EFFECT OF COMPACTION, SOIL CONTAMINATION AND ADDITIVE TREATMENTS ON GRASS SILAGE QUALITY

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INTRODUCTION

Silage quality in practice is still a concern and work to improve it is continuously needed. General good management practices in silage making include tight compaction to ensure anaerobic conditions and avoiding soil contamination to prevent inoculation with spoilage microbes. Additives are commonly used to improve the fermentation quality of the forage (Muck and Kung, 1997). The objective of this experiment was to evaluate how different types of silage additives are able to manipulate the ensiling process under varying management conditions represented by two levels of compaction and soil contamination.

MATERIALS AND METHODS

Mixed timothy (*Phleum pratense*) and meadow fescue (*Festuca pratensis*) grass was harvested on June 4th 2018 at Luke in Jokioinen, Finland (60°48'N, 23°29'E), precision chopped using farm scale machinery and transported to laboratory without any additive. Silages were prepared using two compaction levels (Table 1). The tightly compacted grass was also inoculated with soil and dairy cow faeces. Four additive treatments were used including control without additive, formic acid (FA) based additive, homofermentative strains of lactic acid bacteria (LAB) and salt (SALT) based additive. The grass was ensiled into cylindrical pilot scale silos with 12 litre capacity using three replicates per treatment. Silos were stored at room temperature with protection from light and opened after an ensiling period of 93 days. Deteriorated parts were discarded and silage was carefully mixed and samples were taken and analysed for chemical composition and fermentation quality. Aerobic stability was evaluated by measuring the temperature with thermocouple wires automatically at 10-minute intervals from silage samples stored in polystyrene boxes. Data was analysed using a MIXED procedure (SAS Inc. 2002-2012, Release 9.4; SAS Inst., Inc., Cary, NC) of SAS at 5% of probability with additive, compaction and soil contamination as fixed effects and replicates as random effect.

RESULTS AND DISCUSSION

Grass dry matter (DM) was 346 g/kg, metabolizable energy content 11.7 MJ/kg DM, in vitro organic matter (OM) digestibility 796 g/kg OM and its chemical composition was representative for a typical grass used in Northern Europe (Huhtanen et al., 2006) with ash, crude protein (CP), sugars and neutral detergent fibre of 79, 156, 137 and 503 g/kg DM, respectively. There were no effects ($P>0.05$) of compaction nor soil contamination on DM, ash and CP concentrations of the silages (Table 1). There were effects ($P<0.05$) of compaction and soil contamination on pH, which was higher for loose than tight compaction and higher for non-contaminated than for contaminated material. Control resulted in highest pH among treatments ($P<0.05$), followed by SALT and then FA. Lowest values for pH ($P<0.05$) were found for LAB treated silages. Non-contaminated silages resulted in higher concentration of ammonia ($P<0.05$) and additive treated silages showed lower ($P<0.05$) concentration of ammonia than control treatment. Tight compaction resulted in more extensive fermentation ($P<0.05$) with higher lactic acid concentration than loose compaction. The sugar content of the current material was relatively high and use of LAB increased ($P<0.05$) the conversion of sugars into lactic acid, which may have a positive effect on silage hygienic quality. On the other hand, FA restricted fermentation resulting in silages with higher sugar and reduced concentration of total fermentation products, which would be beneficial if sugar content is low and which may promote higher intake of silage. Aerobic stability was higher ($P<0.05$) for soil contaminated silages than non-contaminated probably due to greater concentration of acetic acid but in general, uncontrolled pathways of fermentation that produces acetic acid are less desirable (Kung, 2010).

CONCLUSIONS

Use of formic acid, lactic acid bacteria strains and salt based additives improved fermentation quality of grass ensiled under different management conditions. Tight compaction resulted in well preserved silages and should be aimed in farm scale. Soil contamination stimulated wild-type fermentation that somehow improved some parameter of silage, but is not recommended as an ideal pathway to preserve silage under farm conditions, because it could cause losses in nutritive value, detrimental effect for animals and hygienic risks in the food chain.

REFERENCES

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Table 1. Chemical composition, fermentation quality, aerobic stability, ensiling losses and microbial quality of grass silage treated with additives under different compaction (Comp) and soil contamination (Cont) levels.

