Fungal pre-treatment in bioenergy production from macroalgal biomass

Nesrine Ben Yahmed, Hélène Carrère, M Nejib Marzouki, Issam Smaali

Fungal pre-treatment in bioenergy production from macroalgal biomass

Nesrine Ben Yahmed [a], Hélène Carrere [b], M.Nejib Marzouki [a], Issam Smaali [a]

[a] Laboratoire LIP-MB INSAT, LR11ES26, Université de Carthage, INSAT-BP 676, Centre urbain nord, 1080 Carthage Cedex, Tunisie

[b] LBE, INRA, Avenue des Etangs, 11100 Narbonne, France

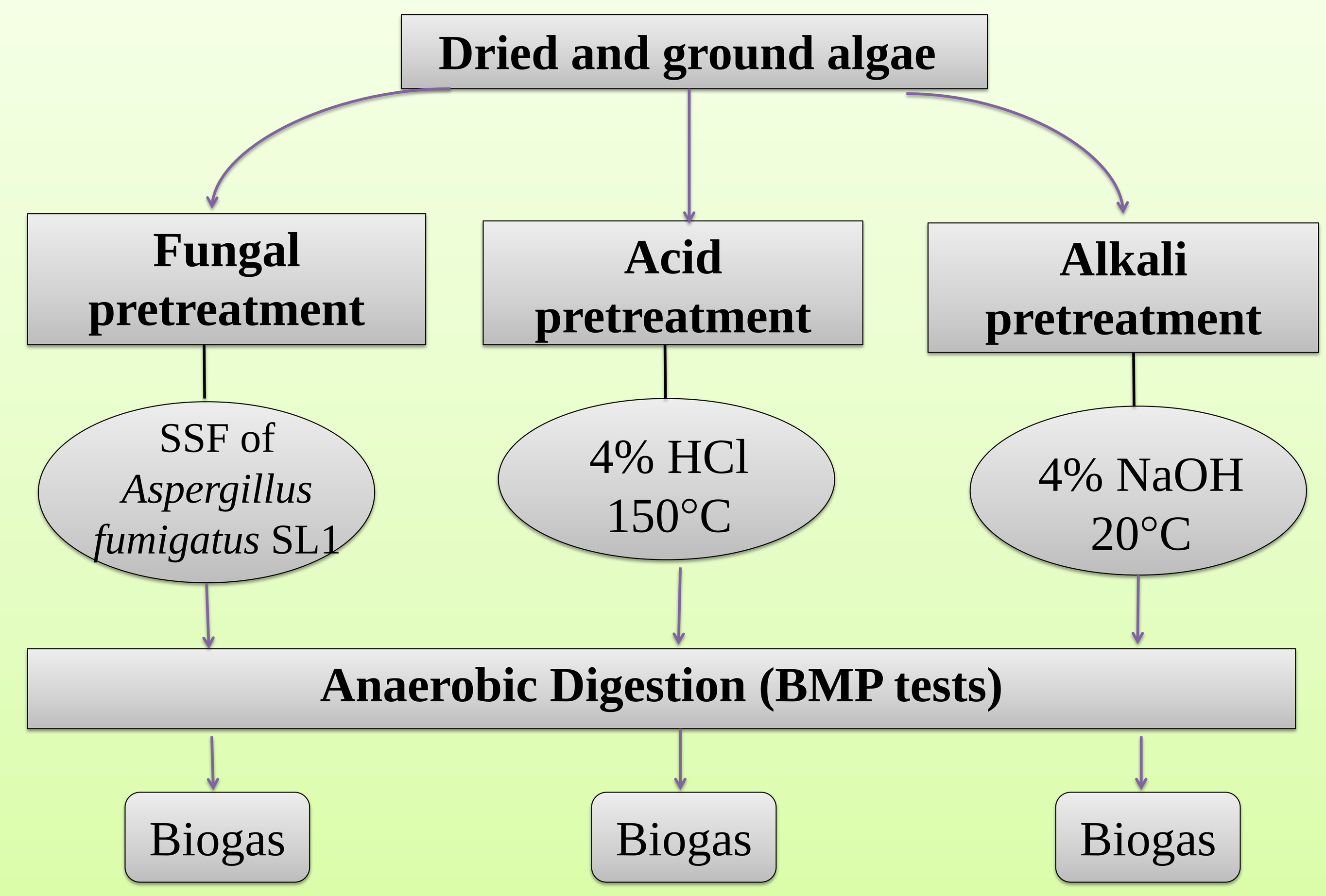
Introduction

The utilization of biomass as renewable source for energy production represents a promising alternative for the substitution, at least in part, of fossil fuels consumption. Macroalgal biomass received a considerable attention as a third-generation biofuel feedstock due to its prolific growth in eutrophic coastal, water fouling beaches and coastal waterways.

