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The effect of relocation of whole-crop wheat and corn silages on their quality

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ABSTRACT

Whole-crop wheat and corn silages in 1.5-L anaerobic jars were exposed to air for 0 up to 48 h during their anaerobic storage period to simulate relocation of silages. Ensiling treatments included control (no additives) and either Koffosil T (Koffolk Inc., Petah Tikva, Israel) comprising a mixture of organic acids or *Lactobacillus plantarum* MTD1 (Ecosyl Products Ltd., Stokesley, UK). In the first set of experiments, the duration of exposure to air had little effect on ensiling parameters or on the aerobic stability of the final silages. In the second set of experiments, both the inoculant and duration of exposure to air had an effect on various fermentation parameters and on the aerobic stability of the final silages. We concluded that if the silages are of good quality, the duration of the relocation process has little effect on silage quality or its aerobic stability. However, if the silage contains any factor that may affect its aerobic stability, it is more sensitive to the time it takes to re-ensile the forage.
Key words: relocation, silage quality, aerobic stability

INTRODUCTION

Silage making is based on anaerobic fermentation, whereby lactic acid bacteria convert water-soluble carbohydrates into organic acids, mainly lactic acid. As a result, the pH decreases and the forage is preserved. Air is detrimental to the ensiling process, as it enables aerobic microorganisms to proliferate and spoil the silage (Woolford, 1990). Therefore, it is important to prevent air ingress into the silage by compaction of the crop particles during silage making and sealing it properly. However, some air usually penetrates into the silage during storage and feedout from the top and the unloading face (Ashbell and Weinberg, 1992; Weinberg and Ashbell, 1994).

In Israel, it sometimes is necessary to relocate commercial silages stored in bunker silos. This happens for various reasons related to current Israeli dairy cattle management. Smaller individual farms may merge into larger ones, and silages that were prepared on one farm are moved to the new location. Sometimes, empty bunker silos on small farms are filled by silage contractors who ship them as needed, mainly from the relatively rainy northern part of Israel to the arid south. In another situation, crop surplus may be ensiled in remote silos during the harvesting season and later moved to a bunker that is closer to the dairy farm.

Relocation of commercial silage involves unloading, transportation, recompaction, and sealing in the new silo. Such operations might take from several hours to 1 or 2 d, during which time the silage is inevitably exposed to air. In such circumstances, it is often asked how much damage is incurred by the relocation of the silage. The objective of the current experiments was to measure losses and changes in silages during relocation in model systems.

MATERIALS AND METHODS

Experiments

The experiments were performed in 2011 and 2012. In 2011, wheat at the flowering and milk stages of maturity and corn at the half milk dent stage were ensiled in 1.5-L anaerobic jars (J. Weck GmbH und Co. KG, Wehr-Öflingen, Germany). Silage treatments included control (no additives) and Koffosil T (Koffolk Inc., Petah Tikva, Israel), a chemical additive comprising organic acids, applied at 0.5 g/kg. The wheat and corn silages were stored at room temperature (25 ± 2°C) for 5 and 2 mo, respectively. Then, they were emptied into open plastic tubs and re-ensiled after 4 to 6, 16 to 17, 24 to 26, and 48 to 50 h. There were 3 jars per exposure time, and 3 jars were kept sealed until the end of the experiment. Similar experiments were performed in 2012 with wheat from the milk stage and corn; silage treatments included control and addition of *Lactobacillus plantarum* MTD1 (Ecosyl Products Ltd., Stokesley, UK) applied at 10^6 cfu/g, and the exposure times in the tubs were 4, 8, 24, and 48 h.

The weight of the jars was determined immediately after the first sealing, just before the first opening, immediately after the second sealing, and at the end of the experiments. The re-ensiled jars were stored for an additional 1.5 mo, after which they were subjected to an

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aerobic stability test in bottle systems for 5 d at 30°C. The aerobic stability test was conducted in triplicate using recycled 1.5-L polyethylene-terephthalate (soft drink) bottles. These systems consisted of 2 parts: the upper part included the screw cork with holes bored in the cork and in the lid of the opposite side. This part was filled with ca. 250 g of silage and was placed upside down over a fitting beaker that contained 100 mL of 20% KOH. In these systems, change in pH, production of CO_2, and numbers of yeasts and molds, as well as visual appearance, served as spoilage indicators. The CO_2 that was absorbed in the base solution was determined on 10-mL aliquots diluted with 90 mL of water, by titration with 1 *N* HCl between pH 8.1 and 3.6, according to the pK values [$\log_{10}(1/K_a)$, where K_a is the acid dissociation constant] of carbonic acid (Ashbell et al., 1991; Weinberg et al., 2009).

