



SILAGE ANALYSIS & INTERPRETATION

What is silage?

Ensiling of surplus feed to obtain silage for use during periods of feed deficit is possible by way of acid fermentation as a means of preservation. Types of forage commonly conserved in this manner are pasture, annual ryegrass, cereal (wheat, barley, oats, triticale), maize and lucerne. Common methods of ensiling involve using a silage pit, stack, silo or as baled and wrapped silage.

During the ensiling process, plant sugars are converted to a range of acids and also a small quantity of ethanol. The lactic acid produced is largely responsible for preserving the silage until needed. Silage inoculant is often used to introduce desirable bacteria for silage fermentation and rapid pH drop.

Making high quality silage starts with harvesting the forage at the appropriate growth stage, with adequate moisture and soluble sugars for good fermentation. Maturity of the harvested crop, rate of wilting, chop-length, compaction and sealing of the stack or bales all impact on the resultant silage quality.

Making silage -the process

- **Aerobic phase**

When the herbage is cut, enzymes consume the water-soluble carbohydrates (WSC), or simple sugars, for respiration producing carbon dioxide, water and heat. Plant enzymes also begin to break down complex carbohydrates to WSC. This initial aerobic phase will continue until the oxygen in the compacted and sealed system is depleted.

Acetic acid-producing bacteria (enterobacteria), active during the aerobic phase that occurs during the first 2-3 days of ensiling, drive the pH down. Lowering of the pH creates a favourable environment for lactic acid bacteria (LAB) to be active. The low pH, resulting from this production of fermentation acids, eventually stops the action of enzymes therefore creating a favourable anaerobic environment for the lactic acid bacteria that finalize the fermentation process over the next 2-3 weeks.

Excessive formation of acetic acid by a prolonged aerobic phase can result in reduced palatability for livestock. Some acetic acid formation is desirable, however, since it also has a preserving effect by inhibiting the growth of moulds and yeasts.

- **Anaerobic phase**

Anaerobic fermentation commences when the oxygen is depleted and the pH has dropped due to microbe activity during the aerobic phase. LAB ferment WSC to mainly lactic acid while very small quantities of other products are formed. A secondary and unwanted clostridial fermentation can occur if lactic acid is produced too slowly and moisture levels are high. *Clostridia* ferments lactic acid and WSC to all the unwanted acids, viz. acetic-, propionic- and butyric acid. If conditions are suitable for clostridia populations to increase, the levels of propionic and butyric acid can increase substantially, resulting in low feed value silage that has a rancid odour and is unpalatable to livestock.

Since the ensiling process and resulting silage is influenced by numerous factors, the aim is to establish the most appropriate set of conditions to ensure the best possible silage produced. Prolonged aerobic phases favouring acetic acid production can be a result of various factors operating simultaneously, or individually, that should be avoided:

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- If the material is too dry, it will hamper the enzyme activity and therefore lactic acid production.
- If the WSC content is too low it will extend the initial fermentation phase resulting in pH dropping too slowly and enterobacteria not being deactivated quickly enough by a sufficiently low pH environment.
- Inclusion of too much air and therefore oxygen in the stack as a result of low compaction.
- Elevated buffering by legume silage resisting pH decrease.

Analytical tests to indicate silage quality

The quality of silage is highly dependent on the quality of the forage harvested and the type of fermentation that has occurred. These factors will influence palatability to livestock, livestock productivity, dry matter losses and the risk of toxins forming in the silage. Even under ideal conditions, loss of at least 8% of the forage dry matter is expected throughout the ensiling process.

Quality indicators for Silage include:

- pH
- Dry Matter (%)
- Crude Protein (%)
- Acid Detergent Fibre (%)
- Neutral Detergent Fibre (%)
- Digestibility (%DOMD)
- Metabolisable Energy (MJ ME/kg DM)
- NH₄:Total N (%)
- Volatile Fatty Acid Profile (%)

Typical feed values

The following table gives general information on the feed quality of a range of typical forages.

Table 1 Feed Quality for Forage Samples

Feed Type	Dry Matter (%)	Crude Protein (%)	Acid Det.Fibre (%)	Neutral Det.Fibre (%)	Digestibility (%DOMD)	Metabolisable Energy (MJ/kg)
Mixed Pasture	12 – 25	20 – 30	20 – 30	30 – 45	65 – 80	9 – 12
Pasture Silage	25 – 30	14 – 20	20 – 35	30 – 45	65 – 75	9 – 11
Cereal Silage	35 – 40	8 – 12	25 – 40	35 – 60	55 - 65	8.5 – 10.5
Maize Silage	25 – 35	6 – 9	25 – 35	35 – 50	60 – 70	9.5 – 11
Lucerne Forage	15 – 25	20 – 30	25 – 30	35 – 45	60 – 70	9 – 12
Lucerne Hay	85 - 90	18 – 25	25 – 35	35 – 45	55 - 65	8 – 11

Dry matter, Crude protein, ADF/NDF, Digestibility and ME

These measures are described in Hill Laboratories' Technical Notes "Pasture and Feed Forage Quality" and "Metabolisable Energy testing at Hill Laboratories".

For silages, the digestibility (and subsequent derived ME) is very dependant on the maturity of the harvested crop. Acid detergent and neutral detergent fibre measures indicate structural carbohydrate levels; these increase with age of the plant causing a decrease in digestibility. Choosing the ideal harvest time is therefore very important in order to produce highly digestible silage.

