Silage additives: Do they make a difference?

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Introduction

The question if silage additives do make a difference has been asked by many farmers all over the world. In France about 30 silage additives are sold. All these silage additives have been evaluated prior to approval by the Ministry of Agriculture (Demarquilly & Andrieu, 1996). The experimentation required to obtain full approval is carried out at INRA (Unit of feed evaluation). Silages are made using the additive submitted for approval together with a negative control (i.e. without additive) and a positive control (i.e. formic acid applied at 3.5 L/t of fresh crop for grasses and 5.0 L/t for lucerne). Silage additives are only approved if the application of the product has produced results that are at least similar or close to those obtained with the positive control.

In the United Kingdom 129 silage additives are marketed and the UK Forage Additive Approval Scheme (FAAS) has been implemented (Haigh et al., 1996). Evaluation of forage additives is done on a voluntary basis. In the UK 39 silage additives (65 products) have been approved by the forage additives approval scheme. Twenty five of these were inoculants, 10 were acids/salts and four were other products. Of the 25 inoculants, 88% improved fermentation, 64% improved live weight gain (+ 90 g/day) and improved 76% milk production (+1 litre/day). To be approved the additives had to result in a meaningful improvement compared to untreated silage in three studies (Weddell et al., 2002). According to Haigh et al. (1996), 45% of silage (mainly perennial ryegrass) made in England and Wales is treated with silage additives.

In Germany more than 50 silage additives are on the market and a voluntarily silage evaluation scheme, the DLG-Quality-Seal for additives scheme has been put in place. Additives are evaluated to determine their effect on the fermentation process, aerobic stability of silage, prevention of clostridial development in silage, effluent production, silage intake and digestibility (Pahlow & Honig, 1996). In Germany the potential of silage additives to improve fermentation quality, to reduce losses and increase aerobic stability has been proven on a broad basis of experimental data (Honig & Thaysen, 2002).

In South Africa no official silage evaluation or approval scheme exists and only a limited number of studies have been undertaken to evaluate silage additives under South African conditions.

Silage additives do have the potential to work. This paper deals with the principals of ensiling and summarises published studies on the use of silage additives to clarify if and when silage additives do work.

Principles of ensiling

The principles of ensilage are well known. The first essential objective is to achieve anaerobic conditions under which natural fermentation can take place. In practice this is achieved by consolidating and compacting the material and the sealing of the silo to prevent re-entry of air. Air that is trapped in the herbage is rapidly removed by respiratory enzymes (McDonald et al., 1991). Where oxygen is in contact with herbage for a period of time, aerobic microbial activity occurs and yeast and mould will grow. This causes the material to decay to a useless, inedible and frequently toxic product (McDonald et al., 1991). Finer chopping of plant material results in improved compaction and fermentation of silage. This then improves palatability and intake of silage (Apolant & Chestnutt, 1985).

The second objective is to discourage the activities of undesirable microorganisms such as clostridia and enterobacteria. Clostridia are present on crops and in the soil in the form of spores. Clostridia multiply under anaerobic conditions, produce butyric acid and break down amino acids resulting in silage with a poor palatability and lower nutritional value. The enterobacteria are no-spore forming, facultative anaerobes, which ferment sugars to acetic acid and other products. Enterobacteria also have the ability to degrade amino acids (McDonald et al., 1991). Growth of clostridia and enterobacteria can be inhibited by lactic acid fermentation. Lactic acid bacteria are normally present on harvested crops and these organisms ferment naturally occurring sugars like glucose and fructose to mainly lactic acid. The lactic acid produced increases the hydrogen ion concentration and undissociated acids to a level at which undesirable organisms are...
inhibited (McDonald et al., 1991). The critical pH at which growth of clostridia and enterobacteria are inhibited depends on the moisture content and the temperature. The wetter the material the lower the critical pH will be. According to Weissbach (1996) the pH required for stability of silage at 150, 250, 350 and 450 g DM/kg, is 4.10, 4.35, 4.60 and 4.85 respectively. The growth of most acid tolerant clostridia will be inhibited by a pH just below 5.0 (Jonsson, 1991). With very wet crops at a DM concentration of 150 g/kg even a pH of 4 may not inhibit clostridial growth. Clostridia are very sensitive to water availability and require wet conditions for active development. Growth of clostridia can be inhibited by reducing the moisture content by wilting prior to ensiling. Lactic acid bacteria have a high tolerance to low moisture conditions and are able to dominate the fermentation of high dry matter crops (McDonald et al., 1991).

Lactic acid bacteria, which are the most important species during ensiling, are usually present on grass in numbers 1000 times lower than their main competitors, fungi and enterobacteria. After ensiling, the microorganisms capable of anaerobic growth namely, lactic acid bacteria, enterobacteria, clostridia, some Bacillus spp. and yeasts begin to grow and compete for available nutrients. The first few days of ensiling are critical to the success or failure of the subsequent fermentation. Under favourable conditions lactic acid bacteria will quickly acidify the environment to such an extent that the competing organisms will not be able to survive and the end result will be a stable, low pH silage. If, however, the pH is not lowered quickly enough the undesirable microorganisms, mainly enterobacteria, clostridia and yeasts will be able to compete for nutrients. This will reduce the chances of obtaining a stable silage (McDonald et al., 1991).

