Protein degradation in silage
A good silage preservation aims to maintain the silage value as close as possible to the fresh forage at the field. However, the fermentation process may alterate this initial value. **From cutting to the stabilization of the silo, every step may impact positively or negatively the dry matter (DM) and the energy recovery and also the protein quality and availability.** Indeed, regarding the protein value, the ensiling process won’t change the level of Crude Protein (CP)* but may impact dramatically the nature of the nitrogeneous compounds with the production of end products from protein degradation, protein being the only molecule containing nitrogen. This drives to the production of ammonia (NH3) and an important increase in the proportion of Soluble Nitrogen (Baumont 2011).

*Crude Protein represents true protein content and other sources of nitrogen with no feeding value (Soluble N and ammonia), both degradation products of proteins.*

Thus, a poor silage (with clostridial and enterobacterial dominating the fermentation) will show a proteolysis and a high release of ammonia.
Excess of soluble N impairs animal health & performance

This excess of ammonia coming from the silage can’t be all used by the rumen microflora and hence will be absorbed through the rumen wall and transferred to the liver by the blood. In the liver, it will be detoxified in urea which will be eliminated through the kidneys toward the urina and saliva.

However, the detoxifying capacities from the liver and the kidneys are limited, and we hence observe an excess of ammonia and urea in the blood, and an excess of ammonia in the rumen. These high levels result in several health problems for the animal, mainly due to the toxicity of the ammonia.

1. Alcalosis

Alcalosis is an excessive accumulation of soluble nitrogen in the rumen. This increases the rumen pH, and we consider the alcalosis when the pH reaches 7.2.
2. Other clinical symptomata

<table>
<thead>
<tr>
<th>“Sub acute” intoxication: continuous intake of poor quality silage</th>
<th>Acute intoxication: grazing young grasses, accidental intake of high levels of urea, short transitions…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reproduction troubles:</td>
<td></td>
</tr>
<tr>
<td>• Abortion, infertility</td>
<td>• Drop in milk production</td>
</tr>
<tr>
<td>• Mastitis</td>
<td>• Lower rumen activity</td>
</tr>
<tr>
<td>• Loss of immunity</td>
<td>• Death</td>
</tr>
</tbody>
</table>

3. Loss of energy & impact on performance

Beyond the troubles mentioned above, the excretion of excessive urea also means the consumption of energy that can be used otherwise for milk or meat production.

\[
\text{ATP} = \text{Energy}
\]

The loss of energy coming from an excess of 2% in protein in the diet is 0.36 Mcal/day, this being equal to a potential of 0.5L milk/day, (= 0.375 NEL = 0.22 UFL) *Vanderhaar (1998)*

\[
\text{1 L milk} = 0.75 \text{ NEL} = 0.44 \text{ UFL}
\]
**4. Blood and milk urea**

Monitoring the blood urea showed data demonstrating the lack or excess of nitrogen in the diet. The ammonia may cross the rumen wall when above 50\( \text{mg/ml} \) of rumen fluid (Lewis et al., 1957). As soon as the ammonia reaches 1\( \text{mg/100ml} \) (blood alcalosis), the intoxication becomes lethal (Maladies des bovins 2000, Institut de l’élevage). The urea concentration in between the blood and others body fluids tends to get balanced, notably with the saliva, urina and the milk. Thus urea in the milk is a good indicator of the protein utilization from the diet.

<table>
<thead>
<tr>
<th>Low Urea</th>
<th>Ideal concentration</th>
<th>High Urea</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg N urea/ L milk</td>
<td>&lt;100</td>
<td>100 - 160</td>
</tr>
<tr>
<td>mmol urea/ L milk</td>
<td>&lt;36</td>
<td>36 – 57</td>
</tr>
<tr>
<td>mg urea/ L milk</td>
<td>&lt;214</td>
<td>214 - 343</td>
</tr>
</tbody>
</table>

**Consequences**

- Lower milk production
- Ideal level for the rumen flora
- Waste of nitrogen/protein

---

**3 Good practices to control proteolysis in silage**

A good silage quality means a low proteolysis (Demarquilly 1998):

<table>
<thead>
<tr>
<th>Soluble N (% N total)</th>
<th>Ammonia nitrogen (N-NH3) (% total N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Grasses</td>
<td>&lt; 50%</td>
</tr>
<tr>
<td>Legumes</td>
<td>&lt; 50%</td>
</tr>
</tbody>
</table>

Two of the main factors affecting proteolysis are the forage cells enzymes and the proteolytic microorganisms. Both have to be inhibited as fast as possible, and certain good silage practices drive a better fermentation and thus lower protein losses.
Things to do

SHORT TERM

Balance the diet
If the diet contains high levels of soluble nitrogen, several conditions must be respected:

• Fulfill the energetic requirements, which are mandatory for a good rumen functioning.
• Dilute the poor quality silage with other compounds, thus avoiding excess soluble nitrogen and minimizing the metabolic troubles due to high levels of nitrogen.
• Adapt the quantities of urea in the diet. Urea is necessary only when the diet lacks soluble nitrogen, for instance when diets are rich in maize silage or low in grass silage.
• Respect the transitions: start with 1/3 of the final quantity and increase gradually.

LONG TERM (next harvest)

• DM: a higher DM may minimize the proteolysis. High DM inhibits proteolytic enzymatic activity.
• pH: ensure a rapid and strong acidification that will inhibit proteases and proteolytic bacteria.
• Respect a lag time between spreading manure/slurry and harvesting: manure/slurry is high in nitrogen and thus increases the buffering capacity of the forage.
• Anaerobiosis: the absence of oxygen inhibits proteases and helps acidification.
• Limit soil/earth contamination: proteolytic microorganisms are mainly located in the soil, thus the cutting height must be higher than 6-7cm.
• T*: avoid silage heating as the increase in temperature increase Maillard reaction and proteolysis = Use of a silage inoculant based on Lactobacillus buchneri NCIMB 40788.
• Application of selected Lactic Acid Bacteria: Accelerate the acidification and increase aerobic stability thus limiting/inhibiting compounds involved in the proteolysis.

Beyond 160mg of urea/ L milk, there’s an excess of nitrogen for the animal, hence a poor use of the protein from the diet. This means first a waste of feed and then a financial loss:
> Current soya 48 @ 500€/t, so approximately 1041€ per ton of CP
> In a 100T silo @ 15% CP, a loss of 5% of this CP by proteolysis is equal to a loss of 780€
In addition, this excess of Nitrogen may cause metabolic troubles (loss of production) and poor fertility results.