The effect of inoculants on DM losses, fermentation pattern and aerobic stability of high-moisture corn

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Introduction Inoculants are widely used in high-moisture corn (HMC) to improve its stability upon exposure to air. Numerous commercial products are available in different market places, and frequently it is claimed that the number of different lactic acid bacteria strains as well inoculation rate influence the result of additive application. Therefore, the aim of the study was to compare different commercially available inoculants (pure heterofermentative products and combinations of homo and heterofermentative bacteria) regarding their effects on DM losses, fermentation pattern and aerobic stability of HMC.

Material and Methods HMC was grown on a dairy farm in Trebbin, State of Brandenburg, Germany and harvested on 18 October 2010 by Class Jaguar and subsequently crimped. The material was packed into either 1.5 L glass jars for strict anaerobic storage for 97 days, or into 1.5 L jars which had a hole (diameter: 5 mm) in the lid of the jar and one at 5 cm above the bottom. These holes were closed by rubber stoppers. On day 28 and 56 of fermentation, the rubber stoppers were removed to allow free air ingress for 24 hours. The length of this type of experiment was 63 days. All jars were stored at constant temperature (25 °C), and three replicates per treatment were prepared.

All inoculant products were purchased from authorized dealers in Germany or Sweden. The following treatments and inoculation rates (IR, cfu/g fresh forage) were tested: T1 – no additive, T2 - *L. plantarum* DSM 12837, *L. buchneri* DSM 12856, *P. pentosaceus* DSM 12834: IR 2.5×10^5 cfu/g; T3 – *L. buchneri* NCIMB 40788: IR 5.0×10^5 cfu/g; T4 – *L. plantarum* DSM 3676, *L. plantarum* DSM 3677; *L. buchneri* DSM 13573: IR 2.0×10^5 cfu/g; T5 – *L. buchneri* DSM 13573: IR 1.0×10^5 cfu/g; T6 – *L. buchneri* CCM 1819: IR 1.5×10^5 cfu/g; T7 – *L. buchneri* LN 4637 ATCC PTA-2494: IR 1.1×10^5 cfu/g. All additives were diluted with tap water to give an application rate of 10 ml per kg fresh forage, and 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 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 17 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 Fresh HMC contained 63.5 % DM, 1.3% crude ash, 8.0% crude protein, 75.7% starch and 3.5% water-soluble carbohydrates (all nutrients based on DM). Epiphytic microbial counts (per g fresh matter) were as follows: lactic acid bacteria: 3.7×10^5 cfu/g, total yeasts: 5.2×10^5 cfu/g, lactate-assimilating yeasts: 2.5×10^5 cfu/g, moulds: 5.7×10^4 cfu/g.

With the exception of T4, all treatments increased DM losses if compared with untreated silages. This observation was reflected by the typical shift in fermentation pattern, caused by *L. buchneri*-inoculation. Lactic acid is partially degraded into acetic acid and 1,2-propanediol, thereby generating CO_2, which escapes from the silo (Oude-Elferink *et al*., 2001). Aerobic stability after 63 days of fermentation was improved only by products which solely contained *L. buchneri*. Increasing the fermentation length not only produced more stable untreated silages, but also excellent results on aerobic stability for all other treatments. Higher aerobic stability is associated with a marked reduction in DM loss upon exposure to air during feed-out so that elevated anaerobic DM losses by heterofermentative inoculation are acceptable. Even more importantly, the use of heterofermentative additives results in a net saving of DM from ensiling to feeding (Weissbach, 2011).

Conclusions Regardless of composition and inoculation rate, all products were shown to be suitable additives to improve aerobic stability of HMC. However, combinations of homo- and heterofermentative lactic acid bacteria should only be used if fermentation length exceeds 3 months, whereas products only containing *L. buchneri* showed their full effects already after 9 weeks even under challenging test conditions.

References

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Table 1. Effects of silage additives on DM losses, fermentation pattern and aerobic stability of high-moisture corn after 97 days of fermentation (unless otherwise stated)

Treatment[1)]	DML[2)]	pH	LA[3)]	AA[4)]	EtOH[5)]	1,2PD[6)]	ASTA[7)]	ASTA[8)]
	(% DM)		(% of DM)				(days)	
T1	3.3[b]	3.98[b]	1.71[cd]	0.30[a]	0.32[ab]	0[a]	0.8[a]	6.6[a]
T2	3.6[c]	3.98[b]	1.71[cd]	0.80[c]	0.31[ab]	0.77[d]	3.0[a]	15.9[c]
T3	4.3[f]	4.44[e]	0.61[a]	1.41[e]	0.56[c]	1.43[f]	16.8[c]	17.0[c]
T4	3.2[a]	3.94[a]	2.01[d]	0.49[b]	0.26[a]	0.13[b]	1.2[a]	10.7[b]
T5	4.4[g]	4.48[f]	0.72[ab]	1.39[e]	0.72[d]	1.48[f]	15.0[c]	16.7[c]
T6	3.7[d]	4.06[c]	1.46[c]	0.77[c]	0.38[b]	0.63[c]	8.5[b]	16.6[c]
T7	4.1[e]	4.29[d]	1.01[b]	1.12[d]	0.51[c]	1.09[e]	9.3[b]	17.0[c]
SED	0.02	0.011	0.098	0.047	0.030	0.026	0.89	0.13
Significance	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001	P<0.001

[1)]for description see Materials and Methods; [2)]DM loss; [3)]lactic acid; [4)]acetic acid; [5)] ethanol; [6)] 1,2-propanediol;
[7)] aerobic stability after 63 days of fermentation; [8)] aerobic stability;
means in columns with unlike superscripts differ significantly