Gas production and volatile composition of CO_2-supplied corn silages

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Introduction: This trial came as a sequence of our previous trial (Schmidt et al., 2018) in order to understand a new phase of negative pressure and gas fixation within the storage of silages. We aimed to evaluate the dynamics of gas production as well as the internal pressure of the silos and the carbon dioxide absorption throughout the fermentation of whole-plant corn silage, in hermetically sealed lab silos.

Materials and Methods: Twenty-four PVC silos (8.8 L) were filled (145 or 180 kg DM m^{-3}) with chopped corn forage (290 g kg^{-1} DM) and hermetically sealed. Silos were stored in a controlled-temperature room (24±1 ºC). Once the silos stopped the gas production and started showing negative pressure (12th day of fermentation), 12 silos were kept CLOSED and weekly submitted to the evaluation of internal pressure using a mercury column manometer. Another 12 silos started being weekly supplied with pure CO_2 (31 weeks) according to the procedures described by Schmidt et al. (2018). After 233 days, the silos were weight and opened. The top silage (2 cm) of each silo was removed and discarded. The next 15 cm of silage was taken and thoroughly mixed in a sterile plastic bag. Two samples of 50 g were collected for VOC analysis (Weiss, 2016) and pH (Kung, 1984). The remaining silage was them removed and homogenized with the upper layer silage for sampling and assessing DM content. The experiment was performed in a complete randomized design with a 2 x 2 factorial arrangement of treatments, using six replicates per treatment. Analysis of variance was used for residual analysis using the GLM procedure of SAS and means compared at 0.05 significance by Test F, by PROC GLM. Correlation analysis using the CORR procedure was applied for VOC composition and CO_2 absorption.

Results and Discussion: The initial phase of gas production after sealing lasted nine days. The average volume of gas produced was 7.84±1.02 L per silo (5.51 L kg DM^{-1}) for the treatment 145 kg DM m^{-3}, and 9,27±1,12 L per silo (6.51 L kg DM^{-1}) for the treatment 180 kg m^{-3}. The volume of gas produced differ between the bulk densities ($P<0.05$). Twelve days after sealing silos started showing negative pressure. The negative internal pressure of the silos started being measured on the 19th day. We have detected a huge variation among replicates in both the bulk densities for internal pressure and CO_2 absorption, probably related to some sealing failure or an unknown effect. Despite the variability, all the silos that were kept closed (n=12) showed negative pressure throughout the trial. The 145 kg DM m^{-3} treatment showed the strongest negative pressure probably related to higher residual gas in the porous space. Silos that received CO_2 supplies absorbed 7.675 L of CO_2 kg^{-1} DM for treatment 145 kg m^{-3}, and 2.572 L of CO_2 kg^{-1} DM for treatment 180 kg m^{-3}. The lower bulk density treatment presented an increase in CO_2 absorption throughout the trial, while the 180 kg DM m^{-3} treatment seemed to reach a plateau at the fifth month. Six of 12 silos presented higher CO_2 absorption, averaging 7.104 L kg DM^{-1}. The maximum observed value was 14.534 L of CO_2 absorbed per kg of DM. The CO_2 supplies did not influence silage pH. Bulk density affected the content of 1,2-propanediol (Table 1). The CO_2 supplies slightly increased the content of 2,3-butanediol. No other effect of treatment was detected. Propionic acid, isobutyric acid, valeric acid, isovaleric acid, acetone, propanol, butanol, propylacetate and 2-butanol were not detected in any sample. The undesirable high variability inside treatments, detected by the variation of internal pressure or CO_2 absorption among replicates, could explain the lack of treatment effect over the volatiles. A trend (P=0.08) of moderate positive correlation (r=0.53) between CO_2 absorption and the content of acetic acid was detected. It may indicate that CO_2 could has been fixed as acetic acid by acetogenic microorganisms (Drake et al., 2008). The stoichiometry calculation supports that finding.

Table 1. Volatile composition of the silages stored for 233 days under two bulk densities (145 or 180 kg DM m^{-3}) in silos closed or receiving CO2 supplies

	Treatments							
	Closed		CO_2			Effect[1]		
Parameters	145	180	145	180 kg	CV(%)[2]	D	C	D*C
pH	3.71	3.66	3.70	3.64	0.99	**	ns	ns
Lactic acid, % of	5.32	6.09	5.93	5.9	19.6	ns	ns	ns
Acetic acid, % of DM	1.57	1.52	1.86	1.62	82.1	ns	ns	ns
mg kg^{-1} DM								
Butyric acid	108	0	105	0	291.1	ns	ns	ns
N-NH_3	841	855	917	853	22.7	ns	ns	ns
Ethanol	730	893	682	576	41.0	ns	ns	ns
Methanol	321	313	364	308	36.3	ns	ns	ns
1,2 Propanediol	653	199	847	378	66.5	**	ns	ns
2,3 Butanediol	436	399	482	531	31.0	ns	*	ns
Ethyl acetate	5	3	5	3	334.4	ns	ns	ns
Ethyl lactate	16	14	18	18	31.9	ns	ns	ns

[1]D – effect of bulk density; C – effect of condition (closed or CO_2 supply); *P<0.05; ** - P<0.01
[2]Coefficient of variation

Conclusions: The absorption of CO_2 by silage microbiota is a brand-new issue that needs more efforts for a better understanding of that consistent effect. Methodology improvements have been doing for avoiding undesirable gas flux in and out of the silos. Since some replicates showed great potential for CO_2 absorption, and a trend of correlation between this variable and acetic acid content was detected, a homoacetogenic pathway performed by some unidentified bacteria may be the most prone explanation for understanding the effect.

References:

Schmidt, P.; Novinski, C. O.; Zopollatto, M. 2018. Carbon absorption in silages: a novel approach in silage microbiology. Pages 20-21. In: Proceedings of XVIII International Silage Conference, Bonn. Universität Bonn, Bonn, Germany.

Drake, H. L., Gössner, A. S., Daniel, S. L. (2008) Old acetogens, new light. Ann N Y Acad Sci. 1125:100-128. DOI:10.1196/annals.1419.016.