step.
At the press exit and in normal and steady production conditions, the pressed pulp presents a temperature between 55 and 60°C, a pH > 5.0, a sugar content of 4 to 6% DM, a low content in lactic acid (<5 g/kg DM) and a density of about 400 kg/m³. These parameters evolve during the storage in the pulp yard and during the delivery, following the cooling (storage to the open air) and the starting of the lactic fermentation (inside the stored heap).
According to the type of storage and evacuation of the pulp after the presses (waiting hopper, pitching of the pulp with or without projection, storage in the pulp yard in one or several waiting heaps, Figure 4), according to the storage delay at the factory and the transport time, one can observe a decrease of the temperature (5 to 10°C at least), a decrease of the pH (from 0.5 to 1 point) and a decrease of the sugar content (± 1 point, either until more of the half of the sugar content if this one is close to the minimum of 2.5% DM at the production!). A decrease of the pH of 0.5 to 1 point (due to a slight increase of the lactic acid content) can be measured in the pulp stored during ± 12 hours in the yard of the factory. It is therefore recommended to limit the manipulation steps of the pressed pulp heaps after its exit of the presses and to deliver it quickly, so the lactic fermentation that started during the first hours of storage in the factory is not disrupted. Unnecessary displacements or transport of the pulp
from one place to another, before its ensilage, must be avoided, to prevent that the pulp cools down to
below 45°C (optimum temperature for lactic acid fermentation) and to interrupt, by repeated
placements, the development of the lactic fermentation.
It is recommended to look after the cleanliness of the pulp circuit, from the diffusion exit and its
arrival at the loading area (or in the loading hoppers). The infrastructures of the pulp presses, of the
transport belts, the recesses and the zones for concentration or stuffing will be ridded regularly of
accumulated pulp. This pulp, altered and quickly colonized by moulds or by mesophile bacteria (in
particular those of the Leuconostoc type that produce heaps of gluey substances) won't be on no
account mixed or evacuated with the pressed pulp. The storage area will regularly be emptied, cleaned,
or even disinfected (Figure 3).
This is also applicable for pulp produced during periods with irregularities or discontinuances during
the diffusion (Note 17) and whose having a doubtful quality can’t be mixed or evacuated with the
pressed pulp.

Note 09 Marc content of the sugar beets
The marc content is an element that is taken in account (in Belgium) to establish the amount of pulp
restored to the beet growers according to the amount of delivered sugar beets.
Indeed, the marc content corresponds to the content in components of the sugar beet that subsists after
complete extraction by the water of all soluble constituents, according to the sugar process and
according to the temperature conditions, the pH, the addition of calcium sulphate, the quality of used
waters, the extraction duration, etc. In brief, it corresponds to the insoluble non sugars content of the
sugar beet. It permits to establish the quantity of pulp produced by a sugar factory.
The marc content varies mainly according to the place and the variety, more than according to the
year. These variations can be of 20%, included generally between 47 and 53 kg DM/t.
The marc content decreases during the growing season, and according to the increase of the sugar
content. It also decreases according to the water supply and, to a smaller degree, according to the
increase of the nitrogen fertilisation. The sugar beet varieties with a high sugar content and having a
few more vascular rings (cambium), have a a little higher marc content than the heavy varieties.
In fact, the marc content corresponds to the proportion of present cells and cell walls in the sugar beet
(function of the number of cambium rings) that have been formed during the first phase of the growth
(until the beginning of summer). It therefore depends on the quality of the content in cell wall
elements, which means in cellulose, hemicellulose and pectin, as recovered after the sugar process.
The size of the cells also intervenes. Sugar beets with small cells will have a more elevated marc and
sucrose content. The most voluminous cells will contain more water and have therefore finer walls.
One finds here again the importance (of the fragility) of the pectin of the cell wall and their
subsistence through the sugar process. Indeed, the cellulose and the hemicellulose are water insoluble,
the pectin is soluble according to its deterioration degree (Notes 4 & 17).
The sugar beet breeders agree that the composition of the polysaccharides of the cell walls (constituent
of the marc) of the new sugar beet varieties has evolved, among others, regarding the level of the
pectin and its consistence and therefore the level of its rigidity. In the same order of ideas, sugar
factory engineers observe differences in fragility and breaking of root tips, during washing at the
factory, according to the years and the regions.

Note 10 Sugar content and quality of the pressed pulp
The pressed pulp produced in Belgium has a total sugar content between 4 and 6% DM, according to
the factories and the diffusion process. The minimal guaranteed content is 2.5% DM. The soluble
sugars, mainly sucrose, are transformed in subunits of glucose and fructose by the lactic fermentation.
Next, the lactic fermentation transforms glucose into lactic acid, that will assure the conservation of
the ensiled pulp.
A sugar content less than 2.5% doesn't allow the lactic fermentation to take place in optimal conditions
anymore. It will allow other fermentations or moulds to develop themselves in the ensiled pulp.
The observations done in other countries show that a content in soluble sugars higher than 5% DM is
not indispensable, because the excess sugar at this level is not transformed in lactic acid. It will be
retrieved when loading.
Many countries practice the adding of molasses to the pressed pulp (addition of 2 to 3% of molasses) to guarantee the optimal threshold of 5% of fermentable sugars. Thanks to such a sugar level, the lactic fermentation perfectly achieves itself quickly throughout the totality of the silo. It limits the competitive development of other ominous fermentations very strongly (butyric and/or pectinolytic fermentations made by the Clostridium type bacteria).

Adding molasses to pressed pulp increases its conservation faculty. It reduces the cost of pressing proportionally while contributing to the obtaining of the final wanted dry matter. It is practiced in countries where the outlets of the sugar beet molasses are more uncertain.

Among the production conditions, ominous to the quality of the pressed pulp, one can mention:
- a too low content in fermentable soluble sugars (excessive weariness or prolonged stop during diffusion),
- a too low presence of lactic bacteria before ensilage (accidental sterilization) (Note 5),
- a too important presence of non lactic bacteria, or of other spores (yeasts, moulds,…). At the infection time, irregularities or prolonged stops during diffusion, these micro organisms produces inverted sugars (sucrose degraded in glucose and fructose) and pectinolytic enzymes (pectate lyase, polygalacturonase) and organic acids (acetic, butyric, lactic acids etc.). The production of this acids decrease the pH during diffusion and before delivery. These enzymes and these organic acids damage much more the pectin of the pulp that they are present (acid hydrolysis) and that the temperature is high.
- a weakening of the pectin of the cell wall (prolonged stop during diffusion, too high scalding of the cossettes, irregular debit in cossettes, etc.) that alters its structure (thermal deterioration) and encourages the “fat” pulp formation (Note 17).

