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AEROBIC STABILITY OF GRASS SILAGE MIXED WITH A RANGE OF CONCENTRATE FEEDSTUFFS AT FEED-OUT

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Abstract

Mixing supplementary concentrates with silage at feed-out could shorten aerobic stability or increase the rate or extent of aerobic deterioration of silage. This experiment quantified such possible effects by twelve contrasting feedstuffs. Four samples (each 6 kg) of unwilted, precision-chop, well preserved grass silage (216 g dry matter (DM) kg^{-1} and pH 4.0) were incubated at 20^{o}C for 6 days in polystyrene containers alone or with the addition of 400 g (solid ingredients were milled) of wheat grain, barley grain, maize grain, molassed beet pulp, citrus pulp, molasses, soyabean meal, maize gluten, sunflower meal, rapeseed meal, dry distillers grains or sunflower oil. Daily temperature profiles were recorded. Silage alone was unstable under aerobic conditions, with an accumulated daily temperature rise during 5 days aerobiosis of 57^{o}C. None of the added ingredients altered ($P>0.05$) any of the indices of aerobic deterioration. For the treatments as listed above, the interval until temperature rise commenced was 2.0, 2.0, 2.0, 2.3, 2.0, 2.0, 2.3, 2.0, 2.3, 2.0, 2.0, 2.0 and 2.0 (s.e.m. 0.11) days, the interval until the maximum temperature was reached was 3.8, 3.5, 4.5, 3.5, 4.0, 3.3, 3.5, 3.8, 4.3, 4.0, 3.8, 3.8 and 3.5 (s.e.m, 0.44) days and the accumulated temperature rise to day 5 was 57, 58, 57, 54, 58, 59, 50, 57, 53, 61, 52, 51 and 58 (s.e.m. 3.1)^{o}C. It is concluded

that mixing the above feedstuffs with grass silage did not alter the aerobic deterioration of grass silage.

Keywords: Silage, aerobic stability, aerobic deterioration, concentrates, feedstuffs

Introduction

The conservation characteristics of silage generally stabilise at some stage of ensilage provided anaerobic conditions are maintained. However, respiration by indigenous micro-organisms commences and silage becomes inherently unstable during the aerobic conditions that prevail during feedout. This results in quantitative and qualitative losses both at the open face of bunker silage and in the feed manger. Furthermore, fungal growth in silage poses health hazards in terms of the challenge from airborne spores to the eyes and respiratory tract, and metabolic disorders associated with the ingestion of mycotoxins (Wilkinson, 1999). Aerobic deterioration of silage is usually initiated by yeast, with moulds and possibly bacteria succeeding them (Driehuis *et al.*, 1999). Yeast readily respire silage sugars or fermentation acids, but can also respire some of the constituents in energy or crude protein-rich concentrate feedstuffs (McDonald *et al.*, 1991). It can be hypothesised that the rate and extent of aerobic deterioration of silage in the feed manger will increase and its aerobic stability will decrease where the silage is mixed with supplementary concentrates (as sources of respirable substrate and/or of inoculum). Such mixing is typical of total mixed rations (TMR’s) produced using feeder wagons. The aim of the present experiment was to quantify the effects of concentrate feedstuffs differing in their contents of starch, oil, sugar and crude protein on aerobic stability and deterioration when mixed with silage at feedout.

Material and Methods

Unwilted, well preserved, precision-chop grass silage was removed from a horizontal bunker silo using a shear grab. The 700 kg sample was thoroughly mixed and subsamples (each 6 kg) were placed in 52 polythene-lined polystyrene (2.5 cm thick) boxes (59 x 39 x 22 cm) with a polystyrene lid loosely fitted. Four containers of silage were allocated to each of the following 13 treatment, with 400 g of each ingredient being manually mixed with the appropriate sub sample of silage (i.e. 400 g ingredient to 6 kg silage): no added ingredient, wheat grain, barley gain, maize grain, molassed beet pulp, citrus pulp, molasses, soyabean meal, maize gluten, sunflower meal, rapeseed meal, dry distillers grains and sunflower soil. The 10 solid ingredients were each ground through a 2 mm sieve in a hammer mill before being mixed with silage. The containers of mixed feedstuff were stored at 20^{o}C for 6 days and mean temperatures were recorded daily. Temperature results were expressed as (1) interval in days until the temperature rose more than 2^{o}C above the reference temperature, (2) interval in days until the maximum temperature was reached, (3) interval in days between commencement of temperature rise and reaching maximum temperature, (4) maximum temperature rise (^{o}C), (5) accumulated temperature rise in the first 5 days of aerobiosis (^{o}C) and (6) rate of temperature rise during (3) above (^{o}C day^{-1}). Yeast and mould counts were made on malt extract agar (pH 3.5) using the double-layered pour-plate technique. Data were statistically analysed by one way analysis of variance.

Results and Discussion

The mean chemical composition of the silage when removed from the silo was dry matter (DM) 216 g kg^{-1}, crude protein 162 g kg^{-1}DM, *in vitro* DM digestibility 697 g kg^{-1}, buffering capacity 1132 mequiv kg^{-1} DM, pH 4.0, lactic acid 89 g kg^{-1} DM and ammonia-N 64 g kg^{-1} total N. Correspondingly the counts of yeast and mould were 9.8 x 1.0^{7} and 0 colony forming units (cfu) g^{-1}, respectively.

