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## Effects of delayed sealing during silo filling – Experiments with lab-scale silos

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### Introduction

Swedish farmers have generally a good understanding of the recommendations for silage making provided by advisory services. However, few farmers apply the recommendation to seal the silo temporarily when the filling process is interrupted (e.g. overnight break or machinery failure). We believe this might be due to a prevailing uncertainty about the negative effects of delayed sealing. The objective of this study was to evaluate effects of delayed sealing on silage quality.

### Materials and Methods

To perform studies in full-scale farm silos is difficult since environmental conditions (e.g. degree of anaerobiosis, moisture content, microbial flora, density and porosity) vary between different places in the silo. A certain treatment applied to a silo will therefor manifest itself in different ways, which usually makes the interpretation of results difficult. This study was therefore performed under controlled environmental conditions in small-scale lab silos.

Three lab-scale ensiling trials with forage composed of chopped grass-clover mixtures (approx. 15-30% clover) and with DM contents between 25 to 30% were conducted within a period of two years. Glass jars (1.7 L) with metal lids were used as silos (Picture 1). Water-filled plastic siphons (water locks) mounted on the lids allowed fermentation gases to escape without the ingress of air. Water columns indicated if a silo was badly sealed (i.e. water columns in level). Silos were filled to forage densities ranging from 117 to 134 kg DM/m<sup>3</sup>. After filling silos were exposed to air for 0, 5, 10 and 24 hours (aerobic period) before lids were screwed on to seal silos. Silos were brought to a temperature controlled room (20±2°C), put in horizontal position and were covered with 45 mm thick glass wool mats to minimize the loss of respiration heat. Forage temperature was monitored during the aerobic period with 2 small, wireless temperature sensors (Kooltrak logger 214002, [www.kooltrak.com](http://www.kooltrak.com)) inserted into centre of each silo. Forage samples were collected at the start and end of each aerobic period for analysis of chemical composition (DM, WSC) and lactic acid bacteria (LAB). To follow the course of acidification, 2 replicate silos per aerobic period were sampled after 3, 6 and 18 days to determine silage pH. The three remaining silo replicates were stored for 90 days for a more extensive quality analysis including fermentation products (organic acids, alcohols, ammonia), aerobic stability and pH. Aerobic stability was determined by monitoring the increase of silage temperature during at least 7 days of aerobic exposure at 20°C ambient temperature.



Picture 1. Glass jar silo with water-filled siphon on lid.

Results were analysed statistically with a one-factorial (aerobic period) completely randomized model. Calculations were made with the PC package SAS 9.1 (SAS Institute Inc., Cary, USA) and the Proc GLM procedure was applied. A significance level of 0.05 (5%) was used for comparisons between aerobic periods.

### Results and Discussion

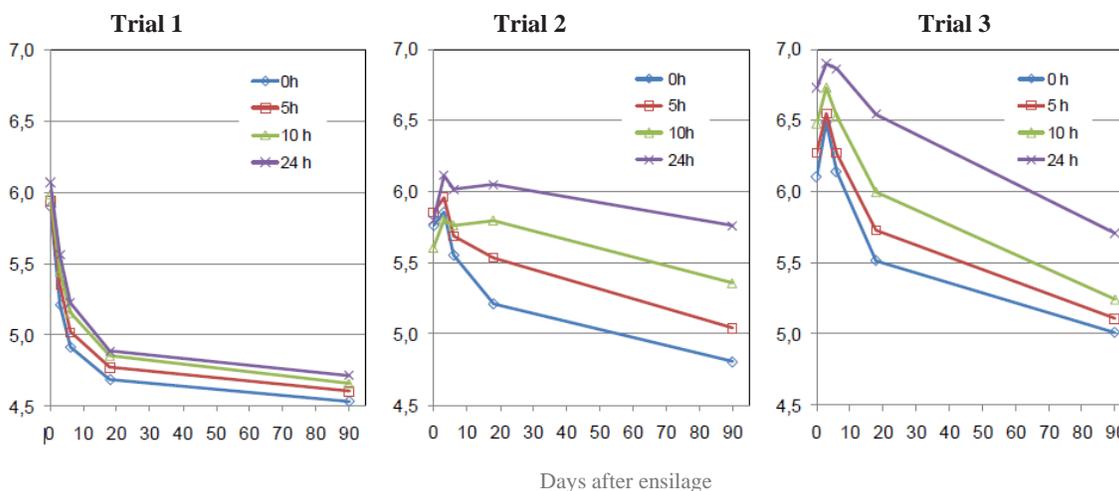
Forage temperature in open silos increased during the aerobic period in relation to the length of the aerobic period. After 24 hours forage temperatures varied between 30° to 37°C (Table 1). The temperature increase was highest in the driest and lowest in the wettest forage, which was expected.