Crude protein is directly related to the nitrogen content of the silage. Where heat damage has occurred during ensilation, some of the protein in this measure will have been converted to forms of protein not available to the animal. Hill Laboratories are investigating tests that may better represent animal-available protein.

pH (Measure of acidity)

Fermentation of forage is intended to lower the pH through the formation of Volatile Fatty Acids (VFA) to preserve the forage. Factors that influence silage pH are: soluble carbohydrate content of the forage conserved, moisture content of the forage, chop length, compaction, micro-organisms that controlled the fermentation (inoculant), contamination of forage with dust or mud and the buffering capacity of the forage.

Different forage types are well preserved at pH levels between 3.7 and about 4.7 due to different buffering capacities of forages i.e. maize silage at pH 3.7 to 4.2 compared to grass or legume silage at pH 4.3 to 4.7.



TECHNICAL NOTES

Ammonium-N/Total-N% (AM-N/TN)

Ammonium-N is the product of protein decomposition. While some protein breakdown will occur normally, this increases where there is either poor preservation or a slow rate of fermentation. The common objective of silage makers is to achieve AM-N/TN of less than 10%.

Where this level is greater than 12-15% it is likely that the pH is also high and that significant protein decomposition has occurred. The storage life of the silage will be reduced.

Hill Laboratories and VFA

The determination of Volatile Fatty Acids (VFA) is a new test offered by Hill Laboratories and complements our existing feedstuff tests. As a result of the complex reactions taking place during ensiling, and various factors affecting the eventual quality of the silage, the VFA profile sheds light on factors not measured appropriately by existing tests. The pH is an indication of the acidity of the silage, but does not give an indication of the organic acid composition that also affects the value of the silage. The VFA of concern are lactic acid, propionic acid, acetic acid and butyric acid.

Recommended volatile fatty acid (VFA) levels

Generally it is recommended that lactic acid should comprise 65 % of the total VFA content and that the lactic acid: acetic acid ratio should not be less than 3:1.

High levels of acetic (> 3 - 4%) or butyric acid (> 0.5%) in any type of silage are indicators of less than desirable silage fermentation. However where *Lactobacillus buchneri* inoculant has been used, the acetic acid level may be elevated without any negative effects.

Although different authors for VFA profiles quote slightly different ranges, the values presented in Table 1 can serve as a guideline.

	Lucerne silage 30 – 35% DM	Lucerne silage 45 – 55% DM	Grass silage 25 – 35% DM	Maize silage 25 – 35% DM	Maize silage 35 – 45% DM	Cereal silage 35 - 40%
pH	4.3 – 4.5	4.7 – 5.0	4.3 – 4.7	3.8	3.7 – 4.2	3.7 – 4.5
Lactic acid	7 – 8	2 – 4	6 – 10	4.9	4 – 7	4 – 7
Acetic acid	2 – 3	0.5 – 2.0	1 – 3	1.4	1 – 3	1 – 3
Propionic acid	< 0.5	< 0.1	< 0.1	N/A	< 0.1	< 0.1
Butyric acid	< 0.5	0	< 0.5	0.25	0	0
NH4-N:TN	10 – 15		8 – 12		5 – 7	5 – 10

Table 1: Typical VFA profiles for different silages based on percentage dry matter content of silage.

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Practical implications

Numerous factors and processes contribute to the quality of silage and the processes involved do not commence and terminate in any abrupt way. Processes overlap and different rates of transformations take place that adds to the complexity of the ensiling process. Knowledge of the VFA profile provides an excellent assessment of the quality of silage produced and effectiveness of practices followed. This additional knowledge can be used in managing decisions regarding use, value and practices:

- The negative effects of high levels of acetic acid can be avoided by including 1 – 1.5 % bicarbonate of soda prior to feeding that will neutralise the acetic acid and improve palatability.
- Knowledge of the VFA profile and factors affecting composition can be used to optimise future practices.
- Additional quality measure.
- Correlates with animal health and production.
- Wilting or pre-cut herbicide treatment of 'lush' pasture or grass forage are effective methods of improving the fermentation characteristics and minimising effluent loss from what would otherwise be wet forage with Dry Matter of less than 25%.

References

1. Andrieu, J., 1976. *Animal Feed Science and Technology*. 1, 381 – 392.
2. Etchebarne, M.A., *Silage and fermentation testing for potential problems*. www.dairybusiness.com/western/April01/silage.htm - 37k - Supplemental Result
3. Kung, L., 2001. In: T.P.Lyons & K.A. Jacques (Eds.) *Science and Technology in the Feed Industry, Proceedings of Alltech's 17th Annual Symposium*, pp. 145 – 159.
4. Kung, L. & Stokes, M.R., *Analysing silages for fermentation end products*. http://ag.udel.edu/anfs/faculty/kung/articles/analyzing_silages_for_fermentati.htm
5. Kung, L. & Shaver, R., *Focus on Forage Vol 3: No.13, Interpretation and Use of Silage Fermentation Analysis Reports*, University of Wisconsin
6. Piltz, J.W. & Kaiser, A.G., 2004. *Principles of silage preservation*. In: A.G. Kaiser, J.W. Piltz, H.M. Burns & N.W. Griffiths (Eds.). *TopFodder Successful Silage*. pp 25 - 56. Dairy Australia and New South Wales Department of Primary Industries, Orange, NSW.
7. *New Tool For Evaluating Silage Quality, Dairy One, Ithaca, New York* www.dairyone.com/Forage/FactSheet/VFA_Score.htm - 16k
8. *Dexcel FarmFact 5-10, Grass Silage – The Preservation Process, February 2001*
9. Lewis, T. Occasional article "Reducing the Cost of Silage", Cundy Technical Services, Auckland, NZ

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