How to preserve silage protein content for profitable dairy production

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At a time when feed represents 40-60% of milk production costs, every gram of nutrient counts! Forage protein content is a key nutritive element that varies greatly according to the crop species, maturity and the soil. Ensiling is a common method of forage preservation, that can lead to degradation of proteins in the forage into ammonia and soluble nitrogen. When produced in excess, these products are detrimental to the animal and lead to a decrease in performance and health problems.

This article discusses the practical implications of poor silage preservation and draws some guidelines on the best silage management practices to limit proteolysis, with a particular focus on specific microbial inoculants, proven to preserve grass protein contents.

Assessing protein content

Donna Amaral-Phillips describes forage nutrient content analysis as 'the first key step towards developing a sound and practical nutritional program for a dairy business'. In this analysis, crude protein (CP) is, with energy value, one of the most important nutrients for livestock, which can be a limiting factor for animal performance. Forage protein content varies greatly according to the crop species, maturity and the soil (use of fertiliser).

Table 1. Clinical symptoms linked to excessive soluble nitrogen in the rumen.

Sub acute intoxication: Continuous intake of poor quality silage. Reproduction troubles, abortion, infertility, mastitis
Acute intoxication: Grazing young grasses, accidental intake of high levels of urea, short transitions. Loss of immunity, drop in milk production, lower rumen activity, death

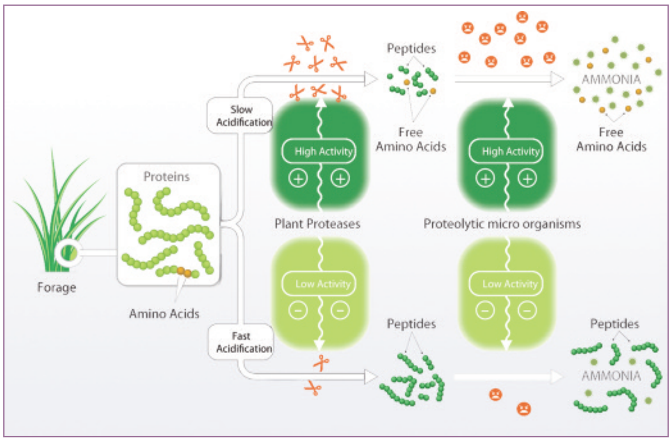

Fig. 1. Proteolysis during the ensiling phase.

It is however important to keep in mind that CP, which appears on our analysis, is an indirect measure of the protein content, based on the total amount of nitrogen in the forage. This is based on the fact that proteins are the only organic molecules containing nitrogen atoms.

Thus, CP level represents protein content, but also other sources of nitrogen with no feeding value, such as soluble nitrogen and ammonia, which come from the degradation of proteins in the forage. Hence, the actual true protein level can vary for a given CP value.

Excess mineral nitrogen

Ensiling is a common method of forage preservation. It is typically known that the ensiling process does not alter the CP content of a forage. However, if we look at the true protein content and not overall nitrogen content (CP value), this is different! Indeed, silage fermentation is often a source of protein degradation, known as proteolysis. This results from the action of either:

- Forage endogenous enzymes, which are released from the plant cells at harvest.
- Proteolytic micro-organisms, such as clostridia or enterobacteria, present on the plant.

Both of these have to be inhibited as quickly as possible following harvest to keep proteolysis to a minimum (Fig. 1). Thus, silage of poor quality (with clostridia and enterobacteria dominating the fermentation) will show an important proteolysis and high release of ammonia.

Impact on performance

Excessive proteolysis in silage not only decreases the true protein content of the forage, leading to loss of nutritive value, but also produces nitrogen sources which are detrimental to the animal, its health and performance.

The excess of ammonia cannot be all used by the rumen microflora and will be absorbed through the rumen wall and transferred to the liver through the blood flow. In the liver, it will be detoxified in urea which will be eliminated by the kidneys in urine and saliva.

However, the detoxifying capacities of the liver and the kidneys are limited. An excess of ammonia and urea in the blood, and an excess of ammonia in the rumen can be observed. These high levels result in several pathologies for the animal, mainly due to the toxicity of ammonia: alkalosis (when rumen pH>7.2), but also other performance and reproduction troubles (Table 1).

In addition, the excretion of excessive urea is an energy consuming process – energy that can no longer be used for milk production.

It is estimated that the energy lost due 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).

Monitoring blood and milk urea remain interesting indicators of nitrogen utilisation from the diet. Ammonia may cross the rumen wall when above 50mg/ml of rumen fluid. As soon as the ammonia reaches 1mg/100ml (blood alcalosis), intoxication becomes lethal. Thus, it is crucial to keep protein degradation, or proteolysis, to a minimum during the ensiling process to preserve the nutritive quality of silage (Table 2).

Controlling proteolysis

Good silage preservation aims at maintaining the silage value as close as possible to the fresh forage in the field: this includes the preservation of its protein content. Certain good silage practices can help ensure an optimal fermentation pattern and thus lower protein losses. Here are some recommendations to attain this goal:

Before harvest:

- Respect a lag time between spreading of manure/slurry and harvesting. Manure/slurry is high in nitrogen and thus increases the buffering capacity of the forage.

Continued on page 9

Table 2. Target ammonia and soluble nitrogen levels to achieve good silage quality (Demarquilly, 1998).

