Irish Journal of Agricultural and Food Research **49:** 81–86, 2010

A note on the conservation characteristics of baled grass silages ensiled with different additives

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The effects of contrasting conventional silage additives on chemical composition, aerobic stability and deterioration, and mould development in baled silage were investigated. Herbage from a grassland sward was wilted for 24 h and treated with acid (formic or sulphuric), sugar (molasses), bacterial (*Lactobacillus plantarum, L. plantarum* + *Serratia rubidaea* + *Bacillus subtilis*, or *L. buchneri*) or sugar + bacterial (molasses + *L. plantarum*) additives prior to baling and wrapping. Silage made without an additive preserved well and had a low incidence of mould growth, and the effects of additives were minor or absent. It is concluded that little practical benefit was realised when conventional additives were applied to wilted, leafy, easy-to-ensile grass prior to baling and ensilage.

Keywords: baled silage; conservation characteristics; silage additives

Introduction

The rapid achievement of anaerobic conditions and inhibition of undesirable anaerobic microorganisms are essential components of silage production. In baled silage systems, anaerobic conditions are achieved by wrapping the bale in adequate plastic stretch film, and this should inhibit mould growth. However, on-farm studies indicate that extensive fungal growth on baled silage is common (O'Brien *et al*., 2008). In a previous study, McEniry *et al.* (2007) showed that silage additives based on formic acid, sucrose + *Lactobacillus plantarum* or a combination of anti-microbial salts could create conditions inhibitory

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to fungal growth. Consequently, applying silage additives could help reduce fungal activity in baled silage.

The objective in this experiment was to assess the effects of acid (formic or sulphuric), sugar (molasses), bacterial (*L. plantarum, L. plantarum* + *Serratia rubidaea* + *Bacillus subtilis*, or *L. buchneri*) or sugar + bacterial (molasses + *L. plantarum*) additives on the chemical composition, aerobic stability and deterioration, and mould development in baled silage, relative to the effects of baled silage made without the use of an additive.

Materials and methods

Baling procedure

The primary growth of an *Agrostis* and *Poa* dominant permanent grassland sward was mown on 28 May, to a stubble height of approximately 6 cm, with a disk mower-conditioner set to place wide windrows on the stubble (windrows covered approximately 70% of the ground area). Forage was wilted for 24 h without tedding. The following additive treatments were applied to forage in the windrows: (1) Control – no additive (C), (2) formic acid based additive (FA; Add SafeR, 70 g ammonia and 640 g formic acid per kg, Trouw Nutrition Ltd., UK) applied at 2.5 L/t herbage, (3) sulphuric acid (SA; Cosil, 450 g sulphuric acid per kg, Nutribio Ltd., Cork) applied at 2.5 L/t herbage, (4) molasses (M) applied at 9 L/t herbage, (5) homofermentative lactic acid bacterial inoculant (LP; Ecosyl, *L. plantarum,* strain MTD/1 (NCIMB 40025), Novokem Ltd., Dublin) applied at 3 L/t herbage to achieve a target of at least 1.0×10^6 colony forming units (cfu) per 1 g herbage, (6) molasses + Ecosyl (M + LP) at the same rates as treatments 4 and 5, respectively, (7) homofermentative lactic acid bacterial inoculant (EB; Ecobale, *L. plantarum*, strain MTD/1 (NCIMB 40027)*, S. rubidaea* (NCIMB 40285) and *Bacillus subtilis* (NCIMB 40286), Novokem Ltd., Dublin) applied at 3 L/t herbage to achieve a target of at least 2×10^6 cfu/g herbage, and (8) heterofermentative lactic acid bacterial inoculant (LB; AxCool, *L. buchneri*, strain NCIMB 40788, Biotal Ltd., Wales) applied at 4 L/t herbage to achieve a target of at least 1×10^5 cfu/g herbage. Each additive treatment was applied to a randomly selected individual windrow within a group of eight adjacent windrows and a single bale was made from within each windrow. This procedure was repeated in seven further blocks across the field. Additives were applied across the full width of the top of grass windrows through a perforated dribble bar, and baling (Class™ Rollant 46 Roto Cut Baler, with the 14 stationary cutting blades engaged; baler capacity was for a bale 1.2 m wide and 1.2 m diameter) was within 15 min of additive application. The 64 bales were immediately transported to the storage area where they were core sampled, weighed and individually wrapped (McHale™ 991 BE wrapper) with four layers of black plastic stretch film (25 µm film thickness; stretched by 70% during wrapping). Wrapping was completed within 60 min of baling. Wrapped bales were stored on their curved side, outdoors on a grass base for 273 days. After storage the bales of silage were scored for visible surface mould growth and core sampled.