According to their importance’s, these conditions can affect the pulp quality and therefore its capacity to be ensiled correctly and stored at the farm. According to the importance of the deterioration, this pulp will rather be used in direct feeding or evacuated rather than destiny to ensilage. These accidental conditions in diffusion (bacterial infections, prolonged stops, breakdowns, etc.) are translated directly, to the level of the factory, by a loss of sugar production.

**Note 11 Legislation relative to the contaminants present in the pulp**

Legally, sugar beet pulp cannot contain any undesirable substances such as residues of defined pesticides¹, residues of some heavy metals² and other noxious elements, like organic micro pollutants and mycotoxins³. These undesirable substances and their value limits are defined by various European Rules and other Belgian Royal or Ministerial Decrees.

Many foreign bodies, of various nature (fragments of little stones, stones, bricks, wood, glass, plastic, metal, cans,…) are found sometimes in the loadings of sugar beets. In spite of the care of the sugar factories at the washing stage, some of these (pieces of plastics, of cans,…) cannot be eliminated systematically. They pass therefore through the beet slicer. Of reduced size, these foreign bodies can be even present in the pulp, in spite of the vigilance of the sugar factories before and after the beet slicing step. It is therefore the duty of the beet growers to stay up especially, at the time of the loading of his sugar beets, to eliminate these foreign bodies and in particular those that could be recovered in the pulp.

**Note 12 Pressed pulp and dietary disorders of the cattle**

Cases of dietary poisoning among cattle (acidosis, enterotoxemie) are often the result of the use of very energizing rations, i.e. very fermentable rations, or are the result of a too brutal change of the feed rations. The young dairy cows, young bull-calves and young calves which are grass-fed too quickly, are sensitive to this phenomenon.

Sugar beet pulp is a feed, which by its high content in easily fermentable carbohydrates strongly stimulates the bacterial activity of the rumen. It will be therefore necessary to carefully integrate it correctly in the livestock compliant feed.

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¹ The pesticides in question (aldrin, dieldrin, camphechlor, endosulfan, lindan,…) are not registered anymore in Belgium
² arsenic, lead, mercury, cadmium, fluorine
³ aflatoxins
The acidosis among dairy cow appears by a set of symptoms: reduction of the consumption; more liquid dung’s; decrease of the dairy production and the milk fat matter content; higher sensitivity to infections; mammitis; faltering fertility…. It is often provoked by an abrupt change of the feeding in the first week of lactation and by rations too rich in energy (too many sugars and starch) and not containing enough structured cellulose.

The cows in first lactation are the most exposed, because their consumption of feed is lower than the older cows. With the primipares, it will be necessary to be careful to assure a smooth transition (3 to 4 weeks) between the given rations before and after calving. The biggest mistake is the urge to compensate a lack of structured cellulose and a surplus in carbohydrates by buffer substances (such as bicarbonates), because the microbial function of the belly is not re-equilibrated.

Enterotoxemie of livestock is also linked to stress and to an abrupt change of the ration. It generates a disbacteriosis to the level of the rumen flora. Some bacteria of the Bacillus types and especially Clostridium, naturally present in limited quantities in the rumen, can, in serious cases, quickly proliferate to a production of toxins, responsible for digestive unrests, or even cardiac trouble. In case of enterotoxemie, one of these bacteria, Clostridium perfringens, sometimes quickly develops himself when the animal dies, or in the hours following his death.

Enterotoxemie expresses itself, in the initial stage, by a distending and an inflation of the stomach. In the absence of straw in the ration, it can sometimes proceed fast or it can even be fatal for the animal in less than one day. Enterotoxemie can also occur when one gives rotting pulp or too brutally changes into the use of pulp of doubtful quality, without complement of fresh straw.

Some fresh straw must always be placed at disposal of livestock. Ideally, it must be placed in racks placed at a certain height and must frequently be replaced (every 2 days), so that it doesn't take the odours of the stall. It is necessary to insure that livestock doesn't abandon straw and stay up in this case to give the palatable feed (pulp and flours, protein complements) after straw and no before. A bull-calf must swallow at least 1 to 2 long fibre kg/day (straw or hay). A cow in beginning of lactation must also receive some, at least 0.5 kg/day.

Rot pulp (badly fermented or badly kept, Note 17) will be refused generally by livestock. It won't be able to be given ever to the young growing livestock or in finishing, nor to the pregnant cows, nor to the young calves. Mouldy pulp will never be used in livestock feed.

A refusal of the animal to nourish itself with the pressed pulp apparently correct can sometimes be bound to a content abnormally raised in calcium, that modifies the osmotic pressure of the rumen. A too high content in sulphur is also an element of refusal. This one cannot pass the threshold of 3 g/kg DM at the risk of dragging a decrease of appetite and the assimilation blockages, in particular for the Cu and the Zn. Expressed in sulphates ions, the content cannot pass 10 g/kg of DM. Based on the natural presence of sulphur in the pulp and while supposing a maximum fixation rate (30%), the sulphuric acid addition (diffusion auxiliary in sugar factory permitting a light acidification of this one) will be limited to 1,300 g/t of sugar beet. The used sulphuric acid dose in the sugar factories in Belgium is of about 200 g/t of sugar beets. Sulphur dioxide (SO2 - acrid odour gas), abandoned by most sugar factories in Belgium, was used at the rate of 150 to 350 g/t of sugar beet. In presence of SO2, some thermophile bacterial infections (Clostridium thermohydrosulfuricum) present in the diffusion, can produce sulphurous hydrogen (H2S), compound rather sickening, even to very low concentration.

Note 13 Ensilie a pressed pulp of good quality

The sugar factories are careful to produce a pulp having a dry matter content of 22%. Besides, many attention points are controlled all along the sugar process to produce, in a regular way, a quality pulp (Notes 4 to 11).