0bjectives

- Evaluation of the biogas production enhancement from *Ulva* sp. biomass after fungal Solid State Fermentation (SSF) pretreatment using locally isolated fungus from algae
- Comparison with conventional acid/alkali chemical pretreatments

Methodology

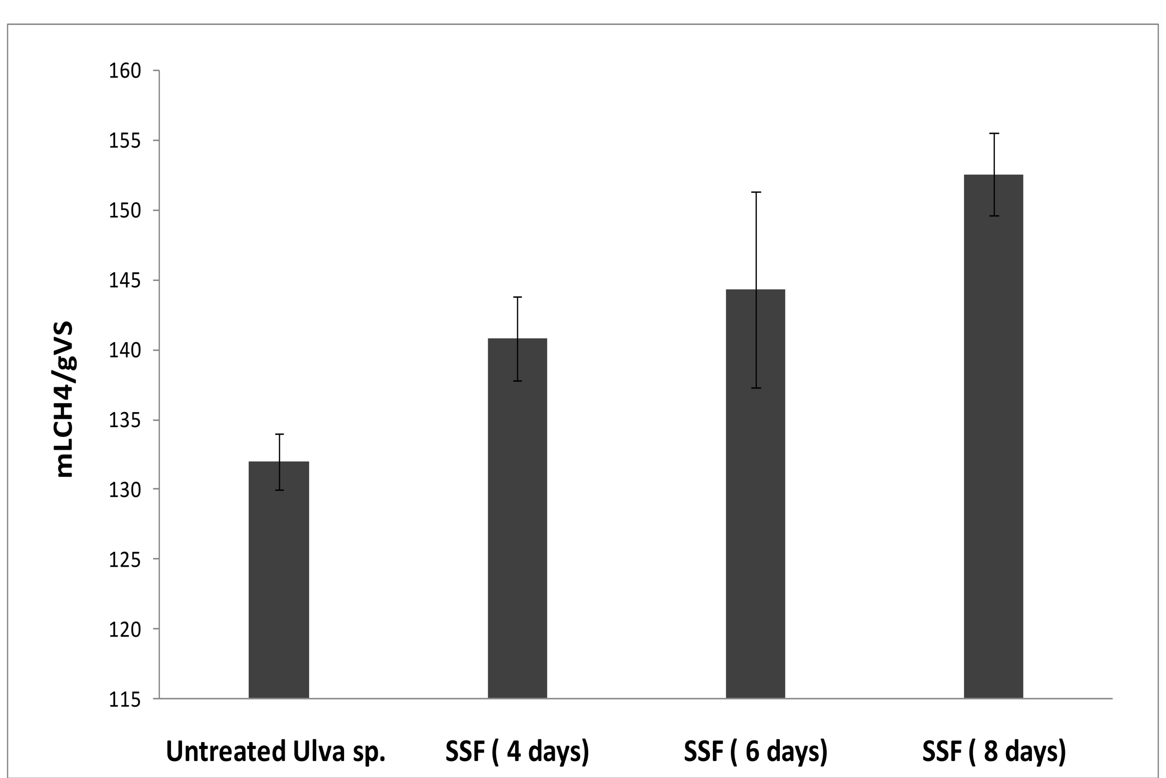


Results

❖ Chemical composition of *Ulva* sp. after drying and grinding

Characteristics	Mean ± S.D
TS (%wet weight)	84.1 ± 0.1
VS (%TS)	67.8 ± 0.1
Total carbohydrates (%TS) [a]	33.2 ± 0.8
Glucose (%TS)	12.4 ± 0.2
Xylose (%TS)	3.9 ± 0.1
Rhamnose (%TS)	9.8 ± 0.8
Arabinose (%TS)	7.1 ± 0.4
Uronic acids (%TS)	5.7± 0.1
Proteins (%TS)[b]	11.4± 0.5
Lipids (%TS)	1.8 ± 0.05