Analytical procedures

Chemical analysis of pre-ensilage (dry matter (DM), crude protein (CP), ash, *in vitro* DM digestibility (DMD) and buffering capacity (BC)) and post-ensilage (DM, CP, DMD, pH, lactic acid, acetic acid, propionic acid, butyric acid, water-soluble carbohydrates (WSC) and ammonia-N) core samples was undertaken as described

by Keles *et al.* (2009) and Playne and McDonald (1966). Fermentation products are the sum of lactic, acetic, propionic and butyric acids.

Each bale was scored for visible mould growth on its ends and barrel (total = ends + barrel). Bales were representatively sampled and aerobic stability (days to temperature rise > 2 °C above ambient) and aerobic deterioration (accumulated temperature rise to day 5 (°C)) were assessed (n = 4 bales/treatment) at 20 °C for 8 days as described by McEniry *et al.* (2007).

Data were statistically analysed as a randomised complete block design, using the general linear model procedure of the Statistical Analysis System (SAS, 2000). Paired comparisons of each additive treatment with the control (C) treatment were undertaken using Dunnett's two-tailed test procedure.

Results

Bale weight and grass composition

The mean (s.d.) fresh and DM weights of bales at ensiling were 629 (54.9) and 193 (30.7) kg, respectively, and the corresponding densities were 464 (40.5) and 142 (22.6) kg/m^3. The mean (s.d.) composition of the herbage pre-ensiling was DMD 768 (9.8) g/kg, ash 119 (3.5) g/kg DM, CP 154 (7.9) g/kg DM and BC 364 (12.1) mEq/kg DM.

Silage composition

Whereas neither silage DM nor CP concentration was affected ($P > 0.05$) by treatment, DMD was increased ($P < 0.05$) by LB (Table 1) compared to the control silage (C).

Relative to C, both FA and SA reduced ($P < 0.05$) the concentration of lactic acid, but only FA reduced ($P < 0.05$) the concentration of fermentation products. None of the fermentation characteristics was altered by treatment M. Both EB and LB reduced ($P < 0.05$) WSC concentration. There were no ($P > 0.05$) treatment effects on pH, on the concentration of propionic acid, butyric acid or ammonia-N, or on lactic acid as a proportion of fermentation products.

Visible mould growth occurred mainly on the bale surfaces and rarely penetrated more than 2.5 cm below the surface. The extent of surface mould growth was small (mean of 0.015 of the bale surface area) for all treatments (data not presented). Treatment had no effect ($P > 0.05$) on aerobic stability, while the extent of aerobic deterioration was larger ($P < 0.05$) for the M + LP treatment than for the C treatment.

Discussion

Pre-ensilage

The herbage used was of high digestibility and underwent relatively rapid drying. The slightly elevated ash concentration suggests some soil contamination occurred during mowing or baling.

Silage composition

Silage preservation was satisfactory as indicated by the relatively low pH, the dominance of fermentation products by lactic acid, the low concentration of butyric acid and the moderately low ammonia-N concentration. Additionally, the incidence of visible mould growth was low.