Many investigations have been performed on the numbers of epiphytic bacteria on silage crops. Numbers of epiphytic bacteria found on standing grass (Fenton, 1987) and lucerne (Muck, 1989) are often below 100/g of fresh material. The numbers present on the crop at ensiling are of more practical importance. After mowing, wilting and chopping increased numbers of epiphytic lactic acid bacteria are found. The numbers at ensiling range from 50 000 to 500 000 with extremes up to 10 million/g (Pitt & Leibensperger, 1987; Ruser, 1989; Spoelstra & Hindle, 1989; Rooke, 1990).

Wilting of crops is often recommended. Pahlow & Weissbach (1996) found that only 10% of the total epiphytic lactic acid bacteria on grasses can grow at a dry matter content of above 450g/kg. Osmotolerant strains of lactic acid bacteria should therefore be identified and included in inoculants added to wilted drier silage crops.

In South Africa no survey has been done to determine the numbers of epiphytic microflora present on crops prior to ensiling. It has been shown that climatic conditions do have an impact on the numbers of viable lactic acid bacteria. High numbers at ensiling positively correlate with environmental temperature and air humidity and negatively with solar radiation (Muck, 1989; Ruser, 1989). Ruser (1989) reported on a survey of 991 grass and 370 maize crops samples and found 46 to 59% of the lactic acid bacteria were homofermentative. By increasing the number of homofermentative lactic acid bacteria more efficient fermentation may take place. The effect of adding lactic acid bacterial inoculants to silage crops under local conditions in South Africa may differ from that found in Europe, as solar radiation is much higher in South Africa.

Silage additives have been developed over years to improve the nutritive value of silages and to reduce some of the risks during the ensiling process (Henderson, 1993). A silage additive should be safe to handle, reduce DM losses, improve the hygienic quality of the silage, limit secondary fermentation, improve aerobic stability, increase the nutritive value of the silage and give the farmer a return greater than the cost of the additive (Meren salmi & Virkki, 1991).

Results of inoculant studies

In Table 1 results of laboratory and production studies where inoculants were evaluated, are presented. Many more studies could have been added to this table but the fact is that positive, no and negative responses on the use of inoculants are reported in literature. It is also possible that not all negative results have been published, thus creating a more positive case for the use of inoculants. Many studies have been undertaken to determine the effect of inoculants on the fermentation process during ensiling in laboratory silos. This creates optimal ensiling conditions that may not always prevail when silage is made on a farm. A limited number of studies measuring growth and milk production of animals fed untreated or inoculated silage have been published.
Tropical grasses are not easy to ensile as they contain low levels of water-soluble carbohydrates and are often difficult to compact. Silage made from these grasses often contains butyric acid and acetic acid that will lower its palatability and intake by animals.

Table 1 The effect of inoculant on silage fermentation, aerobic stability, intake, growth and milk production.

<table>
<thead>
<tr>
<th>Crop</th>
<th>Fermentation</th>
<th>Aerobic stability</th>
<th>Intake</th>
<th>Growth</th>
<th>Milk prod</th>
<th>Author</th>
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<tr>
<td>D. eriantha</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
<td>ND</td>
<td>ND</td>
<td>Meeske et al., 1999</td>
</tr>
<tr>
<td>E. curvula</td>
<td>+++</td>
<td>0</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
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</tr>
<tr>
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<td>+++</td>
<td>ND</td>
<td>++</td>
<td>+++</td>
<td>++</td>
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<td>ND</td>
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<td>ND</td>
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<td>0</td>
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<td>++</td>
<td>+++</td>
<td>+</td>
<td>Gordon, 1989</td>
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<td>++</td>
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<td>++</td>
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<tr>
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<tr>
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<td>Filya et al., 2002</td>
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<tr>
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<tr>
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<td>ND</td>
<td>ND</td>
<td>Filya &amp; Sucu., 2002</td>
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<tr>
<td>Oats</td>
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<td>+++</td>
<td>0</td>
<td>+++</td>
<td>Meeske et al., 2002</td>
</tr>
<tr>
<td>Wheat</td>
<td>+++</td>
<td>- - -</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>Weinberg &amp; Ashbell, 1993</td>
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<tr>
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<tr>
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<td>ND</td>
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<td>ND</td>
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</table>

+++ = large positive effect, ++ = medium positive effect, + = slight positive effect, 0 = no effect, - - - = negative effect, ND = not determined

A positive effect of adding an inoculant to tropical grasses at ensiling can be expected. Inoculated tropical grass silage often has a lower pH, lower acetic acid, lower butyric acid and higher lactic acid content. Less protein is broken down to ammonia in the inoculated silage compared to untreated control silage. The intake and digestibility study of Meeske et al. (1999) has shown that mature Merino rams consumed 20% more of the inoculated *Digitaria eriantha* and that *in vivo* digestibility was increased by 5% compared to control silage. The control silage had 0.75% butyric acid compared to the 0.1% for the inoculated silage.

