DLG Information 2/2006/en

Forage evaluation

Part B - DLG key for assessing the fermentation quality of ensiled green forage on the basis of chemical analysis

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The key is suitable for the assessment of all types of ensiled green forage(silages from grass, legumes, green crop cereals, whole crop maize and small cereal grains, cruciferous plants and beet leaves), independent of the ensiling procedure, dry matter (DM) content and the use of chemical or biological additives. For the assessment of silages from maize cob products, high-moisture cereal grains, root crops and co-products of the food industry of plant origin (pressed pulp, brewer's grains, etc.), it is only applicable insofar as fermentation silages are concerned. Application to alkali-treated silages is generally excluded.

The subject of the assessment is the preservation success in the preparation of silage (success of ensiling). For this purpose, characteristics of the fermentation process and nutrient degradation in the silo are used, which can be verified on the silage. The appraisal of a silage, known as fermentation quality, provides important information on the extent of nutrient losses, the reduction in nutrient and energy content that has occurred as well as the storage stability of the silage in the silo under anaerobic conditions. Indirectly, the silage assessment also provides information on the expected reduction in silage intake and risks to milk quality and animal health.

In principle, the fermentation quality could be assessed on the basis of retained or formed desirable ingredients such as sugar, starch, protein, amino acids or lactic acid. In practice, however, it has been shown that the fermentation quality can be better determined by the analysis of products of undesirable organic matter degradation. As extensive studies at the Humboldt University in Berlin have shown, the fermentation quality can reliably and differentiatedly be derived essentially from the contents and the mutual ratio of butyric acid and acetic acid. Although the inclusion of the pH value usually provides an additional indication of whether or to what extent acidification has taken place, the weighting of pH has been reduced compared to the past. For this assessment, the previous additional use of the ammonia nitrogen fraction of total nitrogen can be waived in the future, as the intended indication of the extent of protein degradation is already adequately captured by the butyric acid content. The new assessment is presented below. It is initially intended for testing. The butyric acid content and acetic acid content as well as the pH value are assessed individually by means of scores, and a summarised judgement is derived from the total score.
The assessment applies to silage that is not mouldy, contaminated or spoiled.

1. Assessment of the butyric acid and acetic acid content

Butyric acid (BA) content[1)]		Acetic acid (AA) content[2)]	
BA (% DM)	**Score**	**AA (% DM)**	**Score**
0 - 0.3	90	to 3	0
> 0.3 - 0.4	81	> 3 - 3.5	- 10
> 0.4 - 0.7	72	> 3.5 - 4.5	- 20
> 0.7 - 1.0	63	> 4.5 - 5.5	- 30
> 1.0 - 1.3	54	> 5.5 - 6.5	- 40
> 1.3 - 1.6	45	> 6.5 - 7.5	- 50
> 1.6 - 1.9	36	> 7.5 - 8.5	- 60
> 1.9 - 2.6	27	> 8.5	- 70
> 2.6 - 3.6	18		
> 3.6 - 5.0	9		
> 5.0	0		

[1)] Butyric acid content denotes the sum of i-butyric acid, n-butyric acid, i-valeric acid, n-valeric acid and n-caproic acid
[2)] Acetic acid content denotes acetic acid plus propionic acid

2. Assessment of the pH value:

Less than 30% DM		30 - 45% DM		More than 45% DM	
pH	**Score**	**pH**	**Score**	**pH**	**Score**
≤ 4.0	10	≤ 4.5	10	≤ 5.0	10
> 4.0 - 4.3	5	> 4.5 - 4.8	5	> 5.0 - 5.3	5
> 4.3 - 4.6	0	> 4.8	0	> 5.3	0
> 4.6	- 5				

3. Overall assessment

Total score (Sum of score of tables 1 and 2)	**Fermentation quality**	
	Grade	**Judgement**
100 - 90	1	Very good
89 - 72	2	Good
71 - 52	3	Needs improvement
51 - 30	4	Bad
< 30	5	Very bad

Supplementary information

Analysis results and reference values

All data in the evaluation key relate to the DM content corrected for losses of volatiles of silages occurring during oven-drying (acids, alcohols, ammonia), both the data for the DM content itself and the concentrations of acids expressed on a DM basis.
If analysis results are used without the above corrections of DM or total N content, only minor deviations from the correct assessment result are observed in the case of good fermentation quality. Silages with poor fermentation quality are assessed harsher without these corrections to the analytical values.

Further quality aspects

It should be noted that the fermentation quality only covers a partial aspect of the overall silage quality. The current assessment based on the determined butyric acid and acetic acid content as well as the pH value, should always be supplemented by a sensory assessment using the DLG sensory test (DLG 2004). This serves both as a plausibility check and to detect hygienic defects that are not detected by this key based on chemical analysis but may be present, such as mould infestation, reheating due to yeasts or bacterial decomposition (rotting).
Furthermore, an assessment of the shelf life (durability) of silage after removal from the silo (aerobic stability) would be desirable, but there are currently no recommendations for this.
The evaluation of the fermentation quality thus complements the determination of the feeding value of silage, i.e. the nutrient and energy contents and, if necessary, other feeding value indicators that are important for ration optimisation (e.g., protein value, structural value).

Determination of scores via regression equations

When analysing test results using a computer, it is recommended that the scores are calculated using the following equations.

Score for butyric acid content:

Score = - 29.985 Ln (x) + 53.982; x = butyric acid content
(scope limited to score = 0 ... 90)

Score for acetic acid content:

Score = - 59.158 Ln (x) + 63.256, x = acetic acid content
(range limited to score = 0 ... - 70)

Score for pH value:

Applicable to silage ≤ 30% DM	
≤ pH 4.0	Score 10
> pH 4.0 - 4.6	Score according to equation (E) E1 or E2
> pH 4.6	- 5 scores
E1: Score = 186.9 + 4.827 x^2 − 63.645 x	x = pH value
E2: Score = 10 − 25 (x − 4.0)	

Applicable to silage > 30 - 45% DM	
≤ pH 4.5	Score 10
> pH 4.5 - 4.8	Score according to equation E3 or E4
> pH 4.8	0 scores
E3: Score = 658.2 + 23.81 x^2 − 251.19 x	x = pH value
E4: Score = 10 − 33.3 (x − 4.5)	

Applicable to silage > 45% DM	
≤ pH 5.0	Score 10
> pH 5.0 - 5.3	Score according to equation E5 or E6
> pH 5.3	0 points
E5: Score = 789.76 + 23.81 x^2 − 275 x	x = pH value
E6: Score = 10 − 33.3 (x − 5.0)	

Publisher: DLG e,V.
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