The dry matter content is an important element in the success of an ensilage. A too low dry matter can disrupt the operations of ensilage while making the spreading and compression operations more difficult. It is the case when these are made with a vehicle that rolls on the silo (tractor with twin wheels,…). A too much high dry matter content (too important pressing of the pulp) can decrease the soluble sugars quantity necessary to the lactic fermentation (Note 6). In some cases it can also disrupt the ensilage operations according to the vehicle used and the wheels.
Note 14 Respect the dimensions of the silo

At the opening and in order to avoid the development of moulds and other ominous micro-organisms (bacteria, yeasts,...) on the front of progression, a pressed pulp silo must advance at least 1 m/week, especially in summer. The dimensions of a silo will be therefore in function of the quantity of pulp consumed per week, while being careful not to exceed a certain silo volume (Note 15) to permit an ideal cooling of the ensiled mass. It will always be more interesting and more comfortable to achieve several silos of common size rather than only one silo of too big dimensions and of which the cooling and the conservation won't be optimal (Note 16).

Knowing the pulp quantity consumed per week (in function of the livestock, of the quantity consumed by the animals per day and the number of animals) (table 4), one can establish the optimal dimensions of a silo easily (table 5). Table 4 is established for a compression density of 850 kg/m³ of the pulp and a width corresponding to a multiple of 1.80 m (middle width of the unloading equipment). If the unloading takes place in self-service, one will be careful not to exceed 1.80 m of height and to foresee a progression of 25 cm per individual big beef.

### Table 4: Quantity of pulp used per week according to the quantity consumed by animal/by day and the livestock.

<table>
<thead>
<tr>
<th>Number of animals</th>
<th>kg consumed pulp by animal and by day tons/week</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
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</thead>
<tbody>
<tr>
<td>10</td>
<td></td>
<td>0.7</td>
<td>1.4</td>
<td>2.1</td>
<td>2.8</td>
</tr>
<tr>
<td>20</td>
<td></td>
<td>1.4</td>
<td>2.8</td>
<td>4.2</td>
<td>5.6</td>
</tr>
<tr>
<td>30</td>
<td></td>
<td>2.1</td>
<td>4.2</td>
<td>6.3</td>
<td>8.4</td>
</tr>
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<td></td>
<td>4.2</td>
<td>8.4</td>
<td>12.6</td>
<td>16.8</td>
</tr>
<tr>
<td>70</td>
<td></td>
<td>4.9</td>
<td>9.8</td>
<td>14.7</td>
<td>19.6</td>
</tr>
<tr>
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<td></td>
<td>5.6</td>
<td>11.2</td>
<td>16.8</td>
<td>22.4</td>
</tr>
<tr>
<td>90</td>
<td></td>
<td>6.3</td>
<td>12.6</td>
<td>18.9</td>
<td>25.2</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>7.0</td>
<td>14.0</td>
<td>21.0</td>
<td>28.0</td>
</tr>
</tbody>
</table>

### Table 5: Minimum quantity of pulp to unload per week according to the height and the width of the silo.

<table>
<thead>
<tr>
<th>Width in meters</th>
<th>height in meters</th>
<th>1</th>
<th>1.5</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.6</td>
<td></td>
<td>3.1</td>
<td>4.6</td>
<td>6.1</td>
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<td></td>
<td>7.6</td>
<td>11.5</td>
<td>15.3</td>
</tr>
</tbody>
</table>

Example: An herd of 50 beef having an individual ration of 30 kg pressed pulp/day will consume 10.5 t/week (table 4). The dimensions of the silo (table 5) that correspond to a quantity under 10.5 t/week can be used, as for example a height of 2 m and a width of 5.4 m.

**NB:** For more important herd., it is obvious that it will be necessary to foresee several pressed pulp silos
Note 15 Do not ensilage over a height of 2 m...

Pressed pulp is 3 to 5 times less rich in soluble sugars than maize or grass. On the other hand, delivered in 24 hours following the press exit, it is still sufficiently hot (> 45°C) and contains germs of lactic bacteria coming spontaneous from the washing of the sugar beets and from the diffusion. These germs correspond to mesophile lactic bacteria (Lactobacillus sp.) that survived the high diffusion temperatures.

The pulp being delivered hot, these bacteria (p. ex., L. delbruckii that has an optimum of development between 45 and 50°C) will be the first to increase and to colonize the whole silo quickly, as far as all conditions of ensilage are founded and that these bacteria are not in competition with other microorganisms. One will be careful therefore not to manipulate and not to displace the pulp uselessly before its ensilage, nor cooling in a too important way.

A temperature fall is observed of approximately 5 to 10°C at the time of the correct confection of a silo (regular spread of the pulp by successive layers). Afterwards the temperature decreases more slowly, but regularly, with in theory approximately 1°C per day.

In other words, the temperature must be at least 45°C during the first days after the ensilage, promoting the pulp colonisation by lactic bacteria. Afterwards the temperature must decrease and after 2 to 3 weeks it has to be approximately equal to the ambient temperature. This cooling is necessary to avoid an ulterior deterioration of the pulp structure (thermal deterioration) resulting of a too prolonged stay in a too hot environment (Notes 16 to 18).

A silo that doesn't exceed a height of 2 m and a width of 8 m permits a regular cooling of the ensiled pulp (Figure 12.).

Figure 12: Pulp cooling in a correct height silo (<2 m). After 2 weeks, the temperature in the centre of the silo (at 1 m height) becomes inferior to 30°C. The stippled line in red corresponds to the theoretical cooling (1°C/day).

Note 16... to assure a regular cooling of the silo...

Figure 12 illustrates the regular cooling of a pulp silo of reduced size (<250 t) and height <2 m. The temperatures inside the silo have been recorded during the first three weeks that followed its confection. One observes that the temperatures (recorded at 3 places in the centre of the silo and at 1 m of height) cool quickly. A light increase of the temperature (± 5°C, release of heat, produced by the lactic fermentation or by other enzymatic aerobe fermentations) is observed during the first days. After 3 weeks, the initial temperature (± 40°C) cooled correctly, but is still over 25°C. The evolution of the
cooling is close to the stippled red line, which corresponds to the theoretical cooling (1°C/day). The fact that this silo and these measurements have been done during a period of wintry temperatures (included between 0 and 10°C) is not determining; this temperature reduction is similar in comparable silos, achieved in fall.

**Note 17... and to limit the apparition of "fat pulp"...**

A phenomenon similar to a "slow cooking" of the pulp can be observed when the temperature of the ensiled pulp remained too long (> 3 weeks) too hot (> 45°C). These conditions are favourable to the apparition of sticky and yellowish pulp zones, named "fat pulp". This pulp is often met in the lower layers of the silos (several tens centimetres, or even more than one meter!), when they are too high or placed above a maize silo, ensiled the same day (Figure 14). This pulp is wrongfully considered as wet pulp. When touching this pulp, it looks like wet pulp, but its dry matter content is close to the one measured at the delivery time. Exposed to air, the yellowish coloration disappears quickly.

