



HAL
open science

SONICATION OR ACID PRETREATMENT IMPACTS AND THEIR CONSEQUENCES ON THE DARK FERMENTATION PROCESS

K Dauplain, E Trably, A Cesaro, H Carrere

► **To cite this version:**

K Dauplain, E Trably, A Cesaro, H Carrere. SONICATION OR ACID PRETREATMENT IMPACTS AND THEIR CONSEQUENCES ON THE DARK FERMENTATION PROCESS. 9th International Conference on Engineering for Waste and Biomass Valorisation, Jun 2022, Copenaghen, Denmark. hal-04124193

HAL Id: hal-04124193

<https://hal.science/hal-04124193>

Submitted on 9 Jun 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

SONICATION OR ACID PRETREATMENT IMPACTS AND THEIR CONSEQUENCES ON THE DARK FERMENTATION PROCESS

K. DAUPTAIN¹, E. TRABLY¹, A. CESARO², H. CARRERE¹

¹ LBE, Université de Montpellier, INRAE, Narbonne, France.

² University of Napoli Federico II, Napoli, Italy

1. Keywords

Biohydrogen, Dark fermentation, Acid pretreatment, Ultrasound, Waste

2. Highlights

- OFMSW were pretreated by sonication or acid pretreatments
- Generally, biomass pretreatments did not increase the H₂ yield
- Substrate pretreatments induced metabolic changes towards butyrate or ethanol
- Metabolic changes are due to the pretreatment impact on indigenous bacteria

3. Purpose

Dark fermentation (DF) can be carried out by indigenous bacteria in a self-fermentation concept or by adding an inoculum [1]. Biomass pretreatments have been widely investigated in order to improve hydrogen production by DF. However, literature on biomass pretreatments mainly focuses on biomass structure, the increase in soluble sugars and hydrogen yields [2]. Nevertheless, the pretreatment consequences on bacterial community selection among the initial ones (indigenous or exogenous bacteria) have been scarcely investigated. This work aims to study the impacts of sonication or thermo-acid pretreatments on sugar solubilization and on biotic parameters such as DF performances, the selection of bacterial communities and the related metabolic pathways.

4. Materials and methods

Biochemical hydrogen potential (BHP) tests were carried out with synthetic organic fraction of municipal solid waste (OFMSW) as reported elsewhere [1]. For each set of experiments, two different BHP conditions were tested: an inoculated control (C), an inoculated and pretreated BHP (P). Three biomass pretreatment conditions were investigated: (1) [HCl] = 0.35 mol/L or 11.0 mmol/gVS_{ini} – 90°C – 30 min -10% TS (2), [H₂SO₄] = 0.72 mol/L or 22.8 mmol/gVS_{ini} – 90°C – 30 min -10% TS, (3) 20 kHz - 600 kJ - 4% TS-700 W - 14min17s – SE = 59.4 kJ/gTS (sonication probe). To confirm the pretreatment impact on indigenous bacteria, experiments with HCl (11.0 mmol/gVS_{ini} – 90°C – 30 min) were performed without inoculum (marked “*”) or with γ -irradiated OFMSW (inactivated indigenous bacteria) at 45 kGy as reported in another work.

5. Results and discussion

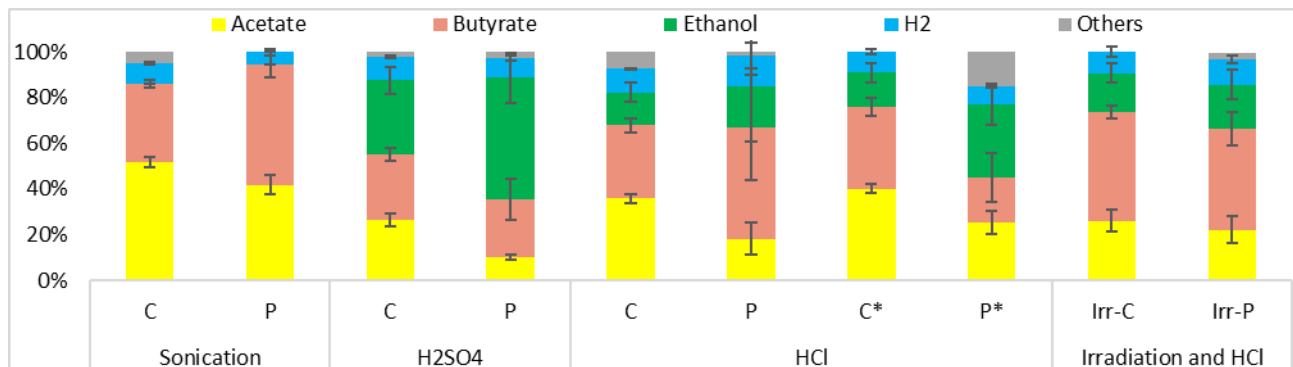
Results showed a 6-fold increase in soluble carbohydrate content after both acid pretreatments of OFMSW. Nevertheless, according to Fig. 1, acid pretreatments led to a slight increase or decrease in hydrogen yields compared to raw biomass experiments. This is not consistent with the results from the study of Kim et al. [3] who observed a significant increase in the H₂ yield after HCl pretreatments of food waste. Interestingly, sonication led to a substrate bioconversion improvement but hydrogen production was similar to experiments using raw biomass. Fig. 2 shows the metabolic distribution at the end of DF for each condition. Interestingly, sonication or acid pretreatments were responsible for metabolic changes from acetate towards butyrate or ethanol due to bacterial community shifts

