Biochar addition at ensiling – effects on silage characteristics

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Introduction

Biochar is a potential carbon sink and soil enhancer. A possible strategy for introducing it into the feed chain of ruminant livestock farms is addition to green chop during ensiling (Pereira et al., 2014). The silage characteristics may then be impacted in several ways. Two experiments were performed that yielded data regarding this: i) a laboratory scale experiment with pure stands of timothy and red clover, respectively, that were ensiled at two different dry matter levels with the addition of 0, 2, 4 or 6% wooden biochar on a dry matter basis and ii) full scale ensiling for a feeding trial with a precision-chopped grass-clover crop in round bales with the addition of 0, 1.5 or 3.0% wooden biochar on a DM basis.

Materials and Methods

For the laboratory scale experiment, the primary growth from pure stands of timothy (11 June, early heading stage) and red clover (15 June, pre-budding stage), respectively, were harvested 2020 in the Uppsala region (Table 1). The crops were mowed and one portion was immediately prepared for ensiling, while another portion was wilted overnight for a target DM of 40%. Prior to ensiling, the crops were chopped with a compost grinder to mimic a precision chopper with 2 cm theoretical cutting length. The crops were then ensiled in triplicates in laboratory scale silos with 4.5-L capacity with the addition of 0, 2, 4 or 6% wooden biochar on a DM basis. Target densities were 160 and 200 kg DM/m^3 for unwilted and wilted material, respectively. The biochar was from spruce/pine (70/30) sawdust pellets and was ground in a food blender, oven dried and maintained at 40°C until the biochar amount for one silo was promptly weighed and mixed with the corresponding green chop amount. The silos were then stored at 20°C for 325 d before opening and sampling for analysis with routine wet chemistry methods described by Eriksson and Rustas (2014).

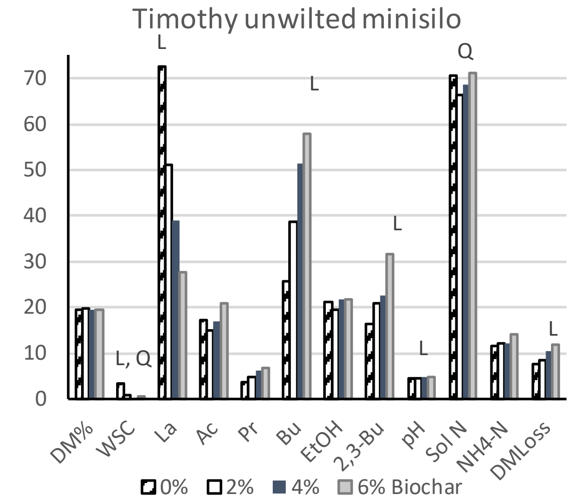
Table 1 Composition of ley crops used for ensiling with incremental doses of biochar

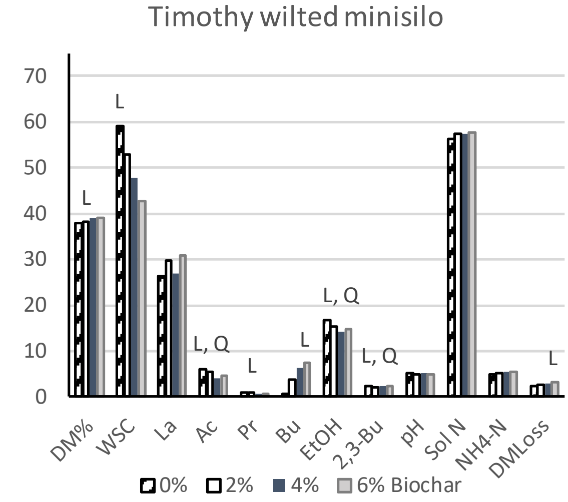
Crop	Silo	DM, g/kg	Ash, g/kg DM	NDF, g/kg DM	WSC, g/kg DM	CP, g/kg DM
Timothy, unwilted	Minisilo	226 ± 0.3	76 ± 1.2	521 ± 7	116 ± 1.5	130 ± 1.4
Timothy, wilted	Minisilo	408 ± 1.5	75 ± 2.0	532 ± 4	111 ± 2.5	128 ± 3.8
Red clover, unwilted	Minisilo	206 ± 1.0	96 ± 0.9	266 ± 10	83 ± 1.9	186 ± 1.3
Red clover, wilted	Minisilo	408 ± 3.9	97 ± 0.2	275 ± 5	96 ± 1.0	180 ± 3.6
Mixed ley	Bales	253 ± 7.5	79 ± 2.2	522 ± 30	65 ± 2.0	188 ± 1.6

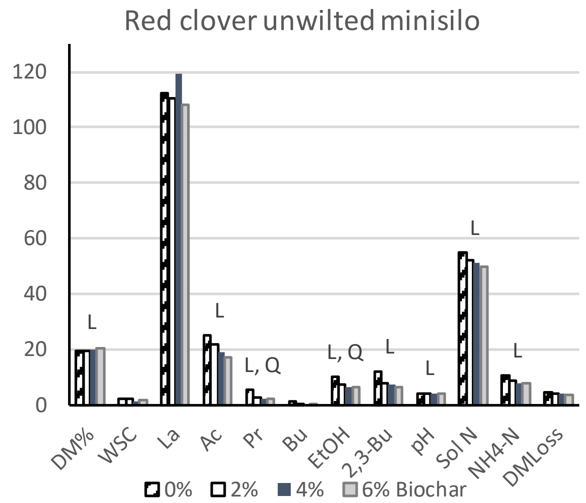
DM = dry matter; NDF = neutral detergent fibre; WSC = water soluble carbohydrates, CP = crude protein