Maize is easy to ensile as it has a high sugar content, a low buffering capacity and is easy to compact. The biggest challenge is to improve its aerobic stability. This will result in a higher silage intake and may improve animal production. The study of Meeske et al. (2003) did show an improvement in aerobic stability, higher silage intake, less protein breakdown in maize silage when an inoculant was added during ensiling. Milk production was, however, not increased. The intake of lambs fed inoculated maize silage was 10.7% higher and growth tended to be 6.6% higher (Meeske & Basson, 1998). According to Richard Muck less than 50% of studies with inoculants added to whole crop maize at ensiling resulted in a more rapid drop in pH. This is to be expected as the pH in maize silage often drops to 4 within the first 48 hours of ensiling leaving very little room for improvement in rate of preservation.

The adding of an inoculant to oat silage made at soft dough stage did result in improved preservation, higher intake (+5.1%) and a milk response of 1 kg/day (+5.9%) in Jersey cows.

Dr Richard Muck of the US Dairy Forage Research Centre presented the following data on the percentage of trials where the pH was lower in the silage as a result of adding of an inoculant. Lucerne/alfalfa and grass showed a positive effect in 59 and 63% of the studies, respectively, while maize and small grain silage did benefit in 43 and 31% of the studies. Two silages with the same pH at the end of the ensiling process may differ largely depending on the rate at which the pH was lowered.
Figure 1. The % of trials where inoculants lowered silage pH
(Muck, R., 2002)

Should I use an inoculant???
The addition of an effective inoculant at ensiling is recommended on forages that are difficult to ensile.
Forages that are difficult to ensile have:
1. A dry matter content below 20%
2. A sugar content of 1.5 to 2% of fresh material
3. A high protein content and high buffering capacity
4. Been wilted for long periods in unfavourable weather conditions

Tropical grasses such as kikuyu, Smutsfinger grass and *Eragrostis curvula* have a low sugar content and legumes such as lucerne and red clover have a high buffering capacity and a low sugar content. They are therefore forages that are difficult to ensile.
Small grain silages may improve when an inoculant is added at ensiling.
Maize silage is the main silage crop. Inoculants may improve fermentation and animal production.

Be practical !!!
Can I improve my silage with the use of an inoculant?
How good is the silage that I make?
Ensure that the basic silage making principles are followed:
- DM content at ensiling at least 28%
- Ensile crop at the right stage
- Filling and closing of the silo in less than seven days (as soon as possible)
- Good compaction: 750 kg wet material/m$^3$ for maize silage
- Allow 3 minutes of compaction time per ton of wet material
- Chop length may vary from 5 to 15 mm for maize silage
- Seal silo well, plastic well pressed down on the material with tyres or sand.
The inoculant will not correct basic management problems. If you can squeeze any moisture out of the silage with your hand the dry matter content is below 28%. You need to wait longer or wilt the forage if possible. Measure the pH of the silage. Is the pH low enough at the specific dry matter content?

\[
\text{pH} = 0.00359 \times \text{DM (g kg}^{-1}\text{)} + 3.44
\]

If the pH is higher than pH needed for preservation, use an inoculant next time.

The silage should have a nice sweat fruity slightly acidic smell. Any bad smell in silage is undesirable. It means that butyric acid is present and that you can improve on the rate of preservation. This often goes hand in hand with a moisture content, higher than 70% (DM < 30%). If you detect a bad smell on your hand after you have discarded the silage it means that there is butyric acid present in the silage. The butyric acid will lower palatability and intake of the silage. When this silage is mixed in a TMR, intake of the total diet will be lower. If cows eat 0.5 kg DM less per day, milk production will drop with 0.8 kg/cow/day. Use an inoculant next time when making silage and repeat the evaluation next year.

A sharp acetic acid smell means fermentation has been dominated by acetic acid bacteria or you have taken too long to fill and seal the bunker. Intake of this silage will be lower.

Conclusions
The addition of inoculants may have a beneficial effect but will not always be successful on all forages.

Tropical grasses and legumes are difficult to ensile and, therefore, the use of an inoculant on these forages is recommended.

Consider use of an inoculant on maize silage, it may work.

Use inoculants that have been evaluated and approved. It does make a difference!!!

Evaluate your silage and decide on the use of an inoculant.

References


Pahlow, G. & Weissbach, F., 1996. The effect of numbers of epiphytic lactic acid bacteria (LAB) and of inoculation on the rate of pH decline in direct cut and wilted grass silages. Proceedings of the 11th International Silage Conference held from 8 to 7 September at the University of Wales, Aberystwyth.