This "fat pulp" presents in facts a deficient structure and a deficient mechanical resistance because the cell walls have been damaged to the level of their pectin constituent. This deterioration is in this case of thermal origin (the thermal degradation of the pectin results from a reaction of β-elimination of the chemical links that joins the subunits of the galacturonic acid chains that form the smooth zones of the pectin). This deterioration is much more favoured by the pulp pH which in the meantime has become more acid. It can also result from the activity of yeasts and pectinolytic bacteria (Bacillus megaterium, Clostridium acetobutylicum,…), which can develop themselves in the pulp if the conditions are favourable. These bacteria damage the hemicellulose and the pectin, by an enzymatic hydrolysis (where the enzymes of hemicellulase, pectate lyase and polygalacturonase type intervene) (see farther in Note 17).

Pectin is an element that contributes to the cellular wall rigidity. It corresponds to a network of flexible fibres that interlaces the network of cellulose and hemicellulose fibres, and which constitute more rigid cell walls (Figure 11). The "fat" aspect of the pulp means that a part of the pectin has been damaged in more elementary and sticky substances, mucilagineous (arabans), which can fragmented until the acetic acid (strong odour of vinegar) by ulterior fermentations (Lactobacillus buchneri and Streptococcus sp.).

Silos where the cooling is too slow (that means where the conditions are favourable for the apparition of fat pulp) are most often:

- big capacity bunker silos having a height > 2 m, combined with a width > 8 m. frequently, in the centre of these silos the temperature remains too long above 45°C (Figure 13);
- too big silos, coupled one to another or leaning on a heated building,
- too high silos, prepared in a bank,
- silos prepared on/under a maize silo, recently ensiled (Figure 14). The temperature of a maize silo generally reaches 20 to 25°C during the first days after its ensilage. This supplementary heat and the insulating capacity of the maize lengthen the cooling time considerably of the pulp situated over or underneath (Figure 15),
- clamp silos where one of the sides is exposed to the South. At sunny moments and with too elevated temperatures for the season, the black plastic placed on the sides could accumulate, in the pulp, a supplementary quantity of heat.

In the same order of ideas, a silo exposed to winds will cool better than a silo placed in a bank or coupled to another silo or a building. A resumption of fermentation, consecutive to a bad compression, can also be at the origin of an internal re-heating of the silo.

Let's note however that it is possible to get an ensilage of good pulp quality, in silos slightly too voluminous (height > 2 m and width> 8 m), as far as the pulp (of good quality) has been ensiled while spreading it carefully in successive layers, to encourage its initial cooling and its evaporation (Notes 22 & 26).
Figure 13: Too slow cooling of the pulp in a silo of more than 2 m height. After 2 weeks, the temperature in the centre of the silo (at 1 m of height) is even higher than 50°C. The stippled line in red corresponds to the theoretical cooling (1°C/day).

Figure 13 shows the cooling observed in a voluminous pulp silo (> 800 t; height > 2 m and width > 8 m). The temperatures inside the silo have been measured during the first three weeks that followed its confection. One observes that the temperatures (recorded at 3 places in the centre of the silo, at 1 m of height) cool too slowly. The increase of the temperature (± 5°C, due to the lactic fermentation or to aerobes enzymatic fermentations) is observed during a period of one week at least. The temperature remained > 50°C during 2 weeks. The structure of the pulp has been altered by the obstinate heat and became fat. Because of a too important height, the theoretical cooling (1°C/day) could not be respected. Figure 15 shows the cooling observed in a relatively big pulp silo (500 t, height = 2 m), but on which a maize silo has been ensiled the same day, on about the half of the pulp silo. The temperatures inside the part of the pulp silo non-covered by maize have been followed during the first week (at 2 places and at 1 m of height, lines aquamarine). These temperatures show a correct cooling. The pulp of this zone presented a satisfactory quality at the unloading. One also observes that the pulp ensiled under the maize (measured at 2 places and at 1 m of height, lines orange red) has been ensiled colder (<45°C). It cools more slowly, the layer of maize serving as insulating layer. After 1 month, the temperature in these zones is again > 35°C. It varies about 30°C after 2 months. In these zones, the pulp has been altered by the prolonged heat and has become fat. The ideal would have been, in this case, to ensile the maize first, then the pulp, and to wait for 1 to 2 weeks between these 2 ensilage operations.
Figure 14: Fat pulp presence in a silo of pulp ensiled the same day on a maize silo. The pulp at this place could not normally cool. A slow "cooking" modified its structure while transforming it in fat pulp of yellowish colour (Note 17).

A very thin layer of" fat pulp" (of some centimetres only) is observed sometimes at the basis of the silos, at the soil level (Figure 16). This pulp presents an acrid or unpleasant odour, it has also been damaged and turned into "fat pulp". In this case, its deterioration results from the activity of pectinolytic bacteria (enzymatic hydrolysis).

The first layer of pulp which is spread out during ensiling on the ground can cool down too abruptly. The temperature decreases then too rapidly to the soil temperature (5 to 15°C). Yeasts and butyric and/or pectinolytic bacteria (Bacillus, B. megaterium, Clostridium sp.,...) can develop themselves thus, thanks to a too cold temperature at this level and to where the lactic fermentation cannot develop itself correctly. This fine layer of pulp, that underwent other types of fermentations (butyric fermentation,...), releases an unpleasant, or even acrid and sickening odour, different from the one of correctly fermented pulp. This pulp has also a very fat aspect and a strong orange yellow coloration, which disappears quickly when exposed to air. It is not appreciated by livestock.

In too high silos, it is not rare to observe, at the bottom part, continuities between this small zone of fat pulp and the more important resulting from thermal deterioration.
**Figure 15:** Too slow cooling of a pulp silo on which a maize silo partly has been placed the same day, each of the silos not exceeding 2 m of height. After 1 month, the temperature in the centre of the pulp (at 1 m of depth) under the maize is even higher then 35°C. It is again of about 30°C after 2 months. The pulp ensiled without maize above cools normally (measures only done during 10 days). The stippled line in red corresponds to the theoretical cooling (1°C/day).

