Quality of baled grass-clover silage as affected by additives and harvest methods

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Introduction

Previous studies have shown increased loading and ensiling capacities with a rotor cutter wagon compared to a precision chopping wagon with no effects on silage fermentation (Arvidsson and Lingvall 2005; Lingvall and Knicky 2008). However, to our knowledge, there are no studies on the effects of different mowing techniques in combination with chopping/cutting of the forage at harvest when the forage is ensiled with different types of additives.

The aim of this experiment was to investigate the effects of mowing method, chopping *vs.* cutting of the forage, types of additives and their interactions on grass-clover silage quality.

Method

A grass (83%)-clover (17%) sward from one field at Götala Beef and Lamb Centre, Swedish University of Agricultural Sciences, Skara, Sweden was mowed with two different techniques as a first regrowth from 14.00 to 15.30 July 13, 2011. The mowing treatments were rotary conditioner (KRONE easy cut) and rotary mower (KUHN GMD), which were used in alternate sections throughout the field and set for wide spreading to a width of 8.7 m. The wide-spread forage was wind rowed from 18.30 to 20.30 July 13. The mean total wilting time for the forage was 21 hours before the forage was chopped or cut by two different techniques. The dry matter (DM) content of the forage at start of chopping/cutting was 42% for the forage mowed by the rotary conditioner and 32% for the forage mowed by the rotary mower. The forage was chopped with a precision chopping wagon (Taarup 480) to a mean length of 27 mm or cut with a rotor cutter wagon (Pöttinger Jumbo 6010) to a mean length of 85 mm in alternate wind rows. The forages were treated with GrasAAT SX (GSX, 40% formic acid, 20% propionic acid, 20% sodium formate, 1.0% benzoic acid, 1.0% sorbic acid, 1.0% glycerol) at 3 l/ton (ADDCON NORDIC AS), KOFASIL COMBI (KC, *Lactobacillus plantarum* DSM 3676, 3677 at 100,000 cfu/g forage, 240 g/t sodium benzoate and 30 g/t potassium sorbate) and KOFASIL ULTRA K (KU, 16.5% sodium nitrite, 11.0% hexamethylenetetramine, 8.1% potassium sorbate, 2.2% sodium benzoate, 0.8% sodium propionate) at 2 l/ton (ADDCON EUROPE GmbH) at chopping/cutting. These treatments were compared to forage without any additive (CONTROL (C)). Both chopped and cut forages were packed in hard-pressed round bales, which were wrapped with 8 layers of plastic film by a stationary baler (Orkel MP 2000) and stored for 150 days.

Bales were weighed at harvest and after 150 days of storage to determine DM losses (Weissbach, 2005). Also, samples from four bales per treatment were drilled and analysed for DM content (Weissbach and Strubelt, 2008) and fermentation products according to conventional methods. Aerobic stability (ASTA) of the silages was measured as the number of days reaching a temperature of 2°C above ambient temperature during a 14-d period (Honig, 1990). Data were analysed by analysis of variance for a 2 x 2 x 4 factorial arrangement of treatments, where two levels of mowing treatments, two levels of chopping/cutting treatments and four levels of additive treatments were used. Data were analysed in PROC GLM of SAS (ver. 9.3) using four bales per treatment and DM content as a covariate. When a significant *F* - value occurred at 5% level, pair wise comparisons between LSMEANS of treatments were done using Tukey´s test.

Results and Discussion

Wilted forage before ensiling contained 485 g NDF and 172 g water soluble carbohydrates (WSC) per kg of DM and had an organic matter digestibility of 87%. The total counts of lactic acid bacteria and yeast of the forage were log 3.2 and log 6.7, respectively. When the forage was mowed by a rotary mower, chopping improved silage characteristics by decreasing concentrations of butyric acid (0.0001 *vs.* 0.338 g/kg DM, $P<0.001$) and ethanol (2.8 *vs.* 5.2 g/kg DM, $P<0.0001$), thereby decreasing DM losses (3.2 *vs.* 3.7%, $P=0.01$) compared to cut forage. When the forage was mowed by a rotary conditioner, chopped and cut silages had similar qualities, except for more acetic acid in the cut than in the chopped silage (10.0 *vs.* 7.3 g/kg DM, $P<0.0001$).

Table 1. Dry matter (DM) losses, water soluble carbohydrates (WSC), fermentation traits (g/kg DM) and aerobic stability (ASTA) of chopped and cut grass silage (n=8).

Measured parameters	Chopped silage				Cut silage				*P* - value
	GSX	KC	KU	C	GSX	KC	KU	C	
DM losses, %	3.0 d	3.2 d	3.2 cd	3.8 ab	3.4 bcd	3.7 abc	3.0 d	4.1 a	<0.01
WSC	79	76	69	57	82	96	89	64	NS
pH, 150 days	4.23	4	4.4	4.08	4.46	4.14	4.63	4.33	NS
Lactic acid	64 cde	90 a	67 bcd	78 ab	45 f	80 a	53 ef	54 def	<0.05
Acetic acid	6.6 bc	7.5 bc	11.2 a	6.0 c	7.6 b	7.5 bc	11.5 a	10.5 a	<0.0001
Butyric acid	0.05	0.002	0.001	0.332	0.079	0.139	0.069	0.63	NS
Ethanol	1.7 d	3.4 c	1.5 d	5.7 b	4.0 c	4.4 c	2.2 d	7.4 a	<0.01
NH_3-N, g/kg N	73	53	61	79	72	58	64	91	NS
Yeast, log cfu/g	2.5 d	2.8 cd	1.0 e	5.3 a	3.1 cd	3.5 bc	1.0 e	4.1 b	<0.0001
ASTA, days	11.3 ab	9.3 bcd	12.7 a	2.9 e	8.8 bcd	8.2 cd	10.7 abc	6.7 d	<0.0001

GSX=GrasAAT SX, KC=KOFASIL COMBI, KU=KOFASIL ULTRA K, C=CONTROL
LSMEANS in a row with different letter differ significantly at $P < 0.05$ according to Tukey´s test.

Cut KC silage had the highest lactic acid concentration but did not differ from the C treatment when the silage was chopped (Table 1). GSX and KU decreased DM losses of C silages in both mowing treatments, whereas KC only decreased DM losses in silage from the mower conditioner treatment ($P<0.05$). Similarly, the chemical additives decreased DM losses in both chopped and cut C silage, whereas KC only decreased DM losses of chopped C silage (Table 1). All additives decreased contents of ethanol and yeast of the C silages from both mowing treatments with the greatest effect by KU ($P<0.001$). Also, all the additives decreased ethanol concentration in both chopped and cut silages (Table 1). Furthermore, yeast count of chopped C silage was decreased by all additives, whereas only the chemical additives decreased yeast count in cut C silage. As a result, ASTA of chopped and cut C silages was improved by use of KU whereas GSX and KC only improved ASTA in chopped C silage. There was a stronger effect of the acid treatment in this experiment compared with our previous study (Nadeau *et al.* 2012). There was a strong negative linear relationship between total yeast count and ASTA of the silages ($R^2 = 0.80$, RMSE = 1.62, $P<0.0001$, n = 16).

Conclusions

Additives had greater effects than harvest methods on silage quality. Both chemical and biological additives decreased the ethanol concentration, yeast counts and DM losses and improved aerobic stability of chopped silage. In cut silage, only the chemical additives decreased yeast counts and DM losses and of these only KOFASIL ULTRA K improved aerobic stability. When the forage is mowed by a rotary mower, chopping instead of cutting of the forage is recommended for high-quality silage.

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