ADDITIVES AS PRESERVATIVES FOR WRAPPED ROUND BALES SILAGE MADE UNDER TROPICAL CLIMATE

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ABSTRACT

In tropical highlands it is difficult to conserve harvested forage as silage. Tests with molasses as an additive, or using ammonium tetraformiate (ATF) or inoculants have been conducted to find out more about the fermentation process in these conditions. Sugar additives are not the primary factor in the fermentation process. Nevertheless, they are essential to make up for the small amounts of water soluble carbohydrates (WSC) in the forages, but only if the dry matter (DM) content is high enough (27% for temperate species, 40 % for the kikuyu grass). Even at high rates such as 5 l t^{-1} of fresh matter (FM) AFT is not an effective preservative because it inhibits lactic acid bacteria (LAB). Caylasil®, a biological preservative, is only worth using if the forage has a DM content of 30% and 100 - 120 g kg^{-1} DM of WSC.

KEYWORDS

Silage, wrapped round bale, conservation, molasses, lactic acid bacteria, ammonium tetraformiate, highlands, tropical climate

INTRODUCTION

It is difficult to store forage harvested in tropical highlands as silage. Their WSC content is very low (< 50 g kg^{-1} DM), and the harvesting period coincides with the rainy season, which explains why DM contents are 25% or less (Paillat *et al*., 1993, 1995). To provide improved protection using round bale wrapping, CIRAD (Centre for International Cooperation on Agricultural Research for Development) is considering including molasses and preservatives such as AFT or bio-ferments.

METHODS

Two preservatives and various doses of sugar (0, 50 and 100 g kg^{-1} DM) have been applied to cock's-foot (*Dactylis glomerata*) and kikuyu grass (*Pennisetum clandestinum*) with low DM contents (between 20 and 30%). Comparisons were made between the 2 forages and the 2 DM rates. Five wrapped round bales were used for each treatment (6 per test). A sample was drawn from each bale for the fermentation analysis (Dulphy *et al*., 1981). The preservatives had the following characteristics: (1) Foraform® (Pionner), AFT (640 g kg^{-1} formic acid) used at rates of 2.5 and 5 l t^{-1} FM, (2) Caylasil® (Cayla laboratory), composed of homofermentative lactic acid bacteria (LAB) (*Streptococcus faecium* and *Lactobacillus plantarum*) and enzymes (hemicellulase and cellulase) used at the rate recommended by the manufacturer.

Follow-through for the silage acidification process consisted of comparing two wrapped bales per treatment. Nine comparisons were made combining the two forages (cock's-foot and kikuyu grass) and different doses of molasses, with or without Caylasil®. Sensors were placed in each bale to measure: (1) temperatures at 20 and 50 cm inside the bale (needle probes), (2) pH using Xérolyt® (Ingold) penetration probes. At the end of the experiment, three samples were drawn from each bale to analyze fermentation.

RESULTS AND DISCUSSION

Effects of sugar additives. Molasses helps enhance lactic acid production in temperate grasses if DM levels are above 27% (Paillat, 1995). Below this level, butyric acid producing bacteria, which are stimulated by high temperatures (Célanie, 1982), soon become active. In the case of kikuyu grass (Table 1), if the DM level is below 27%, silage conservation is very poor. Adding molasses does little to improve the conservation; even worse, it enhances the activity of undesirable bacteria. If the DM exceeds 27%, lactic acid production seems to be adequate, but is not fast enough. Ammonia production levels are always high. Silage can only be well conserved after the DM level reaches a minimum of 40% (Paillat, 1995).

Anaerobic bacteria such as the *Enterobacter* genus or certain strains of LAB may be responsible for the ammonia that is produced in these silages, where, however, little butyric acid is produced (Henderson, 1984; Heron *et al*., 1986, *in* McDonald *et al*., 1991). Plant enzymes can also play a role during the initial phase (Gouet *et al*., 1964 *in* McDonald *et al*., 1991), especially in hot climates. Forage structure, *i.e.* whole blades, can influence fermentation: WSC may not be readily available for the LAB.

Adding sugar is not the main factor in orienting fermentation. It enables greater acidification (Tjandraatmadja, 1994) but only slightly increases the activity rate. It does, however, reduce the formation of ammonia and butyric acid, and favours alcohol production. This said, sugar addition is vital because, if DM is at an acceptable level (27% for temperate grasses, 40% for the kikuyu grass), it provides compensation for low WSC forage levels (Paillat, 1995).

Effects of adding preservatives. Even at high rates (5 l t^{-1} fresh matter (FM)), ATF does little to reduce compounds resulting from fermentation. Furthermore, by inhibiting LAB, it causes the silage to become very unstable (Paillat, 1995). Preservative dissociation seems to be too slow or incomplete. Going further, the ammonia that is released when AFT decomposes is detrimental to the already high ammonia grass silage.

Caylasil® is a bio-ferment that improves acidification if enough sugars are added (Fig. 1). There is a decrease in products resulting from fermentation but the nitrogenous matter is still not sufficiently protected in wet silage (Paillat, 1995). The enzymatic effects of the preservative do not seem very efficient. It may be that too little is being incorporated (Pitt, 1990; Spoelstra *et al.*, 1990). This preservative is only appropriate for forage that has sufficient DM (> 30%) and a large quantity of WSC (100 to 120 g kg^{-1} MS) (Demarquilly, 1993).

For wrapped bales of kikuyu grass, bio-agents combined with sugar additives seem to improve fermentation somewhat (De Figueiredo *et al.*, 1994), but not enough. The stolon structure does not contribute to acidification efficiency: WSC from the stems cannot be released. Since the stolons stay wet, variations of DM levels in the bales have an effect. Certain parts of the bales are wetter and therefore provoke the development of butyric bacteria in microniches (Demarquilly, 1979). These stolons, moreover, contain yeasts which produce alcohol and compete with the LAB (Célanie, 1982).

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Table 1
Influence of adding sugar (molasses for kikuyu grass with 20% DM harvested at stolon stage

total WSC (added sugar), g kg^{1} DM	**20** (0)	**70** (50)	**90** (70)	sign.F
DM content, %	20.2	21.0	21.4	ns
Silage pH	4.77^{c}	4.53^{b}	4.24^{a}	***
DpH	0.83^{c}	0.54^{b}	0.25^{a}	***
Soluble Nitrogen, % total N	54.7^{a}	53.6^{a}	64.2^{b}	*
Ammonia Nitrogen, % total N	20.9^{b}	16.9^{a}	21.3^{b}	**
Volatile Fatty Acids, mmol kg^{1}DM	610^{b}	468^{ab}	348^{a}	*
Acetic Acide, g kg^{1} DM	22.3^{b}	17.0^{ab}	13.9^{a}	*
Butyric Acide, g kg^{1} DM	13.1^{b}	11.5^{ab}	7.3^{a}	*
Alcohols, g kg^{1} DM	48.6	41.7	54.1	ns

ns = not significant ; * = significant P<0.05 ; ** = significant P<0.01 ; *** = significant P<0.001
^{abc} Values on the same line with different superscipts are different, P<0.05
ΔpH = silage pH - stability pH (Mc Donald, 1991)

Figure 1
Follow-through for pH of two wrapped round bales (T2 and T6)made with kikuyu grass with 20% DM harvested at stolon stage.