Silage for the feeding trial was prepared from a third cut of a mixed ley with timothy, perennial ryegrass, festololium, red clover and white clover, harvested near Laholm, S. Sweden on 22 August 2021 (Table 1). The ley was cut with a 10-m mower-conditioner, wilted overnight in swaths for a target DM of 27% and chopped with a precision chopper (Krone Big X 580). The green chop was mixed with biochar and a silage inoculant (Xtrasil Bio Ultra, Lantmännen, at > 210000 cfu/g fresh matter) in 5-ton batches in a mixer wagon

(Kverneland Siloking Duo 20 m^3) and then baled and wrapped with 12 layers of plastic with a stationary round baler/wrapper (Orkel 2000 Compactor).The biochar was from spruce pyrolysed at 650°C (Obio Fórkull, Oplandske Bioenergi, Biri, NO) and milled by the







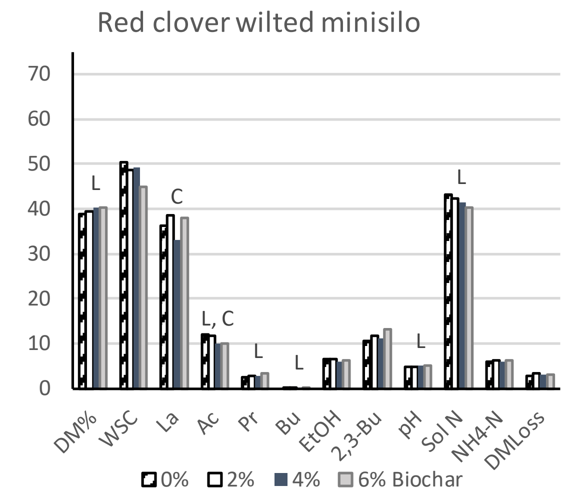
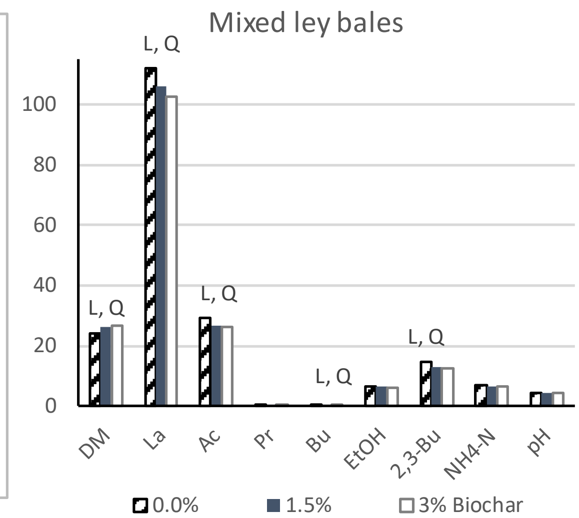


Figure 1 Characteristics of silage prepared with incremental amounts of biochar in minisilos or round bales. Dry matter concentration (DM%). Concentration (g/kg DM) of: Water soluble carohydrates (WSC), Lactic acid (La), Acetic acid (Ac), Propionic acid (Pr), Butyric acid (Bu), Ethanol (EtOH), 2,3-buthanediol (2,3Bu). N fractions, % of total N: Soluble N (Sol N) and NH4-N. Dry matter loss, % of starting amount (DMLoss). L, Q and C denotes linear, quadratic and cubic effects of biochar level, respectively, at $p < 0.05$.



manufacturer to have 53% passing a 1 mm screen and 77% a 2 mm screen. The biochar was dried to approx. 95% DM and precautions were taken to avoid moisture uptake prior to use. Added biochar amounts corresponded to 0, 1.5 and 3.0% of green chop DM. The bales were opened and sampled during the course of a feeding trial running with five 2-w periods from 17 January to 25 March 2022 (147 to 214 d after ensiling). Samples from each period were subjected to the same wet chemistry analyses as in the laboratory scale experiment.

Data were analysed with Proc GLM of SAS 9.4 with biochar level as a class variable, with linear, quadratic and cubic (minisilos only) contrasts < 0.05 being reported.

Results and Discussion

General signs of fermentation intensity for different DM levels (Figure 1) were logical, with higher DM being associated with more remaining WSC, lower protein solubility, less fermentation products and higher pH. Silage DM concentration increased with incremental biochar addition except for unwilted timothy, but increase was smaller than added biochar DM proportions. Butyric acid concentration was very high in unwilted timothy silage at zero biochar addition, and then together with 2,3-buthane-diol increased in a linear fashion for incremental biochar dose while lactic acid at the same time declined. A similar pattern was visible when timothy had been wilted to 40% DM, but butyric acid levels then did not exceed limits for ”acceptable quality” (Spörndly, 2003). Red clover silage and mixed ley ensiled in bales had low concentrations of butyric acid. Timothy crop was probably contaminated with *Clostridia* spores. Aerobic stability was very good for unwilted timothy, temperature increase was less than 2°C after 282 h in 25°C. Wilted control timothy, reached 3°C increase after 65 h. Red clover silage reached 3°C increase after >140 h, with endpoint temperature being negatively linear to biochar dose. Bale silage reached 3°C increase at >188 h with no effect of biochar dose. There were minor effects on protein quality with soluble fraction decreasing linearily in red clover with increased biochar dose and a small quadratic effect in unwilted timothy with least solubility for 2% biochar.

Conclusions

Addition of biochar to ley crops resulted in silage of good quality, except for when butyric acid fermentation occurred in the control silage and then increased with increasing biochar dose. The addition caused a minor reduction of protein solubility in red clover.

Acknowledgments

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