The effect of different types of inoculants on DM losses, fermentation pattern, volatile organic compounds (VOC) and aerobic stability of sorghum silage

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Introduction There has been evidence that **v**olatile organic compounds, e.g. alcohols, organic acids and esters thereof, which can be detected in silages, may detrimentally affect feed intake by dairy cattle (Weiss *et al*., 2009). In addition, those substances have been discussed in relation to climate-damaging ozone formation, and it was reported that silages on dairy farms may be a significant source of VOC emission (Mitloehner *et al*., 2009). As the knowledge of the formation of VOC in silages is still very limited, it was the aim of this study to test the effects of different silage additive types on fermentation pattern, production of VOC and aerobic stability. Sorghum was chosen as this silage type is often characterized by excessive ethanolic fermentation so that high production of VOC could be expected.

Material and Methods Sorghum (*Sorghum bicolor*, varieties: Maya and Goliath) was harvested on a dairy farm in Trebbin, State of Brandenburg, Germany on October 13th 2009 by a Class Jaguar, chopped to a theoretical particle size of 20 mm and subsequently filled into 1.5 L glass jars. Silages were anaerobically stored at 25 °C for 105 days, and three replicates per treatment were prepared. The following treatments were tested: C - Control, LP - *L. plantarum* DSM 3676/*L. plantarum* DSM 3677 (50%/50%, $1x10^5$ cfu/g forage), LB1 - *L. buchneri* DSM 13573 ($1x10^5$ cfu/g forage), LB2 - *L. buchneri* DSM 13573 ($2.5x10^5$ cfu/g forage), LB3 - *L. buchneri* DSM 13573 ($5x10^5$ cfu/g forage), LP+LB1 ($2x10^5$ cfu/g forage) and BS – 500 g/t sodium benzoate + 300 g/t potassium sorbate (applied in 2 L/t as aqueous solution). All additives were diluted with tap water to give an application rate of 10 mL/kg fresh forage. The control treatment received 10 mL of tap water per kg fresh forage.

Chemical analysis of the fresh crop was performed according to official German standards for feed evaluation. DM of silages was measured and corrected for the loss of volatiles during drying according to Weissbach and Strubelt (2008). Determination of pH was done potentiometrically using a calibrated pH electrode. Lactic acid was analyzed by HPLC; volatile fatty acids, alcohols and VOC were determined by GC. Ammonia concentration was analysed photometrically. Losses of DM during fermentation were calculated according to Weissbach (2005). Aerobic stability was measured for 14 days by the temperature method (Honig, 1990). Data were statistically evaluated by employing the procedure MIXED of SAS. Differences among means were tested by Tukey test, and significance declared at $P \leq 0.05$.

Results and Discussion Results are only given on the variety Maya. Fresh forage contained 26.1 % DM, 4.6% crude ash, 5.5% crude protein, 29.1% crude fibre and 27.1% water-soluble carbohydrates (all nutrient based on DM).

There was no effect of treatment on DM and ammonia concentration, and all silages remained stable for 14 days (data not shown). The range in final pH was between 3.72 and 3.82, with significant differences between treatments (data not given), but those were without practical relevance.

All parameters presented in table 1 were significantly affected by treatment. Inoculants had only marginal effects on DM losses as compared with control silages, whereas the chemical additive reduced it by >30%. Lactic acid was reduced by all additives containing *L. buchneri* DSM 13573 and by the chemical mix. According to its special mode of action, the single application of the heterofermentative LAB strain increased acetic acid and 1,2-propanediol contents, and reduced ethanol levels. However, the most significant reduction in ethanol was caused by the chemical additive. As reported by Weiss *et al*. (2009), concentration of VOC (ethyl esters) clearly depended on the concentration of ethanol and the respective organic acids. Formation of ethyl lactate was lowest in silages treated either solely with *L. buchneri* DSM 13573 or the chemical mix, whereas a low level of ethyl acetate level could only be ensured by the chemical product.

Data on the Goliath variety were affected by treatment in a similar way as found for the Maya variety (data not shown). VOC were lowest in silages treated with the chemical additive.

Conclusion Silage additives affected DM losses and fermentation pattern, but no effect was found on aerobic stability. Regardless of variety, formation of VOC depended on the level of ethanol, lactic acid and acetic acid, and thus can be modified by silage additive type. The mix of sodium benzoate and potassium sorbate was superior to all other treatments in reducing VOC.

References

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Table 1. Effects of silage additives on DM losses, fermentation pattern, volatile organic compounds and aerobic stability of sorghum silage

Parameter	Treatment[1)]							SED	P level
	C	LP	LB1	LB2	LB3	LB1+ LP	BS		
DM loss (% DM)	9.0[c]	8.7[bc]	8.7[b]	9.0[cd]	9.2[cde]	9.5[e]	6.1[a]	0.09	<0.001
Lactic acid[2)]	4.03[b]	3.83[b]	2.28[a]	2.46[a]	1.78[a]	2.69[a]	2.44[a]	0.11	<0.001
Acetic acid[2)]	2.73[a]	2.20[a]	3.70[b]	4.55[c]	5.18[c]	2.28[a]	2.79[a]	0.08	<0.001
Ethanol[2)]	3.42[cd]	2.88[c]	1.95[b]	1.83[b]	1.96[b]	3.95[d]	0.78[a]	0.10	<0.001
1,2-propanediol[2)]	1.34[b]	0.29[a]	2.47[c]	3.57[d]	5.11[e]	1.22[b]	1.21[b]	0.05	<0.001
Ethyl lactate[3)]	467[b]	463[b]	294[ab]	237[a]	193[a]	453[b]	195[a]	51.6	<0.001
Ethyl acetate[3)]	120[b]	123[b]	119[b]	128[b]	106[ab]	105[ab]	44[a]	17.9	<0.05
Total ethyl esters[3)]	587[b]	586[b]	414[ab]	365[ab]	299[a]	559[b]	239[a]	67.5	<0.001

[1)] for description see Materials and Methods; [2)] % of DM; [3)] mg/kg DM; means in columns with unlike superscripts differ significantly

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