The 12 concentrate feedstuffs were all of high DM concentration (Table 1) and, with the exception of distillers grains (pH 4.4), all had pH values between 5.2 and 6.5. The feedstuffs represented a wide range in concentrations of crude protein (<2 to 485 g kg^{-1}), ash (<1 to 139 g kg^{-1}), oil A (<1 to 990 g kg^{-1}), starch (<1 to 592 g kg^{-1}) and sugar (<1 to 477 g kg^{-1}). Similarly, there was a wide range in the numbers of yeast (<10 to 8.7 x 10^7 cfu g^{-1}) and mould (<10 to 5.5 x 10^6 cfu g^{-1}). The aerobic stability of the silage was normal for a well preserved, unwilted, precision-chop silage, with an accumulated temperature rise to day 5 of 57^{o}C (Table 2) and a corresponding mean loss of DM during aerobiosis (6 days) of 152 g kg^{-1}. Under the circumstances prevailing in this experiment, none of the added concentrate feedstuffs altered any of the indices of aerobic stability, rate of deterioration or extent of deterioration ($P>0.05$).

Yeast are the most frequent initiators of the aerobic deterioration of silage (Driehuis *et al.*, 1999). Yeast numbers on silage were higher than on any of the concentrate feedstuffs. As none of the added feedstuffs initiated an earlier commencement of aerobic deterioration, this suggests that none of the feedstuffs supplied a quantity or type of yeast capable of altering the effects of the indigenous yeast population on the silage. In the present experiment there were sufficient yeast present in the silage at feedout capable of initiating aerobic deterioration within a relatively short time frame. It is unclear what the outcome would have been in this regard if the indigenous population of yeast on the silage at feedout were much lower.

Although the added concentrate feedstuffs introduced moulds to the silage, in some cases in quite high amounts, these clearly did not lead to an earlier initiation of aerobic deterioration or an alteration in the extent of heat production.

The concentrate feedstuffs were either liquids or finely milled solids, and were intimately mixed with the silage at the commencement of aerobic conditions. They supplied different forms and quantities of energy and crude protein without significantly altering silage aerobic stability or deterioration. The absence of an effect of their addition on aerobic stability or deterioration suggests that a supply of readily available, respirable substrate did not limit the activity of yeast throughout the duration of exposure of silage to air. Clearly, adequate silage fermentation products such as lactic acid, as well as residual WSC, were available to yeast for respiration under the aerobic conditions and duration of this study.

It is concluded that in the present experiment, mixing concentrate feedstuffs with grass silage did not alter silage aerobic stability or the rate or extent of aerobic deterioration. This suggests that adequate respirable substrate and yeast numbers were present in the silage to allow rapid and extensive respiration to occur, resulting in a relatively short duration of aerobic stability and rapid and extensive aerobic deterioration. This experiment should be repeated using grass silage containing substantially lower yeast counts at the commencement of feedout.

References

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Table 1 - Microbiological and chemical composition of concentrate feedstuffs.

Feedstuff	Yeast (cfu g^{-1})	Mould (cfu g^{-1})	Dry matter (g kg^{-1})	Crude protein (g kg^{-1})	Ash (g kg^{-1})	Oil A (g kg^{-1})	Starch (g kg^{-1})	Sugar (g kg^{-1})	pH
Wheat	6.1×10^7	1.1×10^6	863	91	16	14	592	35	6.0
Barley	8.7×10^7	2.0×10^3	850	94	18	16	489	22	5.7
Maize	2.7×10^6	2.4×10^6	862	80	12	32	588	16	5.9
Beet pulp	4.5×10^5	3.5×10^2	902	102	61	4	18	211	5.3
Citrus pulp	6.0×10^3	6.5×10^3	904	67	56	19	<1	193	5.2
Molasses	8.6×10^3	<10	732	41	139	<1	<1	477	5.2
Soyabean meal	2.9×10^5	1.0×10^3	880	485	63	20	42	89	6.5
Maize gluten	4.5×10^4	<10	890	204	65	32	191	30	6.0
Sunflower meal	3.6×10^7	5.5×10^6	878	288	66	16	13	55	5.8
Rapeseed meal	5.0×10^5	<10	882	339	68	15	44	85	5.6
Distillers grains	4.0×10^5	3.0×10^2	898	259	62	81	19	29	4.4
Sunflower oil	<10	<10	993	<2	<1	990	<1	<1	-

Table 2 - Indices of aerobic deterioration of silage with added concentrate feedstuffs.

Concentrate	Interval (days)			Max. temp.	Accum. temp.	Rate of temp.
Feedstuff	To temp. rise	To temp. max	From temp. rise to max.	rise (^oC)	rise to day 5 (^oC)	rise (^oC day^{-1})
None	2.0	3.8	1.8	18.4	57	11.3
Wheat	2.0	3.5	1.5	20.0	58	14.8
Barley	2.0	4.5	2.5	21.3	57	8.7
Maize	2.3	3.5	1.5	18.2	54	13.9
Beet pulp	2.0	4.0	2.0	18.2	58	9.1
Citrus pulp	2.0	3.3	1.3	18.4	59	16.1
Molasses	2.3	3.5	1.3	19.1	50	16.9
Soyabean meal	2.0	3.8	1.8	19.1	57	15.1
Maize gluten	2.3	4.3	2.3	18.5	53	10.9
Sunflower meal	2.0	4.0	2.0	20.8	61	13.5
Rapeseed meal	2.0	3.8	1.8	18.4	52	13.0
Distillers grains	2.0	3.8	1.8	19.1	51	12.0
Sunflower oil	2.0	3.5	1.5	19.2	58	14.2
s.e.m.	0.11	0.44	0.43	1.30	3.05	2.68
Significance	NS	NS	NS	NS	NS	NS

NS = no significant difference