Effects of chemical additives on whole-crop maize silage traits

Horst Auerbach [A] *and Elisabet Nadeau* [B]

[A] ADDCON EUROPE GmbH, Säurestrasse 1, D-06749 Bitterfeld-Wolfen Germany www.addcon.com
[B] Department of Animal Environment and Health, Swedish University of Agricultural Sciences, PO Box 234, S-53223 Skara, Sweden, www.slu.se

Contact email: horst.auerbach@addcon.com

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Introduction

Fungi-associated aerobic instability of maize silages occurs frequently under practical farming conditions. The use of heterofermentative lactic acid bacteria inoculants of the *Lactobacillus buchneri*-type has been demonstrated to improve stability of silages exposed to air (Kleinschmidt and Kung 2006) but is not a viable option if the silo is closed for less than 8 weeks, and for the treatment of the upper layers, which are particularly prone to deterioration due to lower compaction. In those cases, antimycotic chemicals must be applied of which sorbates, benzoates and propionates are most efficient against fungi (Auerbach 1996; Woolford 1975). However, as commercial chemical silage additives differ in composition and concentrations of individual active ingredients it is difficult to directly compare their efficacy. Therefore, this study aimed at investigating the effects of two chemical additives of different compositions and varying application rates on whole-crop maize silage traits. The parameter 'sodium benzoate equivalents' was employed to enable the direct comparison in terms of efficacy regardless of the specific composition of the additives.

Methods

Whole-crop maize (*cv.* Dynasty) was harvested and chopped by a Claas Jaguar at 309 g dry matter (DM) per kg, on October 12, 2010 at Lantmännen Dairy Research Farm, Falköping, Sweden. The herbage was either left untreated or treated with KOFASIL STABIL (KS, ADDCON EUROPE GmbH), containing sodium benzoate (SB): 250 g/l and potassium sorbate (PS): 150 g/l, at 1.0, 1.5 and 2.0 l/t, or with product A (PA, Swedish origin) containing sodium nitrite (SN): 57 g/l, SB: 206 g/l and PS: 85 g/l at 1.5, 2.0 and 2.5 l/t. The material was ensiled in 1.7 L silos and stored for 89 days at 22 °C. Chemical composition and yeast count (YC) were determined by routine analytical procedures. The DM was corrected for the loss of volatiles during drying (Weissbach and Strubelt 2008), and DM losses during fermentation were calculated according to Weissbach (2005). Aerobic stability (ASTA) was determined for 14 days as described by Honig (1990). Sodium benzoate equivalents (SBE) were calculated based on results by Auerbach (1996) assuming PS to be twice as effective as SB against fungal microorganisms, and SN not to exert any effect. Data were subjected to statistical analysis by PROC GLM and PROC REG of SAS, version 9.3. When a significant *F*-value ($P<0.05$) was detected, pair-wise comparisons between LSMEANS were performed using the Tukey´s test.

Results and discussion

Data summarized in Table 1 show overall treatment effects, except for the parameters ammonia-N and acetic acid. Obviously, additives decreased ethanol concentrat-

Table 1. Effects of additive type and application rate (l/t) on whole-crop maize silage traits (n=3)

Parameter	CON1	KOFASIL STABIL			Product A			SEM	*P*- value
		1.0	1.5	2.0	1.5	2.0	2.5		
DM loss (%)	4.5 a	3.7 b	3.8 b	3.7 b	3.7 b	3.7 b	3.8 b	0.045	***
pH	3.66 a	3.64 cd	3.64 cd	3.65 bc	3.64 bc	3.63 d	3.65 ab	0.002	***
NH3-N (% total N)	8.8	10.0	9.9	10.9	8.8	8.8	8.9	0.007	ns
Lactic acid (% DM)	5.29 bc	6.32 a	6.10 ab	6.05 ab	5.95 ab	6.35 a	4.70 c	0.181	***
Acetic acid (% DM)	1.51	1.48	1.55	1.54	1.37	1.41	1.52	0.048	ns
Ethanol (% DM)	0.92 a	0.19 b	0.25 b	0.15 b	0.18 b	0.14 b	0.14 b	0.043	***
WSC2 (% DM)	1.08 b	2.23 a	1.80 ab	2.02 a	2.09 a	2.26 a	2.13 a	0.151	**
Yeast count (log cfu/g)	3.7 a	3.0 ab	1.5 abc	<1.0 bc	3.4 a	1.7 abc	2.3 abc	0.465	**
Aerobic stability (days)	2.0 b	4.7 b	13.4 a	>14.0 a	3.4 b	7.0 b	8.1 ab	1.29	***
pH after ASTA3 end	6.21 a	6.66 a	3.60 b	3.53 b	6.91 a	5.71 a	5.07 ab	0.414	***