Under conditions where the control silage had a relatively extensive fermentation (fermentation products = 94 g/kg DM at a DM concentration of 308 g/kg) that was dominated by lactic acid (729 g/kg fermentation products) it is not surprising that FA restricted the extent of fermentation (fermentation products of 75 g/kg DM). This, together with the

Table 1. Chemical composition (g/kg DM, unless otherwise stated in footnotes; no units for pH), aerobic stability and aerobic deterioration of baled silage

Variable[2]	Treatment[1]									
	C	FA	SA	M	LP	M + LP	EB	LB	s.e.	Significance
Chemical composition										
DM	308	286	291	277	285	289	285	259	11.5	
CP	148	153	159	153	159	157	167	158	4.0	
DMD	725	746	731	743	745	740	737	753	5.7	*
pH	4.33	4.29	4.18	4.26	4.26	4.21	4.36	4.28	0.041	
LA	68	55	56	72	76	76	72	76	3.0	***
AA	23.0	16.3	19.7	25.8	20.1	19.0	26.8	27.1	2.41	*
PA	0.7	0.4	0.5	0.7	0.6	1.0	0.7	1.0	0.20	
BA	2.4	2.5	3.4	4.5	4.2	4.8	5.4	3.8	1.00	
WSC	35	44	30	30	24	27	21	21	2.8	***
NH_3-N	110	112	95	108	115	105	114	127	7.5	
LA/AA	3.1	3.7	3.1	3.1	4.2	4.5	3.1	2.9	0.37	*
FP	94	75	80	103	101	101	104	108	4.4	***
LA/FP	729	744	712	704	755	758	697	703	24.3	
Aerobic stability										
Days to temperature rise > 2 °C	3.8	3.0	3.3	3.5	3.3	2.3	2.5	2.5	0.46	
Aerobic deterioration										
Accumulated temperature rise to day 5 (°C)	11	12	16	13	11	23	16	19	2.03	**

[1] C = control; FA = Formic Acid; SA = Sulphuric Acid; M = Molasses; LP = *L. plantarum*; M + LP = Molasses + *L. plantarum*; EB = Ecobale; LB = *L. buchneri.*
[2] DM = dry matter (g/kg); CP = crude protein; DMD = *in vitro* DM digestibility (g/kg); LA = lactic acid; AA = acetic acid; PA = propionic acid; BA = butyric acid; NH_3-N = ammonia-N (g/kg N); LA/AA (g/g); FP = fermentation products (LA + AA + PA + BA) (g/kg); LA/FP (g/g).

higher concentration of unfermented substrate in the silage made using FA compared to that made with SA, is in accord with O'Kiely (1998), and reflects the lower anti-microbial effect of SA compared with FA.

The apparent absence of an effect of added sucrose (as molasses) on fermentation agrees with McEniry *et al.* (2007) who suggested that such an outcome indicates that the supply of fermentable substrate from the herbage to the indigenous epiphytic microbial population did not limit the ability of the microbes to produce adequate lactic acid. It is possible that much of the added sucrose, which was surplus to requirements for fermentation, was converted to ethanol (not measured) as reported by Chamberlain (1988).

The extent of the dominance of lactic acid among fermentation products in the control silage suggests that homofermentative lactic acid bacteria were present in adequate numbers on the herbage at baling. These bacteria would have posed a challenge to the added homofermentative lactic acid bacteria in LP, LP + M and EB. Hence, any numerical responses recorded were not statistically significant. However, both EB and LB tended to increase acetic acid concentration. This reflected the less exclusively homofermentative lactic-acid-bacterial composition of EB and the heterofermentative *L. buchneri* in LB.

Intimate mixing of additive with herbage may be more difficult to achieve when wilted (less translocation via juice from lysed cells) herbage is harvested by a round baler (less mixing than with precision-chop system). The method of additive application used in the present experiment was considered a practical approach that could be undertaken on farms. However, it may have limited the extent of uniform mixing, and thus the opportunity for these additives to fulfil their potential may have been restricted. This may, at least partially, explain the smaller then expected effects of most of the additives.

Other conservation characteristics

There was no treatment effect on aerobic stability and, although some treatment effects occurred for aerobic deterioration, the overall scale of aerobic deterioration was small across all treatments and the treatment effects were therefore of minor importance.

It is concluded that baled silage made from well-wilted grass underwent a satisfactory preservation when ensiled without an additive, and that even though some additives modified fermentation characteristics their effects were generally quite modest. These findings, together with the small amount of visible mould growth, suggest that little practical benefit occurred when additives were applied to wilted, leafy easy-to-ensile grass that was then baled and securely wrapped in plastic stretch film.

Acknowledgements

The input of Mr. J. Hamill, Grange Farm staff, and the staff of Grange Laboratories is acknowledged.

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Received 22 October 2009