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Starch degradability in ensiled maize products

An adequate energy supply of high yielding dairy cows requires specific attention. That is important during early lactation, when the milk yield is highest, and the feed intake is still limited. In that period a negative energy balance can be expected. An extensive energy deficit should be avoided due to negative effects, such as loss of body weight, reduced fertility as well as metabolic disorders. Feed material rich in starch, most notably the cereal grains, as the primary energy component in ruminant nutrition, provide a practical method of delivering a sufficient energy density in the diet to promote both, high levels of production and reduced negative energy balance.

Taking current recommendations into account, about 15 to 25% rumen degradable carbohydrates (starch & sugar) should be used in dairy rations. Higher concentrations of easily degradable carbohydrates result in excessive amounts of acids in the rumen and consequently lead to acidosis. As the performance increases, the importance of ruminal undegradable starch is rising and should be included in the diet with a proportion of 1 to 5%, depending on the milk yield. The digestion of rumen undegradable starch in the small intestine enables a higher efficiency of metabolizable energy utilisation, that is attributed to reduced energy losses by ruminal fermentation and minor need for the energy-intensive process of gluconeogenesis in the liver. The better energetic use of consumed starch is particularly advantageous in the phase of early lactation, since the extent of the negative energy balance can be reduced without an increase in feed intake. Nevertheless, no more than 1.3 to 1.8 kg/d of rumen undegradable starch should be fed to dairy cows, because starch digestion in the small intestine is limited and higher amounts cannot used efficiently.

Depending on maturity level, maize grains contain more than 40% of rumen-undegradable starch and therefore significantly more than comparable cereal grains like wheat, barley or rye. Furthermore, there are considerable differences regarding to the rate of breakdown in the rumen. While the starch of maize is moderately rumen-degradable, whereas the starch of other cereal grains is classified as easily rumen-degradable. Therefore, maize starch not only provides more metabolizable energy per kg intake than comparable starch sources but also leads a lower volatile fatty acid accumulation in the rumen per unit of time, whereby the pH value is less strongly influenced and thus enables constant feed intake and fibre digestibility.

The distinctly slower degradability of maize starch is attributable to several factors, which reduce the enzymatic and microbial hydrolysis of starch granules, respectively. Besides the strongly hydrophobic properties of starch granules, the granules are surrounded by a protein matrix that is quite resistant to proteolytic activity of rumen microorganisms and thus protects the starch from degradation by amylolytic bacteria.

However, it must be considered when using maize products in the ration that the degradability of starch in the rumen is highly variable. In addition to degree of plant maturity, type of preservation also has a significant influence on the resistance to ruminal digestion (Table 1). Grain maize, dried or preserved with **KOFA GRAIN pH 5**, has the lowest degradation rate. In ensiled grounded maize grains as well as CCM, the stability is reduced to about 25%. In terms of whole plant maize silage, 15% of the starch are undegradable in the rumen, if the dry matter in the grain exceeds 60%, whereas a resistance to digestion about 10% can be assumed for maize silages with lower maturity levels. Despite comparable degradation rates for maize silages and, for example, wheat grains, the slower degradability per time unit in the rumen must still be considered, with the result that maize silage cannot easily be replaced by wheat products due to their different properties. If a maize product with slow starch availability is required to enhance the ration and chemical preservation is not an option, maize grain silage, inoculated with **KOFASIL S 1.2** is an excellent alternative.

The increased degradability of starch in ensiled feed material is due to effects of acids and proteolytic activities during the ensiling process, making the starch granules more accessible for microbial degradation in the rumen. The starch degradability is closely correlated with the duration of the ensiling process, since starch granules broken down by the constant exposure to the acidic environment and the progressive hydrolysis of the protein matrix by proteolytic enzymes.

To achieve highest possible concentrations of rumen undegradable starch in ensiled maize products, great attention should be paid to plant maturity level, hybrid effect, and the type of silage. Moreover, a purposeful ensiling process with an optimized fermentation pattern, such as when KOFASIL S 1.2 is used as an inoculant, is advantageous because, on the one hand, undesired proteolytic processes are limited and, on the other hand, the strongly acidifying lactic acid is converted into acetic acid and 1,2 propanediol, which results in an improved aerobic stability after silo opening as well as enhanced feeding value.

Table 1: Starch degradability in the rumen of various maize products (according to PRIES & SPIEKERS, 2008)

	DM (%)	starch (g/kg DM)	degradability (%)
Grain maize, dried	88	> 690	58
Grain maize, ensiled	60 – 65	> 660	75
Whole plant maize, fresh	< 30	< 280	75
Maize silage (kernel DM < 55%)	< 32	< 280 – 300	90
Maize silage (kernel DM 55-60%)	> 32	< 300	85
CCM silage	60 – 65	> 620	75

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