Analyses

Dry matter content was determined in triplicate by oven drying for 48 h at 60°C. Dry matter losses were calculated from weight losses and differences in DM content. Ash content was obtained in a muffle oven after 3 h at 550°C. Lactic acid concentration was determined by the spectrophotometric method of Barker and Summerson (1941). Ethanol and VFA concentrations were determined in aqueous extracts with a gas chromatograph equipped with a semi capillary FFAP (nitroterephthalic acid-modified polyethylene glycol) column (Hewlett-Packard, Waldbronn, Germany), over a temperature range of 40 to 230°C. Neutral detergent fiber [NDF inclusive of ash − NDF] concentration was determined according to Van Soest et al. (1991) with an Ankom fiber analyzer (Ankom Technology, Macedon, NY). Losses in the mini-silos were assessed by weighing. The DM and NDF digestibility were determined with the 2-stage fermentation technique according to Tilley and Terry (1963), with all samples in triplicate. Rumen fluid was obtained from a ruminally fistulated dry Holstein cow fed 6 kg (as DM) of wheat hay and 4 kg (as DM) of TMR containing 30% of concentrated grains, 35% of wheat and corn silages, 15% of soybean and sunflower meals, and 20% by-products (cottonseed, wheat bran, and gluten feed). Microbiological evaluation included enumeration of yeasts and molds on spread-plate malt extract agar (Difco Laboratories Inc., Detroit, MI) acidified to pH 4.0 with lactic acid. The plates were incubated for 3 d at 30°C. Microbiological analysis was performed on a single representative silage sample from each treatment.

Statistical Analysis

Statistical analysis included ANOVA and the Tukey studentized range test, which were performed with PROC GLM procedure of SAS (SAS Institute Inc., Cary, NC). The main effects included silage treatments, re-location duration, and their interactions.

RESULTS

The experiments with the wheat and corn silages from 2011 revealed that exposing the silages for up to 48 h resulted in only some drying of the forage. However, DM losses, aerobic stability, and other silage parameters were not affected significantly ($P < 0.05$) by the exposure to air. Table 1 summarizes the results from the experiment with the corn silages as an example for this set of experiments. In the aerobic stability test, the pH values remained at 4.2, CO_2 production was low (1.0–2.2 g/kg of DM), and yeast and mold numbers were below the detection limit ($\log_{10}$ cfu/g <2). The longer exposure times resulted in a significant decrease in DM and amylase-treated NDF digestibility.

Results from the experiment with the wheat silage from 2012 are presented in Table 2. Time of exposure did not affect DM losses; however, ensiling losses decreased significantly by the added lactic acid bacteria inoculants. Both the control and inoculated silages had relatively high ethanol concentrations. The various control silages had higher contents of acetic and butyric acids (10–14 and 19–24 g/kg of DM, respectively) than the inoculated silages (6–8 and 3–12 g/kg of DM, respectively), whereas lactic acid content was higher in the inoculated silages (59–64 vs. 25–43 g/kg of DM in the inoculated and control silages, respectively, with a significant treatment effect). The duration of exposure to air of the silages in the middle of the anaerobic storage resulted in substantial drying of the silages and affected ethanol and butyric acid contents and DM digestibility but not lactic and acetic acid contents.

Results from the experiment with the corn silage from 2012 are presented in Table 3. The lactic acid bacteria inoculant had an effect on fermentation end products and resulted in decreased losses. The acetic acid content of the control and inoculated silages was 8 to 15 and 4 to 9 g/kg of DM, respectively. The duration of exposure to air of the silages in the middle of the anaerobic storage resulted in a decrease in fermentation product concentrations but it did not affect total DM ensiling losses or ash or digestibility values.

Table 4 summarizes the aerobic stability test of the wheat and corn silages from 2012, which was performed after the final opening of the jars. Values for each treatment are given separately because the experiments were designed so that the inoculants should affect the aerobic stability of the silages as compared with the control silages. In the wheat silages, treatment with *Lb. plantarum* had a significant effect on