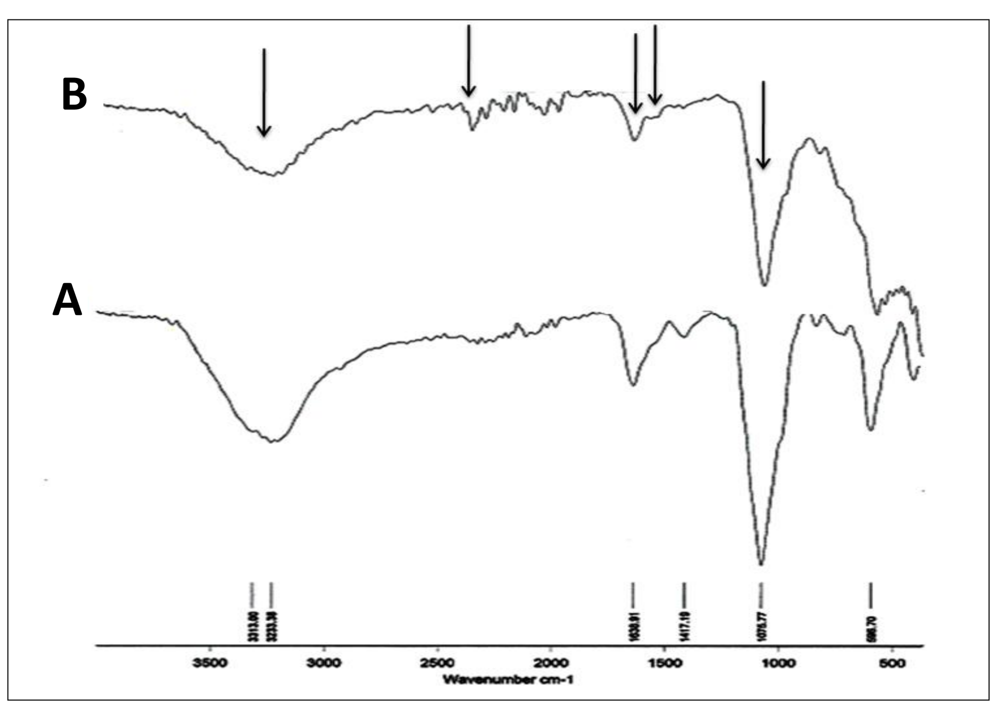
Ulva sp. collected from Tunis lagoon was rich on volatile solids, carbohydrates and proteins with absence of lignin
➡ Good substrate for biogas production.