**Figure 16:** A thin fat pulp layer is sometimes observed at the basis of the silos, at the soil level. This pulp presents an acrid or unpleasant odour. Its deterioration results in general from the activity of pectinolytic bacteria (Note 17).
The presence of "fat" pulp in a silo can occasionally have either been led or favoured, in the sugar factory, by an accidental elevation of the temperature or by a slowing, or even interruption of the transit of the cossettes during their extraction (during the scalding or the diffusion) or by a brutal acidification of the diffusion juice (Notes 4, 5 & 10). One momentary addition of antifoam, intended "to cram the presses ", or some ulterior bacterial developments can encourage the fat or sticky and compacted aspect of the pulp (Notes 6 & 8). Generally, in these conditions, the pulp pectin is too much damaged. Therefore, the pulp can present a sticky and fat aspect, already at the exit of the presses. It then presents compact blocks of fat pulp, which does not disintegrate by itself. These blocks release a characteristic acidulous and acrid odour, different from the one produced by the lactic fermentation. The pH of this pulp, at the exit of the presses, is already under 4.0 and even reaches a value of 3.5. Organic fermentation acids can be present in too important quantities for this step (lactic acid > 5 g/kg DM, acetic acid > 2 g/kg DM). The content in soluble sugars can being apparently correct, but the inverted sugars can be present in too big quantities (glucose + fructose > 5% DM). These various elements reflect a deterioration of the pulp during its production, ominous to its conservation by ensilage. According to the importance of the deterioration, the use of this pulp will rather be affected to a direct feeding or evacuee rather than destiny to ensilage.

These various circumstances (too high temperatures, too acid pH, prolonged stay in the diffusion - thermal hydrolysis, acidic hydrolysis and/or enzymatic hydrolysis) increase the change of the cell wall of the cossettes. These are going to release some quantities then too important of fragments of pectin and other colloids in the diffusion juice. These excesses of pectin in suspension disrupt the steps of purification and of the filtration of the diffusion juice and of the crystallization of the white sugar. The too important deterioration of the pectin can also produce some pigments (monomers of galacturonic acid…) that will harm to the whiteness of the sugar. Because of these various reasons, the people responsible for the sugar extraction process, will pay close attention to limit the deterioration of the cossettes cell wall.

Note 18... that encourages the crumbling and the ulterior development of moulds

Under the weight of the upper layer of pulp, the unsteady zones of "fat pulp" slip easily out of the silo (Figure 17). This slip entails the crumbling of pulp blocks (of several tons) and the apparition of cracks and zones of fractures at the rear of the front of progression. The presence of air in those new cracks encourages the fast development of moulds. These moulds, situated beyond the front of progression, will often develop more quickly than the progression of the front himself, especially in summer.

It happens that some breeders persist in achieving pulp silos of a too high height (> 2 m) while succeeding in limiting the consecutive slips to the "fat pulp" zones. To do so, they spread the pulp at the time of ensilage and open their silo at the opposed side than the one of loading. These breeders especially need large quantities of pulp.
Figure 17: Too voluminous silos (height> 2 m, width> 8 m) are favourable for the formation of fat pulp zones. These unsteady zones, slip easily out of the silo.

**Note 19 Organize very well the ensilage operations to work quickly**

Well organising the ensilage operations mean in the first place, well respecting the supply planning, which was agreed by both parties (sugar factory and pressed pulp user). Then a good coordination must be insured of the ensilage machines, especially when ensilaging in tube silo’s (Note 28). The pulp is delivered hot. It must be ensiled quickly not to disrupt the lactic fermentation that started spontaneously in the hours following its exit of the presses (Note 8). It is necessary to be careful not to extend the delivery time and to reduce to the minimum the numbers of manipulations. It is also necessary to completely achieve one silo, without important interruptions. If an important interruption occurs (more than 12 hours), one must treat the already ensiled part of the pulp silo like a fully-fledged silo (spreading, packing and closing temporarily). Ideally, the pulp must be ensiled in the 24 hours following its exit of the presses.

Opposite, too cold temperatures (< 30°C) of the pulp at the time of ensilage will be not be auspicious to the development of the lactic bacteria. The development of other fermentations (butyric,…) will, in this case, be encouraged, which will harm the conservation potential of the ensiled pulp. It has been demonstrated that to cold ensilage conditions of pressed pulp entails an insufficient pH, a too important content in butyric acid and a bad quality of pulp conservation.

The delivery rate should also allow the breeder to ensile the pulp regularly, without delay periods between two deliveries (meaningful cooling of the exposed layers), but also without too short intervals that will incite one to ensile his pulp too hastily, without having the necessary time for a regular spreading and pucking.
**Note 20 to ensile the pulp on an adequate and clean site**
The ensilage place must be easily accessible and steady (surface either consolidated or concrete), with rigid walls (bunker silo with rigid walls or tube silo). Clamp silos (Note 29), not having any rigid sides, don't permit a perfectly homogeneous compression of the pulp, over the whole height of the silo. The silo place and the surroundings must be clean and spotless (rests of previous ensilage, soil, manure…). The surroundings of the silo must allow the lorries to operate comfortably, without going on the pulp.
In a bunker silo, it is also necessary to be careful and to place a new plastic cover on each of the lateral wall. The lateral plastic foils limit the water infiltrations at the silo sides (Note 26). They also protect the concrete against the acidity of the ensiled mass. The basis of each of these foils must cover the soil partially (at least 1 m). The remnants (at least 1 m) will be folded on the summit of the silo, to avoid water infiltrations (Figure 21).

**Note 21 Work with rigorously clean equipment**
During the ensilage operations it will be necessary to avoid all impurities (soil, manure,) in order to limit the introduction of ominous germs (moulds, bacteria coming from soil or manure…) in the silo. Too big contamination of the pulp by telluric bacteria (present in the soil such as Bacillus cereus, Clostridium perfringens, Clostridium butyricum….) or present in faeces (Listeria monocytogenes,….) cause digestive or nervous disorders among livestock.
According to the allocation of the lorries, the skips transporting the pulp will therefore be washed, especially if they previously served for sugar beet loading or for other transportation. Some sugar factories have an installation for washing these skips.
On the farm, the machines used to spread and pack the pulp should remain permanently on the silo or on clean surroundings. It cannot be used for other tasks nor can it leave the silo site before the complete duration of the silo production.
The contamination degree of a silo by impurities can be expressed by the \( \frac{\text{NH}_3}{\text{N}_{\text{tot}}} \) ratio. This ratio gives a preview of the level of proteins deterioration (proteolysis), achieved by the butyric flora that damages these proteins. The content in ammonium nitrogen must be lower than 5 to 7% DM. A 20% content in soluble nitrogen indicates a good conservation of the nitrogenous matters.