	Soluble N (% N total)	Ammonia (% total N)
Maize	<50	<5
Grass	<50	<7
Legumes	<50	<10

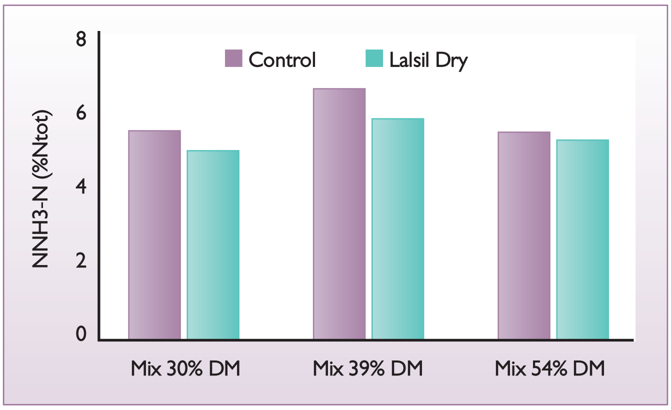

Fig. 2. Effect of Lalsil Dry inoculant on the level of N-NH3 in grass and legumes mix at different DM content (Posieux University, 2008).

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At harvest:

● High dry matter (DM) inhibits proteolytic enzymatic activity. Ensiling at higher DM may minimise proteolysis.

● Proteolytic micro-organisms are mainly located in the soil. A cutting height above 6-7cm should limit soil contamination and the presence of these micro-organisms

● Ensuring a rapid and strong acidification at ensiling quickly inhibits the activity of proteases and proteolytic bacteria. The use of adapted acidifying inoculants, designed for grass forages, accelerates the acidification process, thus limiting proteolysis.

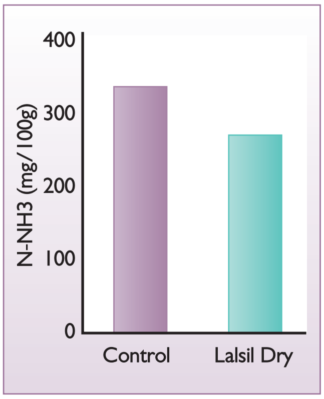

Fig. 3. Effect of Lalsil Dry inoculant on alfalfa soluble nitrogen content (P<0,05) (USZ College of Agriculture, Hungary, 2005).

● Optimal packing and sealing to favour anaerobiosis: the absence of oxygen within the silo inhibits proteases and contributes to a better acidification.

After harvest:

● Avoid silage heating: the increase in temperature increases Maillard reaction and proteolysis. Certain forages, in particular when high in DM, are prone to heating. This can be prevented by the use at harvest of adapted silage inoculants containing L. buchneri NCIMB 40788, proven to prevent mould development after ensiling and heating.

Focus on silage inoculants

The benefits of effective silage inoculants on protein preservation is widely recognised: for example, the INRA system takes the use of inoculant into account when evaluating true protein contents of forages, attributing different proteolysis value according to the use of inoculant or not. Hence, for an equal CP value, there are differences in valuable proteins used in the feeding plan.

Various field data and scientific trials assessed the effect of selected microbial inoculants on grass silage protein preservation:

● Reduced protein loss in grass and legumes: a controlled trial performed in Switzerland shows the effect of Lalsil Dry (a combination of cellulolytic enzymes with a specific lactic acid bacteria and the patented Lactobacillus buchneri NCIMB 40788) on protein loss, as shown by a decreased level of soluble nitrogen at various DM contents when compared to non treated silages (Fig. 2).

● Improved true protein content and aerobic stability of legumes: a controlled trial conducted on alfalfa micro-silos showed that the use of Lalsil Dry:

• Increases acidification kinetics during fermentation, leading to decreased protein losses (Fig. 3).

• Improves aerobic stability at feed-out, reducing moulds and losses (Fig. 4).

● Reduced protein loss in grass silage: in a German trial (Honenheim University), the effect of Lalsil PS (a specific combination of enzymes and acidifying bacteria) on the fermentation profile of 40% DM grass silage showed an improved acidification process, leading to higher protein preservation (Fig. 5).

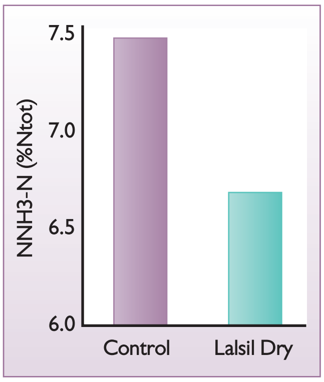

Fig. 5. Effect of Lalsil PS inoculant on protein loss in grass silage (Honenheim University, Germany, 2003).

● Improved aerobic stability in grass silage: a recent field survey conducted by Lallemand (2013) across close to 60 silos and aimed at assessing grass silage quality on farms, showed that for the Lalsil Dry treated silos (n=30), there was no increase in average silage temperature above ambient temperature at feedout, while the untreated silos (n=27) were on average +4°C above ambient temperature.

● Reduced clostridia development in silage. It has been shown that, from a basal contamination level, improved acidification and aerobic stability due to the effect of the inoculant leads to the inhibition of clostridia development within the silo, hence reducing protein breakdown by these micro-organisms.

In conclusion, the use of adapted silage inoculant proven to improve the acidification process and silage fermentation and increase aerobic stability at feed-out is an important tool to help preserve the true protein value of grass and legume silages in addition to good silage practices. ■

Fig. 4 Effect of Lalsil Dry inoculant on alfalfa aerobic stability 45 days after ensiling (USZ College of Agriculture, Hungary, 2005).