(microbial data not shown). For instance, butyrate proportion increased after sonication from $34.4 \pm 1.8\%$ to $53.0 \pm 5.6\%$ at the expense of acetate with a decrease from $51.8 \pm 2.2\%$ to $41.8 \pm 4.1\%$. For experiments performed with sulfuric acid pretreated OFMSW, similar results were noticed with a metabolic change from acetate ($26.7 \pm 2.9\%$ [raw]; $10.2 \pm 1.3\%$) towards ethanol ($32.6 \pm 5.9\%$ [raw]; $53.3 \pm 10.9\%$). Moreover, the decrease in acetate proportions after pretreatments occurred regardless of inoculum addition as observed for HCl pretreatments. The metabolic changes were attributed to the biomass pretreatment impact on indigenous bacteria as any change was observed in the metabolic profile after performing thermo-acid pretreatment on irradiated OFMSW (inactivated indigenous bacteria).

Table 1 Initial soluble sugars, hydrogen yield and total bioconversion for raw, pretreated and irradiated OFMSW.

Pretreatment	Experiment	Initial soluble sugar concentration (g eq.-glucose/L)	H ₂ (mL/gVS _{ini})	Metabolites (gCOD/gVS _{ini})
-	Control	-	29.1 ± 1.8	0.23 ± 0.03
Sonication	Pretreated	-	22.2 ± 5.2	0.30 ± 0.03
-	Control	1.1	43.6 ± 1.7	0.30 ± 0.01
H ₂ SO ₄	Pretreated	6.0	37.1 ± 5.6	0.29 ± 0.01
-	Control	1.5	38.8 ± 4.4	0.27 ± 0.02
HCl	Pretreated	8.7	44.8 ± 2.0	0.24 ± 0.00
-	No inoculum - Control	1.5	28.7 ± 0.9	0.23 ± 0.00
HCl	No inoculum - Pretreated	8.7	23.2 ± 16.0	0.20 ± 0.06
-	Irradiated - Control	-	36.0 ± 2.9	0.27 ± 0.01
HCl	Irradiated - Pretreated	-	41.2 ± 5.3	0.24 ± 0.01

Fig. 1 Metabolite distribution for raw, pretreated and irradiated OFMSW in percent (gCOD/gCOD_{ini}). Irr = Irradiated, * = No inoculum.



6. Conclusions and perspectives

This study proves that thermo-acid pretreatments are particularly efficient to improve sugar solubilization. Sonication and acid pretreatments were inefficient to improve H₂ yield. Nevertheless, they induced metabolic changes from acetate toward butyrate or ethanol. As suspected, these metabolic changes did not occur when indigenous bacteria were inactivated by gamma irradiation. Further investigations are required with other biomasses and pretreatment methods to confirm the possibility of pretreatments to cause metabolic and microbial shifts by impacting indigenous bacteria.

7. References

- [1] Dauplain K, Trably E, Santa-Catalina G, Bernet N, Carrere H. Role of indigenous bacteria in dark fermentation of organic substrates. *Bioresour Technol* 2020;313:123665. doi:10.1016/j.biortech.2020.123665.
- [2] Rafieenia R, Lavagnolo MC, Pivato A. Pre-treatment technologies for dark fermentative hydrogen production: Current advances and future directions. *Waste Manag* 2018;71:734–48. doi:10.1016/j.wasman.2017.05.024.
- [3] Kim DH, Jang S, Yun YM, Lee MK, Moon C, Kang WS, et al. Effect of acid-pretreatment on hydrogen fermentation of food waste: Microbial community analysis by next generation sequencing. *Int J Hydrogen Energy* 2014;39:16302–9. doi:10.1016/j.ijhydene.2014.08.004.