# Targets for the aerobic stability of silage*

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**Introduction** When silage is exposed to air either on opening the silo, or subsequently after removal from the silo, fermentation acids are oxidised by aerobic bacteria, yeasts and moulds which can develop rapidly in well-preserved silages. The consequential loss of dry matter (DM) represents a nutritional and a financial loss to the farmer. The physical, microbiological, and biochemical factors affecting the aerobic stability of silage are reviewed in this paper with the objective of defining targets which should be achievable with good management of the entire ensiling making and feeding process. Research targets are outlined and a standard protocol for assessing silage aerobic stability is proposed.

**Definition of aerobic stability** Aerobic deterioration is normally determined under laboratory conditions at constant ambient temperature by mixing several sub-samples of fresh silage and then placing the composite sample loosely in a polystyrene box and leaving the silage exposed to air for several days. During this period the temperature of the silage is monitored along with the ambient temperature. Aerobic stability is defined as the time which elapses before the silage shows clear evidence of heating i.e. when temperature of the silage exceeds ambient by 2oC (Ranjit and Kung, 2000). Some workers (e.g. Weinberg et al., 2008) measure carbon dioxide production directly at 5 to 10 cm depth at the exposed silo face. Silages producing less than 10 g CO2/kg DM and a change in pH of less than 0.5 units over a 5-day period are deemed to be stable.

**Key factors affecting aerobic stability** The over-arching factor affecting the aerobic stability of silage is exposure to oxygen during the storage period and after the silo is opened for feed-out (Pahlow and Muck, 2009). The most important crop factor is probably the count of epiphytic yeasts and moulds at the time of harvest, which should ideally be less than 105 colony forming units g-1 fresh matter. Key physical factors affecting rate of ingress of air into the silage mass during the feed-out period are silage density and porosity (Holmes and Bolsen, 2009) together with the extent of permeation of oxygen through the sealant film (Borreani et al., 2007). The concentration of undissociated acetic acid in silage is probably the most significant biochemical factor affecting aerobic stability (Wolthusen et al., 1989).

**Practical targets** A realistic practical target for silage aerobic stability is 168 hours (7 days) exposure to air without significant temperature rise or visible mould development, inclusive of time in the feed trough. To reach this target four key objectives should be achieved: i) minimal pre-harvest contamination of the crop with epiphytic yeasts and moulds; ii) sufficient consolidation of the silage mass; iii) effective sealing of the silo, preferably with an oxygen barrier film; iv) a rate of removal of silage from the exposed feed-out face which exceeds that of air ingress. For the control of aerobic deterioration in crops of 250 to 350 g DM/kg fresh weight ensiled in bunker and clamp silos, targets include close coordination of speed of harvest with total packing tractor weight to achieve a minimum density of 210 kg DM/m3, maximum proportional porosity of 0.4, removal of at least 1 metre depth of exposed silage feed-out face per week in winter and 2 metres per week in summer.

The use of additives designed to increase aerobic stability is recommended when there is a significant risk of the above objectives not being met. However, current microbial approaches such as the use of heterofermentative lactic acid bacteria (e.g. Lactobacillus buchneri) produce silages with increased losses of dry matter compared to additives containing homofermentative lactic acid bacteria such as L. plantarum. Additives comprising combinations of homofermentative bacterial inoculation and chemical suppression of yeasts and moulds are promising recent developments.

**Research targets** A standard protocol is proposed for research on silage aerobic stability comprising i) definition of the crop epiphytic yeast and mould count at the time of harvest; ii) exposure of mixed silage to air for at least 240 hours (10 days) at a constant temperature relevant to the climatic region; iii) assessment of either CO2 production or silage temperature during the entire period of exposure to air. Research is needed to define the factors affecting populations of epiphytic yeasts and moulds on crops for silage and on chemical components in legume silages which might be of significance in contributing to their enhanced aerobic stability compared with grass silages (Pahlow et al., 2001). Rapid methods are required for assessing the microbial, physical and biochemical status of crops and silages to aid prediction of aerobic stability. Novel microbial approaches to solving the problem of silage aerobic deterioration are needed, which could lead to the development of improved additives capable of increasing aerobic stability without increasing loss of dry matter during the fermentation process.

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