**Table 1.** Mean forage temperature (°C) in open silos at the end of the aerobic period. Ambient temperature was 20°C.

Trial	Delayed sealing (hours)		
	5 h	10 h	24 h
1	24	26	30
2	28	31	35
3	25	30	37

Ensilability coefficient (FC) of the fresh forage, expressed as a function of buffering capacity (BC), DM and WSC contents (Weissbach 1996), deteriorated as the aerobic period increased. FC values in Table 2 indicate that delayed sealing for more than 10 hours will increase the risk of producing silages with lower fermentation quality. This is in agreement with increasing BC, pH and ammonia-N values and decreasing WSC values during the aerobic period.

Fermentation products typical for badly fermented silages such as butyric acid, 2,3-butanediol tended to increase and lactic acid and WSC levels tended to decrease towards the longest aerobic period (Table 3). This shows that delayed sealing gradually decreased the fermentation quality of silages.



*Forage conservation and feed processing*

**Table 2.** Forage composition at the end of the aerobic period.

Parameters <sup>1</sup>	Trial 1				Trial 2				Trial 3			
	0 h	5 h	10 h	24 h	0 h	5 h	10 h	24 h	0 h	5 h	10 h	24 h
DM, %	24.7	25	25.4	24.9	28.3	28.2	28.2	28.1	29.7	29.7	30	29.3
WSC	10.4 <sup>a</sup>	10.0 <sup>ab</sup>	9.6 <sup>b</sup>	8.4 <sup>c</sup>	11.7 <sup>a</sup>	11.0 <sup>b</sup>	10.3 <sup>c</sup>	7.5 <sup>d</sup>	3.3 <sup>a</sup>	2.8 <sup>b</sup>	2.2 <sup>c</sup>	1.5 <sup>d</sup>
BC	7.35 <sup>a</sup>	7.27 <sup>a</sup>	7.44 <sup>a</sup>	7.93 <sup>b</sup>	6.61 <sup>a</sup>	7.09 <sup>bc</sup>	6.98 <sup>b</sup>	7.34 <sup>c</sup>	7.63 <sup>a</sup>	8.11 <sup>b</sup>	8.46 <sup>c</sup>	9.59 <sup>d</sup>
FC	36 <sup>a</sup>	36 <sup>a</sup>	36 <sup>a</sup>	33 <sup>b</sup>	42 <sup>a</sup>	41 <sup>ab</sup>	40 <sup>b</sup>	36 <sup>c</sup>	33 <sup>a</sup>	32 <sup>ab</sup>	32 <sup>ab</sup>	31 <sup>b</sup>
pH	5.92 <sup>a</sup>	5.94 <sup>a</sup>	5.99 <sup>b</sup>	6.07 <sup>c</sup>	5.76 <sup>a</sup>	5.86 <sup>b</sup>	5.61 <sup>c</sup>	5.80 <sup>a</sup>	6.10 <sup>a</sup>	6.27 <sup>b</sup>	6.48 <sup>c</sup>	6.73 <sup>d</sup>
NH <sub>3</sub> -N <sup>2</sup>	1.10 <sup>a</sup>	1.11 <sup>a</sup>	1.17 <sup>b</sup>	1.70 <sup>c</sup>	0.66 <sup>a</sup>	1.00 <sup>b</sup>	1.06 <sup>b</sup>	1.41 <sup>c</sup>	1.49 <sup>a</sup>	1.86 <sup>b</sup>	2.74 <sup>c</sup>	4.50 <sup>d</sup>

<sup>a,b,c,d</sup>Different superscript letters within parameter and trial indicate significant differences at p<0.05; <sup>1</sup>BC = buffering capacity in g lactate/100 g forage DM; FC = fermentability coefficient = DM + (8 x WSC / BC) acc. to Weissbach (1996); <sup>2</sup>% of N.

**Table 3** Silage composition after 90 days as affected by delayed sealing. Values in % of DM if not indicated otherwise. Values are means of 3 silo replicates