**Note 22 Spread and compress homogeneously and sufficiently...**
It is necessary to carefully compress the pulp on a homogeneous way, while spreading it over the whole length of the silo in successive horizontal layers of 20-30 cm, by this way expelling all air pockets still present (Figure 5). This spread facilitates cooling and evaporation of the water steam, especially if the pulp is hot at the delivery. This spread permits to get a sufficient compression density (> 800 kg/m³) which is homogeneous over the whole height of the silo.
The pulp delivery rate is also an element for successful ensiling. A too short supply time between the different freight carriages, forces the breeder to a very superficial and very uneven compression. In this case, the pulp is pushed in large packages against each other by means of a machine provided with a frontal shovel to the desired height. The whole silo is then packed in its entirety, by driving over it before closing. In this case, only the superficial layers will be more or less correctly compressed.
Fast ensiling by directly pushing the deliveries against each other or skipping directly in the silo, and afterwards pushing roughly in 1 movement, doesn't correspond with the good rules of ensilage. Wanting to save time and simplifying one's work by not spreading out the pulp, the breeder achieves a heterogeneous silo, which reduces the conservation possibilities of the pressed pulp. Besides, when too fast ensiling the pulp will tend to keep its temperature of delivery longer and becomes fat, if it has been ensiled in a too high silo (Note 17) or on a maize silo (Figure 18). In the same way, its possible evaporation will be more difficult, which will also harm its conservation (Note 26).
Figure 18: Silo of pulp achieved directly on a maize silo. The pulp has been ensiled in oblique layers, while pushing the different deliveries against one other, without spreading them. The fat pulp formation, favoured by the maize silo, accentuates the instability of the pulp layers which slip according to the slant of the ensiled layers.

Note 23... create an anaerobic environment and get an acid pH quickly...
The lactic fermentation transforms the soluble sugars present in the pulp into lactic acid. It entails a fast increase of the acidity level (level of pH) of the pulp. This fermentation is achieved mainly by lactic mesophile bacteria so-called homofermentating (homolactic). They produce two molecules of lactic acid from a glucose molecule (derived of sucrose). These Lactobacillus are already present at the factory in the stored pulp (10⁹ to 10¹⁰ spores/g DM). During 10 to 15 hours after the exit of the presses, the lactic flora increases quickly and reaches 10⁵ to 10⁶ spores/g DM. Then the pH of the pulp reaches a value of about 4.5. The maximum activity of the Lactobacillus is reached after 48 hours and their population reaches 10⁹ spores/g DM (Note 8).

From a level of pH lower then 4.0, the development of the aerobes micro-organisms and other fermentations (moulds, butyric fermentations, coliform bacteria,…), harmful to the conservation, begin to slow down.
The pulp also undergoes an acetic fermentation, achieved by heterolactic bacteria which produce a non negligible quantity of acetic acid. These heterofermentating Lactobacillus produce a lactic acid molecule from a glucose molecule, with production of ethanol, CO₂ or acetic acid. The activity of these bacteria is blocked when the acidification of the pulp reaches a level of pH lower then 4.2.

An optimal pH value (3.6 ± 0.2) is reached after a few days (Figure 19), according to the development of the lactic bacteria. To this pH level (and in the absence of air), the development of the other microorganisms is stopped completely. Then this acidification must stabilize. This is why it is recommended to wait for about 30 days before opening a pressed pulp silo. A pH of ensiled pulp higher than 4.0 and the presence of water are favourable to the development of butyric flora. This decreases the food value of the pulp and causes, according to the conditions, the production of toxins (cadaverin, putrescin,… ) which modify the digestibility of the pulp and disrupt the metabolism of the animal.
Figure 19: Decrease of the pulp pH during the first days following its ensilage. The ideal value of 3.6 is reached after 10 days and stabilizes thereafter (Note 23).

Note 24... due to the lactic acid production
There exists a direct link between the lactic acid content and the pH level of ensiled pulp (Figure 20). The reached quantity of lactic acid depends on the quantity of soluble sugars at the exit of the presses (4 to 6% DM) and of the good progress of the lactic fermentation. A pH of 3.6 corresponds to a lactic acid content of 30 g/kg DM. A silo whose pH remains superior to 4.5 reveals a very weak development of the lactic fermentation.

A correct ensilage of the pressed pulp also presents different contents in several volatile fatty acids (VFA), formed by the lactic fermentation (table 2.). Some acetic acid is also produced (Note 23), but its content is generally lower to 15 g/kg DM. Other organic acids (butyric acid, etc…) are the reflection of ominous fermentations. They must not be present in the pulp, nor before, nor after its ensilage. The butyric acid is often present when the pH remained higher than 4.2. It must be normally absent or must present a content lower than 2 g/kg DM. A more elevated content reveals the development of bacteria (Clostridium sp.) harmful to the conservation of the pulp, to the health of the animals and to the quality of the milk. These bacteria can develop themselves if the lactic fermentation didn't take place correctly.

One can finally detect the propionic acid (<5 g/kg DM) and the iso-butyric acid (<2 g/kg DM). The succinic, formic and valeric acids are little present in the pressed pulp silos.
**Figure 20**: Correlation between the acidity level (pH) and the lactic acid content in pressed pulp (IRBAB/KBIVB survey 2002-2003). It is necessary to reach 30 g/kg DM of lactic acid to get a pH of 3.6.

**Note 25 Equalize the last layer**

In a bunker silo, the height of the last layer at the centre must be higher than the ones at the sides of the silo. Placed in the middle, it procures a well-rounded summit of the silo, which avoids the stagnation of the rainwater on the surface of the silo.

The last layer must be levelled perfectly. The compression of the final layer (with one’s feet or with an equalizer device) reduces the presence of cavities and air pockets and therefore the possibility of ulterior development of moulds right under the closing tarpaulin, especially when old tires are used as ballast.

Agricultural salt in solution (3 kg/m²) can be applied on the surface of the silo before its closing. This treatment inhibits, to a certain extent, the development of moulds sometimes observed at the opening and in this zone, between the plastic cover and the pulp surface.

This addition of salt modifies the osmotic pressure (“water activity”) of the pulp at this level. It often reduces the faculty of this aerobe and less acidified zones (sometimes pH > 4.0) to be colonized by moulds. At the opening of the silo, the effect of this practice would also reduce the contamination of the pulp situated at the periphery of the silo. It could reduce the global contamination of the silo by 50%, half of the contamination of the silo being situated at the periphery.

