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► **To cite this version:**

C van Vlierberghe, R Escudie, N Bernet, S Frederic, H Carrere. ALKALINE ALTERNATIVE TO ENSILING FOR THE STORAGE OF A CATCH CROP FOR BIOGAS PRODUCTION. 8th International Conference on Engineering for Waste and Biomass Valorisation WasteEng2020, May 2021, online, France. hal-04124111

HAL Id: hal-04124111

<https://hal.science/hal-04124111>

Submitted on 9 Jun 2023

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ALKALINE ALTERNATIVE TO ENSILING FOR THE STORAGE OF A CATCH CROP FOR BIOGAS PRODUCTION

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1. Keywords

Storage, pretreatment, catch crops, biomethane, anaerobic digestion

2. Highlights

Alkaline storage of rye in dry condition had better weight preservation than ensiling

Alkali-stored rye had faster conversion into methane than fresh and ensiled crop

Maintaining pH around 12 was necessary to avoid microbial activity during storage

3. Purpose

In order to face the increasing demand in sustainable biomethane, more substrates have to be mobilized for anaerobic digestion (AD). Catch crops are an interesting option for massive production of feedstock for biogas while avoiding competition for arable land and providing many agro-ecological advantages [1]. However, catch crops are harvested once or twice a year while digesters are fed continuously. Efficient storage of biomass, usually done by ensiling, has to be performed in order to preserve their methane potential. In addition, cell walls of plants are made of lignocellulosic matrix, whose biomethane yield can be increased by pretreatments. This study aims to find an alternative to ensiling for catch crop storage prior to AD, uniting long duration alkaline pretreatment and storage in a single and low requirement process at high DM content and ambient temperature.

4. Materials and methods

The raw material was a sample of rye (*Secale cereale*) cultivated as a winter catch crop and harvested at early milk stage (BBCH 73, 38% DM). The whole plant was hand-harvested and chopped into approx. 1-2 cm pieces for storage experiments. Laboratory-scale storage experiments were conducted in 2L glass jars. Six replicates were prepared for each storing condition to be sacrificed after 2, 7, 21, 60, 180 and 365 d of storage. CaO was chosen because it is compatible with the use of digestates as biofertilizers and inexpensive. It was added as dry powder at the dose of 100 gCaO kg⁻¹ DM. In the 1st alkaline storage condition, DM was kept to 38 % (ALK38). In the 2nd one, water was sprayed to reach a DM of 25% (ALK25). In addition, the fresh material was ensiled directly after chopping (ENS). All the samples were packed into the jars which were then flushed with N₂, sealed with a rubber that allows pressure release and gas sampling, and stored in a dark place at 22°C. Dry and organic matters were measured directly on fresh and stored samples and corrected as described in [2]. Soluble compounds were extracted as described in [2]. After extraction, the pH was measured and the liquid phase was separated and frozen for further analyses of Volatile Fatty Acids (VFA), Water Soluble Carbohydrates (WSC), NH₃ and metabolites. Solid samples were freeze-dried for further analysis of fiber distribution and total nitrogen. Gas production was analyzed periodically and weight loss was measured after gas release. Biochemical Methane Potential (BMP) tests were conducted in batch as described in [3].

5. Results and discussion

After two-month storage, weight losses of 3.3%, 0.3% and 2.5% of initial VS were observed for ALK25, ALK38 and ENS samples, respectively. Soluble COD increased by 143, 68 and 133%, respectively, showing the solubilization of the organic material while metabolites were released. The pH of ENS samples dropped quickly and stabilized at 4.0 as WSC were converted in lactic acid (Figure 1). pH of ALK25 remained stable at about 12 during the first 3 weeks, and then decreased to 7.4, simultaneously with gas production (H_2 and CO_2) and weight loss, indicating that microbial activity started. pH of ALK38 remained stable around 12 for more than 2 months and almost no gas production nor weight loss were observed. BMPs of the raw substrate and the substrate stored during 7 and 60 days were monitored. CH_4 production of ALK25 and ALK38 was increased by up to respectively 39 and 32% compared to the fresh crop and ENS after 12 days of reaction, but no significant difference was observed after a longer digestion time of 37 days (Table 1, experiment in progress).

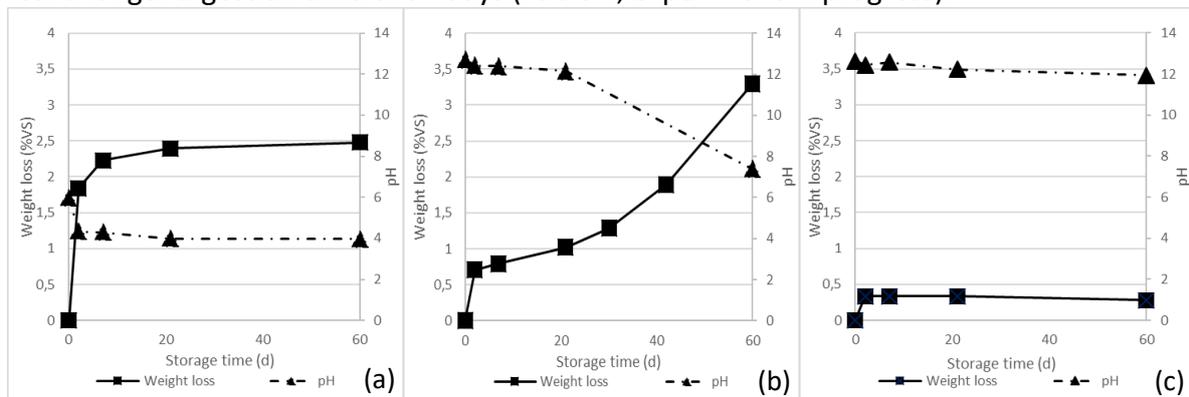


Figure 1: Weight loss and pH dynamics for (a) silage, (b) wet alkaline storage and (c) dry alkaline storage

Table 1: Methane cumulated volume after 12 and 37 days of BMP batch assay, expressed in $NmLCH_4.gVS_{init}^{-1}$ - temporary results

	Freshly harvested	ENS 7 d storage	ENS 60d storage	ALK25 7 d storage	ALK25 60d storage	ALK38 7 d storage	ALK38 60d storage
BMP – 12d batch	140 ± 20	157 ± 11	150 ± 1	195 ± 7	185 ± 5	185 ± 4	188 ± 9
BMP - 37d batch	296 ± 18	316 ± 15	313 ± 12	316 ± 14	302 ± 10	304 ± 24	305 ± 24

6. Conclusions and perspectives

Alkaline storage of catch crops can constitute an efficient alternative to ensiling for the storage and pretreatment of catch crops prior to anaerobic digestion. However, the parameters that allow to maintain the pH stable and to prevent microbial activity are still not completely understood, and further analyses are still in progress. Investigating the dynamics of soluble compounds profiles will bring more information for this purpose. Fiber distribution and final BMP will allow to conclude over the efficiency of the alkaline pretreatment.

7. References

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