Parameters	Trial 1				Trial 2				Trial 3			
	0 h	5 h	10 h	24 h	0 h	5 h	10 h	24 h	0 h	5 h	10 h	24 h
DM, %	25	24.6	24.5	24.4	27	26.8	26.7	26.4	28.2	29.1	29	28.9
pH	4.53 <sup>a</sup>	4.60 <sup>b</sup>	4.66 <sup>c</sup>	4.72 <sup>d</sup>	4.81 <sup>a</sup>	5.04 <sup>b</sup>	5.36 <sup>c</sup>	5.76 <sup>d</sup>	5.01 <sup>a</sup>	5.11 <sup>b</sup>	5.24 <sup>c</sup>	5.71 <sup>c</sup>
NH <sub>3</sub> -N <sup>1</sup>	7.3 <sup>a</sup>	8.0 <sup>ab</sup>	8.6 <sup>bc</sup>	9.0 <sup>c</sup>	12.6	11.9	13.6	13.7	14.7	14.2	14.9	15.6
Lactate	6.6 <sup>a</sup>	6.9 <sup>a</sup>	6.8 <sup>a</sup>	5.5 <sup>b</sup>	6.6 <sup>a</sup>	5.5 <sup>b</sup>	4.0 <sup>c</sup>	2.5 <sup>d</sup>	6.2 <sup>a</sup>	5.7 <sup>b</sup>	5.2 <sup>c</sup>	3.8 <sup>d</sup>
Acetate	1.5	1.6	1.7	1.9	1.4	1.4	1.3	1.5	2.6 <sup>a</sup>	2.6 <sup>a</sup>	2.5 <sup>a</sup>	2.4 <sup>b</sup>
Butyrate	0.05 <sup>a</sup>	0.09 <sup>b</sup>	0.10 <sup>b</sup>	0.10 <sup>b</sup>	0.06 <sup>a</sup>	0.16 <sup>ab</sup>	0.29 <sup>bc</sup>	0.36 <sup>c</sup>	<0.03	<0.03	<0.03	<0.03
2,3-butanediol	0.6 <sup>a</sup>	0.8 <sup>b</sup>	1.0 <sup>c</sup>	0.9 <sup>b</sup>	3.0 <sup>a</sup>	3.3 <sup>bc</sup>	3.4 <sup>c</sup>	3.2 <sup>b</sup>	0.2 <sup>a</sup>	0.3 <sup>b</sup>	0.4 <sup>c</sup>	0.5 <sup>d</sup>
Ethanol	1.5 <sup>a</sup>	2.1 <sup>b</sup>	2.2 <sup>b</sup>	1.8 <sup>ab</sup>	2.3 <sup>a</sup>	3.2 <sup>ab</sup>	3.4 <sup>b</sup>	3.5 <sup>b</sup>	0.1	0.1	<0.1	<0.1
WSC	1.9 <sup>a</sup>	1.2 <sup>b</sup>	0.9 <sup>c</sup>	0.7 <sup>c</sup>	0.21 <sup>a</sup>	0.14 <sup>ab</sup>	0.07 <sup>b</sup>	0.07 <sup>b</sup>	0.12	0.18	0.06	0.16
NDF	46.9 <sup>a</sup>	48.2 <sup>b</sup>	48.4 <sup>b</sup>	50.1 <sup>c</sup>	49.3 <sup>a</sup>	49.2 <sup>a</sup>	49.6 <sup>a</sup>	51.2 <sup>b</sup>	46.6 <sup>a</sup>	46.9 <sup>a</sup>	47.2 <sup>a</sup>	48.6 <sup>b</sup>
iNDF <sup>2</sup>	23.1 <sup>a</sup>	23.2 <sup>a</sup>	24.7 <sup>ab</sup>	26.4 <sup>b</sup>	18.4 <sup>a</sup>	20.2 <sup>b</sup>	19.9 <sup>b</sup>	23.0 <sup>c</sup>	11.0 <sup>a</sup>	12.5 <sup>b</sup>	14.3 <sup>c</sup>	17.0 <sup>d</sup>

<sup>a,b,c,d</sup>Different superscript letters within parameter and trial indicate significant differences at p<0.05; <sup>1</sup>% of N; <sup>2</sup>% of NDF.

Fermentation characteristics were negatively affected in relation to the length of the aerobic period. The pH drop during ensilage was slower and final pH values higher in silages that were exposed to the longest aerobic periods (Figure 1). After 90 days all pH values were significantly different from each other. We have no good explanation for the pH increase at day 3 in trial 2 and 3.

The aerobic stability of silages after 90 days of storage was not affected by delayed sealing. All silages were completely stable over the entire test period of 7 days and silage temperatures increased with only 1-3°C (Table 4). It is probable that the low fermentation quality of our silages contributed to their high aerobic stability.

**Table 4.** Aerobic stability of silages after 90 days storage as affected by delayed sealing. Values represent the highest silage temperatures detected during 7 days of aerobic exposure (means of 3 silo replicates)

Trials	Delayed sealing (hours)			
	0 h	5 h	10 h	24 h
1	19.2 <sup>a</sup>	19.5 <sup>a</sup>	21.6 <sup>b</sup>	19.5 <sup>a</sup>
2	21.3 <sup>a</sup>	20.8 <sup>a</sup>	20.7 <sup>a</sup>	22.9 <sup>a</sup>
3	21.3 <sup>a</sup>	19.8 <sup>a</sup>	20.8 <sup>a</sup>	21.1 <sup>a</sup>

## Conclusions

Negative effects on fermentation quality of silages emerged clearer the longer the sealing of silos was postponed. However, the negative effect varied considerably among the 3 trials as illustrated in the graphs showing the pH drop after aerobic periods of 5, 10 or 24 hours (Picture 2). Conditions such as high ambient temperatures and long transports stimulating plant respiration might amplify the loss of WSC and increases the risk of producing badly fermented silages (increased concentration of butyric acid and reduced lactic acid) particularly when the fresh forage has a low sugar concentration already at the time of cut. The results of this study support the recommendation to minimize aerobic exposure of fresh forage during silo filling.

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