Before closing the silo by means of a tarpaulin, some breeders use a wet pulp or a beet tails layer to achieve the last layer. In presence of moulds in this layer, the loss in this feed is economically less important. This feed sometimes contain even some important quantities of water that can, by ulterior evaporation, create some air pockets at the level of the contact zones, and therefore sensitive zones to the development of moulds. In this case it is sufficient to let the beet tails drain (one day or two if necessary) before using them as a last layer.

In a clamp silo (Note 29), the compression of the last layer is more uncertain and can sometimes be even problematic. These last layers are all the more susceptible to be degraded by moulds as the required density of compression is not reached (> 800 kilog/m³).
Note 26 Clos

Note 26 Closing the silo correctly
The closing of a bunker silo is achieved while folding over on the silo (each on 1 m at least) the laterally beforehand placed plastic foils, while covering the whole surface then by means of 2 other plastic foils (Figure 21). The top cover will be an old one because this one is more flexible and can be stretched better. It will be placed therefore at the end in order to cover the irregularities of the surface better. The first cover will be a new one, without rips or perforations. Putting one (new) cover foil only to close the silo, doesn't limit the presence of small vestigial air pockets, between the cover and the top side of the silo. While only using one cover foil, one will recover plots of moulds, just under the cover foil, more easily.

Figure 21: To close a bunker silo correctly, it is first necessary:
1. to place new foils on each of the sides, before ensiling. It is necessary that these covers are 1 to 2 m longer than the height of the silo, as well as 1 to 2 m larger than the basis of the silo. It will limit water infiltrations from the top or bottom of the silo.
2. after ensilage of the pulp, close the silo again while folding the side covers toward the inside and place a third new and a fourth (used) on the whole, while being careful that these two foils surpass the partitions of the silo.
3. to seal the silo airtight and waterproof by using pieces of rubber transport belts. The old tires are easier to put, but not always give a satisfying result.

It is usually recommended to close the silo, the same day of its confection. Rain (light or normal) at the silo confection time is not a disrupting element. It is important not to wait to close a silo if the rainfall becomes abundant. However, the pressed pulp can release big quantities of water steam, during the confection or during the first 24 hours following its ensilage, especially if the spread of the pulp was insufficient (Note 22). In this case and according to the climatic conditions, one observes that delaying (1 to 2 days) the closing of the silo limits the moulds development in the silo or more specifically in a zone generally situated 20-30 cm under the surface (Figure 22). These zones where moulds develop themselves (generally when the progression of the unloading is insufficient) would correspond to zones of fine cracks or fractures resulting from the water condensation in these places, at the time of ensilage. The hypothesis is the following: in presence of water steam, it would be best to release it completely. In similar situations and if the silo is closed directly, the water steam would remain blocked by the plastic covers. It can not escape out of the silo. This phenomenon would create thereafter thin
interstices where moulds can enter. These particular zones would result from the confluence of two inverse fronts of temperature and humidity, directly after ensilage. One front, humid and hot, coming from the inside of the silo, the other front, colder, coming from the outside and penetrating at the top of the silo. The water steam contained in the pulp, can not evacuate itself because of the plastic cover, and will condense in the zones corresponding to the confluence of these two foreheads.

Not covering immediately a silo can be considered if the weather conditions are favourable and if the pulp releases a lot of water steam (often the case in silos where the pulp has not been spread, but merely skipped and pushed). Delaying the covering by 12 to 24 hours is absolutely to avoid if the silo is finished under an abundant rain. Exposing a non covered silo during 12 to 24 hours under an abundant rainfall will re-humidify the pulp and will harm its density of compression and would strongly compromise the conservation of the re-humidified pulp layer.

Figure 22: The presence of a fine mould layer, generally situated 20 to 30 cm under the silo surface, would result from the condensation of the excess of water steam, even present in the pulp at the time of ensilage (Note 26).
According to certain regions, some breeders use a layer (15 - 20 cm at least) of mashed potato, coming from the potato processing companies, to cover and to close their silos entirely. This layer, while drying up, keeps himself easily and don't release any odours. It presents a good feeding value. It limits the damages of birds and of rodents and reduces the warming-up of the silo in summer. This practice doesn't use any plastic cover of closing therefore. These breeders don't observe the formation of these mould zones anymore, in their silo, 20 to 30 cm under the surface, or elsewhere. In this case, because of the absence of plastic closing covers, the excess of water steam of the pulp escapes completely out of the silo.

In the same sense, other breeders use a layer (> 30 cm) of sugar beet tails (or of chicory) correctly compressed to finish their silo (Figure 23). They also don't use any plastic cover for closing. This technique encourages the acetic fermentation in the last pulp layer (supplementary contribution of matters rich in soluble sugars in this zone). It also seems to be favourable to the evacuation of the excess of water steam out of the pulp. Such silos don't present any development of moulds. The pulp is kept perfectly and the feeding value of whole is extremely satisfying. Even simpler is the sowing of winter barley directly on the surface of the pulp silo. These interesting techniques are carried out more easily for finishing some bunker silos than to cover entirely a clamp silos.

**Figure 23:** Some breeders use a layer of beet tails to finish and to close their silo. They don't use any plastic closing covers. This technique seems to be favourable for the evacuation of the water steam excess, at the time of the pulp ensilage. These silos, compressed with great care, don't present any development of moulds (Note 26).
Note 27 Ballasting uniformly the top of the silo
The closing covers of a bunker silo, as the ones of a clamp silo, must perfectly be applied against the surface of the silo. It is necessary to limit to the maximum the formation of air pockets under the plastic foils and therefore to use a uniform ballast system, on the whole surface of the silo. The ideal ballast is gotten with straps of belt strips. Sand bags will complete the maintenance of the tarpaulin on the sides of the silo.
Old tires are easier to use, but they don't always give a satisfactory result. They can encourage the formation of vestigial air pockets easily in their centre. Besides, according to the recycling taxes or the regional legislation, the use of old tires could prove to be more coercive, or even forbidden. The ensilage techniques where no plastic closing cover is used (Note 26) could therefore develop itself in future.
Some breeders ballast their silo with a soil layer drilled by winter barley. In winter, the frozen soil will then be easier to remove, by whole clods.