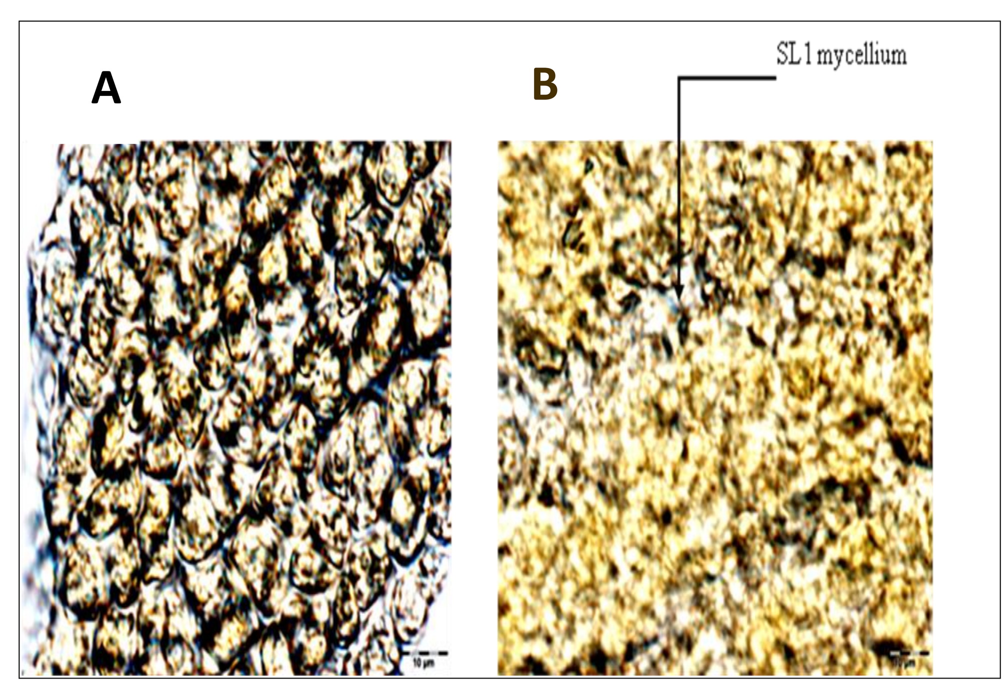
Effect of SSF pretreatment time on BMP of *Ulva* sp.
(All values are significantly different (p<.0001))

After 8 days of SSF ⟶ Significant increase (p<0.05) in BMP which reached 153 ± 3 mL CH4/gVS

❖ Effect of *Aspergillus fumigatus* SL1 based SSF pretreatment on *Ulva* sp. structure and methane potential



FTIR spectra (400–4000 cm-1) of untreated (A) and fungal pretreated *Ulva* sp. by SSF with *Aspergillus fumigatus* SL1 (B)



Scanning Electron Microscopy picture of *Ulva* sp. without pretreatment (A) and with fungal pretreatment (B)

Untreated macroalgae have strong stretching vibration peaks corresponding to the O-H and N-H groups, but those transmittances decrease in the pretreated macroalgae
➡ Decomposition of carbohydrates and proteins after SSF fungal pretreatment.

Penetration of *Aspergillus fumigatus* SL1 mycelium:
⟶ Increasing pore sizes and surface areas
⟶ Facilitating the accessibility to enzymatic attacks
⟶ Transforming the algae and making it more digestible (improving BMP)

❖ Comparison of fungal and conventional chemical pretreatments

Pretreatment conditions	BMP (mL CH_4 g^{-1} VS)	Increase BMP (%)	BD (%)
Untreated	132 ± 2	_	49
Acid pretreatment (4% HCl at 150°C)	77 ± 5	- 55	29
Alkali pretreatment (4% NaOH at 20°C)	148 ± 11	16	55
Fungal pretreatment (SSF with *Aspergillus fumigatus* SL1)	**153 ± 3**	**21**	**57**

<u>Acid pret</u>: Negative effect: loss of organic matter (High Temperature)
<u>Alkali pret</u>: BMP↗ Destructuration of algae thallus by NaOH; the solubilization of cell wall sugars.
<u>Fungal pret</u>: BMP↗↗ Decomposition of algae thallus with an increase of biomass degradability; the bioconversion of nutrients molecules related to the growth of mycelium.

Conclusion and perspectives

- The study demonstrated the proof of using fungal SSF as effective biological pretreatment method for enhancing biogas production from green macroalgae.
- Performing SSF with a specific fungal strain, isolated from the same algal biomass, and growing on it as the sole carbon source allowed to benefit from all the advantages of SSF, notably the large biomass loading, the low chemical risk related to the strong alkali and its high cost, facilitating therefore the scale-up and the design of eco-friendly processes.
- The utilization of this latter still quite recent and needs further investigations to assess an optimal biomethane yield, related to the both origin and composition of the algal biomass.

Contacts: nesrine.benyahmed@gmail.com /Issam.Smaali@insat.rnu.tn/ helene.carrere@supagro.inra.fr