Contamination	Non-contaminated								Soil contaminated				SEM^{1}	P-value^{2}	
Compaction	Loose				Tight				Tight						
Additive	Control	FA	LAB	Salt	Control	FA	LAB	Salt	Control	FA	LAB	Salt		Comp	Cont
Dry matter (DM), g/kg	331^{b}	345^{ab}	348^{ab}	337^{ab}	332^{ab}	345^{ab}	344^{ab}	335^{ab}	341^{ab}	348^{a}	339^{ab}	341^{ab}	3.2	0.67	0.20
pH	5.78^{a}	4.85^{c}	4.02^{ef}	5.48^{b}	5.53^{b}	4.78^{c}	4.00^{f}	5.36^{b}	4.26^{d}	4.83^{c}	4.01^{f}	4.21^{de}	0.039	<0.01	<0.01
Ammonia N, g/kg N	64^{a}	26^{c}	21^{c}	42^{b}	59^{a}	25^{c}	21^{c}	43^{b}	43^{b}	25^{c}	22^{c}	43^{b}	2.2	0.46	0.03
Chemical composition, g/kg DM															
Ash	88^{a}	82^{dc}	85^{abcd}	88^{a}	86^{ab}	82^{d}	85^{abcd}	86^{ab}	86^{ab}	83^{bcd}	84^{bcd}	86^{abc}	0.8	0.11	0.80
Crude protein	177^{a}	164^{c}	172^{abc}	177^{a}	172^{abc}	166^{bc}	171^{abc}	175^{ab}	170^{abc}	169^{abc}	170^{abc}	171^{abc}	1.9	0.27	0.35
Sugars	87^{cd}	187^{a}	73^{d}	120^{bc}	120^{bc}	195^{a}	76^{d}	135^{b}	5^{e}	181^{a}	66^{d}	6^{e}	8.2	0.02	<0.01
Ethanol	29.9^{ab}	7.8^{de}	3.6^{e}	31.8^{a}	16.5^{c}	4.7^{e}	3.2^{e}	22.0^{bc}	16.4^{c}	2.5^{e}	3.9^{e}	15.0^{cd}	1.56	<0.01	0.06
Acids, g/kg DM															
Formic^{3}	0^{d}	0.9^{c}	0^{d}	0^{d}	0^{d}	1.7^{b}	0^{d}	0^{d}	0^{d}	2.9^{a}	0^{d}	0^{d}	0.14	0.07	0.01
Lactic (LA)	12.7^{d}	1.2^{e}	113.1^{a}	12.4^{d}	21.8^{c}	1.6^{e}	114.5^{a}	17.7^{c}	86.2^{b}	0.7^{e}	115.5^{a}	87.8^{b}	0.93	<0.01	<0.01
Acetic	7.5^{c}	7.5^{c}	12.8^{b}	9.0^{bc}	8.3^{bc}	7.7^{c}	12^{bc}	9.9^{bc}	30.4^{a}	7.4^{c}	9.4^{bc}	25.9^{a}	0.95	0.72	<0.01
Propionic^{3}	0.15	0	0.08	0.11	0.17	0	0.10	0.09	0.24	0.34	0.11	0.23	0.100	0.94	0.06
Butyric	0.91	0.28	0.03	0.19	0.29	0.37	0.05	0.16	0.03	0.85	0.03	0.03	0.288	0.51	0.94
Total volatile fatty acids	8.64^{bc}	7.82^{c}	12.90^{b}	9.39^{bc}	8.76^{bc}	8.12^{bc}	12.12^{bc}	10.19^{bc}	30.76^{a}	8.82^{bc}	9.55^{bc}	26.18^{a}	0.964	0.87	<0.01
Total fermentation acids	21.3^{d}	9.0^{e}	126.0^{a}	21.8^{d}	30.5^{c}	9.7^{e}	126.6^{a}	27.9^{c}	116.9^{b}	9.5^{e}	125.0^{a}	114.0^{b}	1.16	<0.01	<0.01
LA/total fermentation acids	0.59^{d}	0.12^{e}	0.90^{a}	0.57^{d}	0.71^{bc}	0.15^{e}	0.91^{a}	0.63^{cd}	0.74^{bc}	0.07^{e}	0.92^{a}	0.77^{b}	0.022	<0.01	0.12
Total fermentation products	51^{b}	17^{c}	130^{a}	54^{b}	47^{b}	14^{c}	130^{a}	50^{b}	133^{a}	12^{c}	129^{a}	129^{a}	1.7	0.05	<0.01
Aerobic stability^{4}	41^{d}	109^{bcd}	118^{bc}	46^{cd}	73^{bcd}	98^{bcd}	133^{b}	48^{cd}	469^{a}	127^{b}	90^{bcd}	480^{a5}	14.8	0.37	<0.01
Ensiling losses, g/kg of initial DM	89^{a}	13^{fg}	3^{i}	60^{d}	79^{b}	10^{gh}	17^{f}	68^{c}	44^{e}	4^{hi}	41^{e}	43^{e}	1.2	0.01	<0.01
Yeasts, cfu/g	4.7×10^{5}	2.9×10^{3}	1.6×10^{3}	1.4×10^{4}	1.4×10^{4}	4.3×10^{2}	3.0×10^{2}	1.3×10^{3}	1.0×10^{2}	9.6×10^{2}	4.0×10^{4}	1.0×10^{2}	9.4×10^{4}	0.09	0.93
Moulds, cfu/g	3.1×10^{3b}	2.2×10^{3b}	3.2×10^{2b}	1.4×10^{4a}	5.2×10^{3b}	4.1×10^{2b}	3.1×10^{2b}	1.4×10^{4a}	1.0×10^{2b}	3.1×10^{3b}	4.6×10^{2b}	3.0×10^{2b}	1.6×10^{3}	0.94	<0.01
Clostridia, spore/g	-	-	-	-	42	34	3	7	3	13	3	14	16.3	-	0.28
Zearalenone, ppb	403	371	-	-	234	221	-	-	1598	313	-	-	-	-	-
Deoxynivalenol, ppb	299	297	-	-	322	385	-	-	558	252	-	-	-	-	-

Additive treatments: control without additive; formic acid (FA) based additive (AIV Ässä Na, Eastman Chemical Company, Oulu, Finland at 5 l/t); homofermentative strains of lactic acid bacteria (LAB) *Lactobacillus plantarum* (KOFASIL® LAC, ADDCON, Bitterfeld-Wolfen, Germany at 1 g/t); and salt based additive (Safesil Challenge, Salinity AB, Göteborg, Sweden at 2 l/t). Values with same letter in a row are not significantly different at 5% Tukey test.

[1] Standard error of the mean. [2] Effect of compactions (583 vs. 424 kg/m^{3} for tight and loose compactions, respectively) and soil contamination. Tight compaction was done manually by dropping a lead plummet ten times after adding a handful of grass into the cylindrical silo, while loose compaction was done by dropping the lead plummet two times. [3] Corrected for its amount in the FA based additive. [4] Time taken to increase the temperature of samples by 2 °C above the ambient temperature (22 °C). Data collection lasted for 480 h. [5] Treatment did not reach the threshold during the evaluation period.