Note 28 Ensilage in plastic tube silo
Used in Belgium since 1997, special ensiling machines (ROTOPRESS type) permit to ensile pressed pulp and other forages (maize, brewer’s grain draft, grass,…) in enormous plastic tubes. A few 10,000 t/year of pressed pulp is actually ensiled by this technique. The diameters of the available plastic tube (2.4 and 3 m) permit to ensile respectively 4 t/m and 6 to 7 t/m of pressed pulp, for a maximum tube length of 70 m (Figure 6).
As far as the tube silo is achieved on a concrete area (or consolidated) easily accessible, this ensilage technique presents many advantages. It permits to achieve a quality ensilage and to get optimal conservation conditions.
Among other advantages, such as:
- working speed (± 100 t ensiled / hour),
- cleanliness (the pulp doesn't enter in contact with soil nor is it soiled by the compression device),
- excellent compression homogeneity,
- regular cooling of the ensiled mass,
- good evacuation of the excess of water steam before setting in the tube,
- fast advancement of the face front at the unloading,
- a better palatability of the pulp...
This technique has been experimented by the IRBAB/KBIVB in 1996 and 1997 and regularly thereafter. The pulp ensiled in tube silo has an optimal density level (> 800 kg/m³), pH (± 3.6) and lactic acid content (> 30 g/kg DM) (Figures 24 to 26). The risk of contamination by the butyric flora is reduced. There is normally no zone at all of mouldy pulp to eliminate.
Made by contractor, this technique is ideal for breeders who don't have any sufficient ensilage infrastructures to ensile the pressed pulp correctly. It is perfectly convenient for summer silos or for farms using few pulp for their cattle (pigs, sheep,…).
This technique, still not enough frequent in Belgium, procures a very good conservation quality of pressed pulp. Apart from the relatively high cost of this technique, the gain of time, the quality and the feed uptake of the pulp must be taken in account.

Note 29 Ensilaging in a clamp silo
The ensilage of the pulp in a clamp silo (absence of lateral walls) is practiced a lot in Belgium. This technique doesn't require specific ensilage infrastructures and is easy to achieve. It can give a satisfying conservation of the pulp, as far as the pulp is spread and compressed correctly by regular layers until the top of the silo (Figure 7)!
A clamp silo achieved merely by skipping the pulp loadings against each other and by rudely packing the entire silo doesn't correspond with the good rules of ensilage.
Ensilage in clamp silo is generally characterized by a heterogeneous and insufficient compression (<800 kg/m³), especially in the top layers. These elements encourage the presence of vestigial air and the development of moulds. In the same order, the pH levels and the lactic acid contents are often insufficient (Figures 24 to 26). The covering and the regular ballasting of the covers are more delicate.
The last layers of pulp frequently present some too low densities (<500 kg/m³). These layers are colonized very quickly by moulds and must be eliminated.

To limit the losses to the level of the last layers, some breeders finish their clamp silo with a layer of beet tails (if necessary drained) or of wet pulp. This layer nevertheless must be sufficiently compressed to limit the development of moulds.

In relation to ensilage in a bunker silo or in a tube silo, the technique of the clamp silo is less expensive, but it offers less guarantees of optimal conservation. It presents more risks of feed losses.

During a survey made in 2002 and 2003 by the IRBAB/KBIVB on ± 35 silos of apparently correct pressed pulp, it has been noted that in the clamp silos, the pulp never really didn't reach the expected density values, pH value and lactic acid content as presented in table 2. As illustrated respectively in figures 24, 25 and 26, the density, the pH level and lactic acid content (measured at 6 places/silo) proved to be almost systematically insufficient and very heterogeneous for 11 clamp silos, variable enough and often been sufficient for 21 - 22 bunker silos, optimal and very homogeneous in 2 to 3 observed plastic tube silos.

**Figure 24:** Density levels (kg/m³) (6 measurements/silo) and average density in 2 plastic tube silos, 21 bunker silos and 11 clamp silos. The optimal density must be at least 800 kg/m³ (IRBAB/KBIVB survey 2002-2003).
Figure 25: pH levels (6 measurements/silo) and average pH in 3 plastic tube silos, 22 bunker silos and 11 clamp silos. The optimal pH must be 3.6 ± 0.2 (IRBAB/KBIVB survey 2002-2003).

Figure 26: Lactic acid content (g/kg of DM) (6 measurements/silo) and average content in 3 plastic tube silos, 22 bunker silos and 11 clamp silos. The optimal content in lactic acid must be of at least 30 g/kg DM (IRBAB/KBIVB survey 2002-2003).
**Note 30 Loss of dry matter**

During unloading, it is possible to observe a slight decrease of the dry matter content in a pressed pulp silo. Usually from 0.5 to 1 point in relation to the one determined at the delivery, either a maximum middle loss (often apparent) of 1 to 2% due to fermentation. These losses vary from one silo to another and from the place in a silo, but one observes on the whole and for silos fermented correctly, a less important loss of dry matter (<1%) in silos where the dry matter at departure was more important (> 25%).

The lactic fermentation decomposes the sucrose still present in the pulp in its subunits of glucose and fructose. Glucose is then transformed into lactic acid. This chemical transformation doesn't entail any dry matter loss. Non homofermentary lactic fermentations (or heterolactic) can decompose sucrose also in glucose that is transformed then in lactic acid and in ethanol. The production of ethanol, volatile compound, comes with a more important dry matter loss (24% according to the chemical conversion formula). Other fermentations convert fructose in lactic acid and in acetic acid (volatile compound) and in mannitol. This fermentation corresponds (according to the chemical conversion formula) to a dry matter loss of 4.8%. When different fermentations, lactic and non lactic, occur in a pulp silo, one can attend an apparent dry matter loss, following the volatilization of a part of these compounds at measurement moment with an incubator. These volatile compounds (ethanol and volatile fatty acid - VFA: acetic, butyric, iso-butyric, propionic acids, etc.) are especially present when some non lactic fermentations took place.

The measurement of the dry matter content of a pressed pulp silo after a long conservation time won't necessarily permit to estimate a dry matter content similar to the one determined at the delivery time. An insufficient dry matter content, determined at unloading, can correspond to a pulp lot of which the dry matter content at departure was too weak. It can also correspond to a pulp lot where the production of volatile compounds, resulting of an insufficient lactic fermentation and therefore of a deterioration of matter made by other types of fermentations, was important.

The enzymatic hydrolysis of the polysaccharides constituting the cell walls produces mainly glucose (from the cellulose), glucose, xylose and arabinose (from the hemicellulose) and galactose, galacturonic acid and arabinose (from the pectin). The "fat pulp" resulting mainly from a deterioration (thermal, chemical or enzymatic) of the constituent chains of the galacturonic acid (Note 17) doesn't correspond to a hydrolysis producing volatile compounds. The "fat pulp" will have a dry matter content therefore very generally close to the one measured at delivery.
The Correct Use of Pressed Beet Pulp
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