1 untreated control, 2 water-soluble carbohydrates, 3 aerobic stability test, abcdLSMEANS in rows bearing unlike superscripts differ ($P<0.05$, Tukey´s test), ***$P<0.001$, ** $P<0.01$, * $P<0.05$, ns not significant

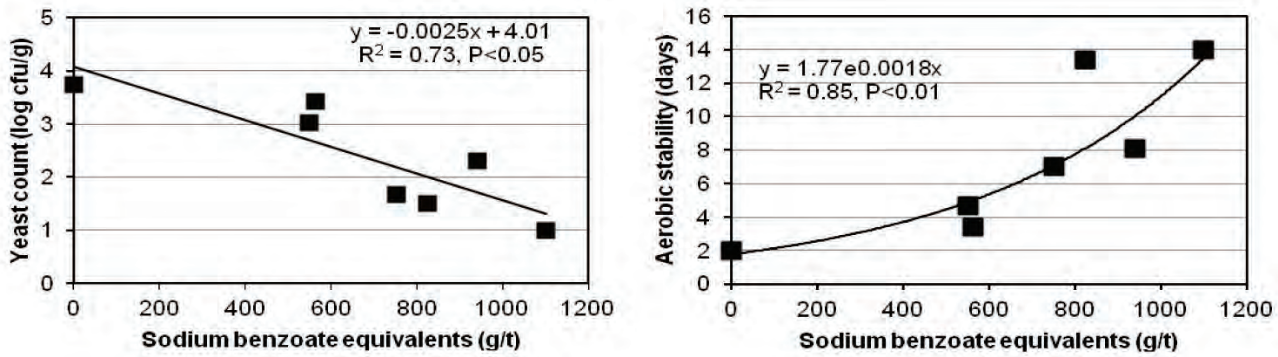

Figure 1. Relationship between sodium benzoate equivalents and (left) yeast count in maize silages and (right) aerobic stability in maize silages.

($P<0.001$) and DM losses ($P<0.001$) irrespective of additive and application rate in comparison with untreated silage. Although significant effects were detected, the differences between treatments regarding pH, lactic acid and water-soluble carbohydrates were considered of no practical relevance. Only treatment KS at 2.0 l/t decreased the YC compared to untreated silage. The aerobic stability of untreated silage was low and could be improved most effectively by treatments KS at 1.5 and 2.0 l/t. Product A did not enhance ASTA in this study, which may be associated with too low of an application rate as good effects were found by Knicky and Spörndly (2010) who applied 3.0 l/t in grass silage. Data on silage pH after the termination of the ASTA-test, which can be used as an indirect parameter for microbial deterioration, substantiated the results on ASTA. A negative linear relationship existed between YC and ASTA (R^2=0.87, $P<0.001$, n=7), which confirmed previous data by Muck (2004). As can be seen in Figure 1, YC decreased with increasing concentration of SBE (R^2=0.73, $P<0.05$, n=7). Data presented in Figure 2 strongly suggest that the magnitude of the effect of the chemicals on ASTA depended on the added amount. The positive relationship between SBE and ASTA was found to be exponential (R^2=0.85, $P<0.01$, n=7).

Conclusion

It is concluded that the most prominent effect of chemical additives in whole-crop maize silage is enhancing aerobic stability. The magnitude of the effect depends on the individual active ingredients applied and their concentrations in the mixture. The use of the parameter sodium benzoate equivalents is a novel approach and seems to be a promising tool to enable the direct comparison of different commercial chemical silage additive preparations in terms of their potential to improve aerobic stability.

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