CAUSES OF PROTEIN DEGRADATION

Avoidance and effects on ruminant health

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Ruminants are primary consumers which have evolved to become specialised herbivores. In natural nutrient cycles they feed mainly on forage crops while these are in the vegetative growth phase. During this phase the nutrients present in the plant are in a fundamentally different form compared with their form in ripe seeds and in a mature stage.

In the vegetative growth phase, the plant initially produces leaf growth to provide a sufficiently large assimilation area that enables it to bind as much energy as possible through photosynthesis. Nutrients flow in soluble form from the roots to the leaves. But the roots and the nodule bacteria in legumes also need nutrients and energy during this growth phase, just like the above-ground plant parts. So energy and nutrients have to flow to the roots as well. In this vegetative phase plants need very mobile energy, non-protein nitrogen (NPN) and protein compounds.

The metabolic processes are different during the generative phase of flowering, fruiting and seed development. Photosynthesis and the flow of nutrients to the roots ceases. The metabolisable nutrients are transferred to the seeds where they are incorporated into stable starch and protein compounds. These reserves of stable energy and protein form the basis for the germination capacity of ripe seeds, which can often last for several years.

The seeds form the main staple of monogastric organisms – secondary consumers which obtain energy through the efficient utilisation of starch.

Feeding ruminants in the natural nutrient cycle

At the start of the vegetative phase, ruminant forage crops contain NPN compounds, simple proteins and readily available carbohydrates. A wide variety of grasses, herbs and legumes at different stages of

Good forage is critical for healthy animals

maturity are available from June onwards. At the end of the vegetative phase, mature grasses containing starch in the seed heads provide the main source of forage for dry cows during the lean winter months.

In rumen symbiosis, obligate anaerobic bacteria, with the help of energy, can synthesise NPN compounds such as ammonium, urea and amino acids to produce endogenous protein. This bacterial protein is the optimal protein supply for dairy cows. Protozoa and anaerobic rumen fungi break down poorly digestible forage constituents such as cellulose, pectins and hemicellulose.

Forage conservation

In recent decades, hay production has been superseded by ensiling in silage clamps. Silage is now the mainstay feed for dairy cows housed indoors all year round. This practice increasingly removes livestock from their natural nutrient cycles, leading to three major risk factors affecting the health of dairy herds:

Early cutting means that the cattle are fed a basic ration all year round which, in the natural scheme of things, they would encounter only at the start of the growing season and the start of lactation.

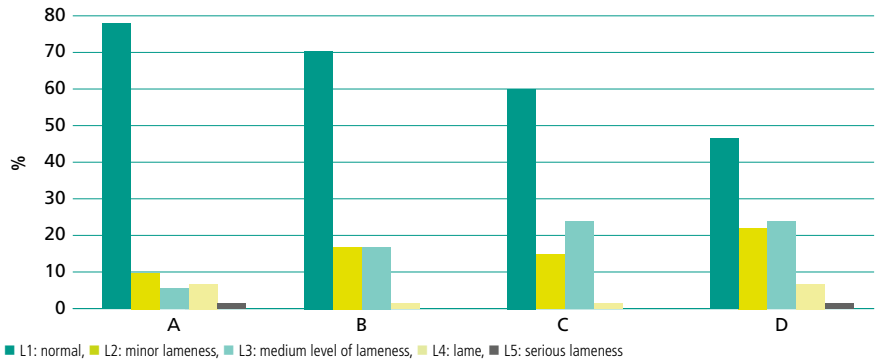
To prevent decomposition and spoilage in the clamp, ensiling is based on the principle of reducing pH levels to 4–4.5 by lacticacid fermentation in the clamp where conditions are moist and anaerobic and DM levels at 30–40 %. However, a cow's rumen needs a pH value of 6.5–6.7. A DM intake of 16–18 kg silage would require additional metabolic performance and an extra energy input to neutralise the pH and provide the right environment for rumen microbes.

In the natural nutrient cycle whereby nutrients in the soil are taken up by plants which are consumed by animals, anaerobic processes take place only in the animals' digestive tract. All other processes take place under aerobic conditions. Where anaerobic conditions occur, they lead to decay and ultimately to mineralisation and loss of these compounds to the cycle of organic mat-ter. Under the conditions prevailing in silage, there is a risk that these negative degradation processes will occur as a result of harmful organisms.

