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Technical Article

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The two Ls of silage, *Listeria* and *licheniformis* – are they losing you money?

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All too frequently farmers experience the problem of aerobic spoilage in their silages, the most visible indicator of this being mouldy, inedible material. Once the silage has got to this sorry state it is the end of the process and so, for this article, I am going to describe this as aerobic spoilage to differentiate it from aerobic deterioration which is the process that begins when any oxygen, no matter how small in concentration, is present in silage. This deterioration can commence when the silo is believed to be sealed but isn't, or immediately after exposure to air, when oxygen is more obviously present.

In this article I will focus on two specific bacteria, the two Ls of silage, namely *Listeria* and *licheniformis* (or more precisely *Bacillus licheniformis*). If either of these is present in your silage, life can become hell! *Listeria* and in particular *L. monocytogenes* and *L. ivanovii* both cause diseases in ruminants, most notably abortion in sheep, but also, among others, listeria eye (often called 'silage eye') in cattle. *B. licheniformis* is a notable cause of abortion or the birth of small, un-thrifty calves, in cattle, although for both groups of bacteria the host animal and disease is not specific. Silage is often implicated as the means of transmission of both.

The bacteria now known as *Listeria* were first isolated in 1926, but it was not until 1940 that they were given the genus name *Listeria*.

Ironically, they were named after Joseph Lister, who was the first to isolate members of the beneficial, health promoting, lactic acid bacteria (in 1873), and is generally accepted as the father of modern surgery due to his development of aseptic techniques. Lister died in 1912 and he is honoured in science by having a genus of disease-causing microbes named after him!

Bacillus is a genus containing over 260 different species of bacteria and they are everywhere. Anthrax is an infection caused by *B. anthracis*. Biological washing powders first developed in the 1950s contain enzymes from various *Bacillus* species. *Bacillus thuringiensis*, a pathogen of insects, has been used to produce insecticides and more recently the production of GM crops that are resistant to some insect attack.

So where and why does the aerobic deterioration of silage have an impact?

Both *Listeria* and *B. licheniformis* are a particular challenge in silage for a number of reasons. Both are relatively closely related to the lactic acid bacteria and, as they produce similar end products, they are able to survive under many of the conditions found during ensiling. *Listeria* are what we call microaerophilic, which means they require very low levels of oxygen to grow, but they can survive under both aerobic and anaerobic conditions. There is often an assumption that *Listeria* are present in mouldy silage, but in fact they are more likely to be present in silage in higher numbers where mould is absent but where oxygen has been allowed to penetrate the silage either knowingly or unknowingly, as in the case of small pin holes in silage bale wrap or the ramp of the silage clamp where sealing is often less efficient and the volume to surface area is greatest.

The challenge from *B. licheniformis* is potentially even greater as it is a facultative anaerobic organism, meaning that, whilst it prefers to grow in the presence of oxygen, it can grow well when oxygen is absent.

B. licheniformis produces both fermentation products such as 1,2, propane-diol (a.k.a. Propylene glycol) and natural antibiotics that inhibit the growth of yeasts and moulds. Thus, the visual inspection of silage for fungal growth will not give a good assessment

of whether or not your silage has undergone aerobic deterioration or contains either of these pathogenic microorganisms.

It is often assumed that *Listeria* are mainly a problem in baled silage and increasingly the same for *B. licheniformis*, but this is not necessarily the case. Studies in Scotland have shown that, for abortions caused by *B. licheniformis*, in fact, clamp silage is a bigger issue and I see *Listeria* problems in clamps fed to sheep.

Therefore, to control these organisms it is essential that during the whole process of silage-making the good ensiling rules are followed. These organisms are everywhere. *Listeria* are associated with dead and dying vegetation, so are found in the base of the grass sward or in over-mature crops, whereas *B. licheniformis* is a soil-borne organism and so accidental contamination of forage in the field is almost unavoidable.

Thus, the first point of control is to ensure that crops are healthy at harvest, the cutting height is varied depending on crop quality and ground conditions, and all post-mowing tedding and raking jobs are carried out to ensure further soil is not dragged into the forage. Once forage is contaminated with the two Ls these bacteria will be doing their best to grow and survive.

During the ensiling process, be it in a clamp or a bale, compaction density is the key consideration. The higher the density the less oxygen is present, giving a competitive advantage to the lactic acid bacteria to out-compete the growth of these undesirable pathogens.
Chopping, high-density balers and thin, even layer depths compacted with a SilaPactor in the clamp, are the most efficient ways of achieving this. Once the silo is filled (again bale or clamp) then it is essential to ensure that it is properly sealed, and that the seal is well looked after from the day it's closed to the day it's opened to feed out. This means using good quality side sheeting in conjunction with oxygen barrier top sheet and sufficient top weight to ensure the top region of the forage in the clamp maintains a high density; with bales, six layers of good quality wrap and bales stacked carefully and protected from bird and rodents to ensure the wrap is not damaged.

Due to the ability of these organisms to grow when oxygen becomes available, or when it is not depleted quickly enough at the initiation of ensiling, an additive/preservative to improve the silage fermentation is the final control mechanism. The use of an inoculant containing heterofermentative bacteria, designed to improve aerobic stability at feed-out by producing acetic acid, is likely to exacerbate the problem of these pathogenic bacteria as one of the main end-products of *Listeria* is acetate, enabling it to survive in acetic acid.

Further, the slower pH decline promoted by heterofermentative inoculants allows more time in the early stages for *Listeria* and *B. licheniformis* to grow and survive.

Therefore, a product that enhances the fast production of lactic acid is essential to ensure a rapid pH drop in the clamp or bale to a level that is low enough to inhibit the growth of these pathogens.

The final stage is to ensure good aerobic stability at feed-out. Whilst you may not see mould growth, if the pH is rising due to the growth of yeasts, then aerobic spoilage is occurring. Move across the clamp face quickly (three days is ideal), but a preservative that will inhibit microbial activity at feed-out, and therefore deterioration, will significantly help in the fight.

Currently the only way to achieve all these aspects of control from an additive is, unfortunately, a chemical product containing sufficient levels of the food preservatives potassium sorbate and sodium benzoate. Applying this type of product in combination with sodium nitrite at harvest will ensure that the lactic acid bacteria at ensiling have the competitive advantage to dominate the silage fermentation and then, at feed-out, the yeasts will also be inhibited and this will not allow the silage pH to increase sufficiently to allow any of the remaining pathogenic Ls to grow and proliferate either in the open silo or bale before feeding or in the feed trough.

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