Tab. 1: Soil values in grassland and average silage contamination with biogenic amines on the four farms participating in the EIP grassland and animal health project in the Eifel region, Germany (time period 2016–2018)

Farm		A	B	C	D
Grassland soil value to Stählin soil evaluation system		64,2	70	59,5	45,4
Grassland soil value to Klapp soil evaluation system		6,5	7,1	6	5,7
Silage-making method		Harvestore	Clamp	Clamp	Clamp
Number of grass silage samples taken in the 2016–2018 period		6	10	8	8
Gamma-Aminobutyric acid (GABA)	g/kg	2,61	1,87	1,76	2,24
Biogenic amines					
Tryptamine	mg/kg	0,00	4,51	7,58	4,74
Tyramine	mg/kg	135,30	157,72	282,89	320,39
Putrescine	mg/kg	44,20	73,96	135,66	111,60
Histamine	mg/kg	4,95	20,75	74,10	76,71
Cadaverine	mg/kg	36,48	84,91	191,10	229,39
2-Phenylethylamine	mg/kg	8,19	5,07	15,30	14,32
Spermidine	mg/kg	1,82	2,23	3,70	1,21
Spermine	mg/kg	0,00	95,78	0,50	0,31
Total	mg/kg	230,92	444,92	710,82	758,66

Fig. 1: Average level of lameness on the farms A, B, C, D EIP project, conducted from March 2017 to April 2019



Protein degradation; a major risk factor in the silage-making process

Proteolysis is a natural process that occurs in forage plants at the time of cutting, and continues after the plants have been mown. It is inhibited only by reducing the cellular water content. As a result, best practice is to mow the forage crop when it is as dry as possible and the weather is stable.

Microbial protein degradation

Even in perfectly compressed and covered silage, degradation processes can occur due to microorganisms such as Listeria, Clostridia, etc. present in dirt. Clostridia are bacteria which break down organic material under anaerobic conditions. They are found in soil and in the intestine of humans and animals. They enter the silage chain through animal carcasses, dust and soil particles.

Of the more than 200 Clostridia species, 35 are pathogens and 15 of these pathogenic species produce toxic biogenic amines. The spores of Clostridia can also survive unfavourable conditions in oxygen-rich environments. These spores germinate under anaerobic conditions where there is sufficient moisture – and the silage clamp provides the ideal conditions. The activity of these microorganisms leads to the degradation of energy and proteins. Proteins are broken down into amines, amino acids and finally to ammonia (NH_3). So the NH_3 content in percentage of crude protein combined with the pure protein content has previously served as an indicator for microbial protein degradation. This degradation process can also give rise to toxic biogenic amines.

The EIP project "Grassland and animal health Eifel" has been conducting field tests to monitor and record grassland and forage crop growth, silage quality and the effects on animal health on 4 dairy farms with 1.200 cows since 2016. The data collected has yet to be evaluated, but preliminary results (Table 1) suggest that biogenic amines have a significant impact on hoof health (Fig. 1). The quality of grassland growth also appears to influence the formation of biogenic amines in the silage (figures according to Klapp and Stählin Tab. 1). So it makes sense to test the level of biogenic amines present in silage.

The following recommendations can be inferred from observations to date:

The only way to avoid degradation processes is to follow a good hygiene practice throughout the silage-making process. This includes a good grassland management: a dense canopy with creeping low-growing grasses and white clover ensures a good yield potential, closes gaps arising from sward damage and reduces the risk of contamination. Also, it is important to have a diverse mix of species within the forage crop which allows for "harvesting flexibility". This can be cut at a later date to give the soil chance to dry, thereby minimising the risk of contamination and preventing faster protein degradation by rapidly reducing the cellular water content. Cutting heights should not be too low, ideally 6–7 cm, and the dry matter content of the silage should be 35–45 %. Animal carcasses increase the risk of infection with Clostridium botulinum, which produces the foul-smelling biogenic amine cadaverine. Clean implements, tractors and access routes to the clamp can also help prevent contamination.

These degradation processes can be avoided by drying the crop in driers with solar heating and dehumidifiers. Farm evaluations show that this process can be cost-effective despite the high initial investment costs. This practice should be considered when building new facilities.

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