Cultivation of the green macroalgae Ulva lactuca and Ulvaria splendens for biofuels production

Angelidaki, Irini; Galanidis, Stefanos; Holdt, Susan Løvstad; Jørgensen, Marianne Willemoes

Publication date:
2011

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):

General rights
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.
The green macroalgae Ulva lactuca and Ulvaria splendens are two species particularly interesting in an algal biorefinery concept including biofuel production in Denmark and Greenland, respectively. The possibility of using digested pig manure (DPM) as nutrient source for the cultivation of the two species was investigated, and the macroalgae were also used as substrate for anaerobic thermophilic digestion with DPM as inoculum. Half the algal fronds were washed with fresh water in order to investigate the effect of sea salt in the anaerobic digestion. Furthermore, Ulva lactuca contains a high amount of carbohydrates (>60%) making them suitable for cellulosic ethanol fermentation. The yeast potential as candidates for future algal biorefineries using diluted DPM as nutrient source for biomass production and the biomass utilized for biofuels.

Aims

- Review products that can be derived from the green macroalgae Ulva lactuca and Ulvaria splendens.
- Determine the growth rate of Ulva lactuca and Ulvaria splendens cultivated under different nutrient regimes.
- Investigate digested pig manure (DPM) as nutrient source candidate for algal growth.
- Quantify the biogas and bioethanol potential production of Ulva lactuca and Ulvaria splendens.
- Investigate the possible inhibition of the biogas process, by the marine sea salt contained in the superficial seawater present on the algal fronds.
- Determine the alkaline/oxidative pretreatment effect of the macroalgae on the ethanol production.

Materials and methods

Natural populations of Ulva lactuca and Ulvaria splendens were collected at Danish and Greenlandic shores, respectively, and cultivated in 300 mL aerated seawater enriched with NO₃ (8.72), NH₄ (standard algal medium) and diluted (1:200) digested pig manure (mainly NH₃) as nitrogen source corresponding to 12.35 mg N/L. Light was provided 24 hours daily with intensity of 48μmols photon/s/m² temperature of 15°C and experiment duration was 21 d. For experiments of biogas potential 550mL bottles were used with organic loading of 1, 2, and 4 g VS/L macerated algal biomass (washed with fresh water or left with seawater on surfaces), water and inoculated with digested pig manure to volume of 200mL. The ethanol potential of the species was measured by HPLC after enzymatic hydrolysis by citric buffer (pH:4.8) and incubation (50°C, 120 rpm, 24h) and fermentation by yeast Saccharomyces cerevisiae. Pretreatment consisted of cutting (<2mm) and addition of MgSO4 (1g/L), H2O2 (3% V/V) and 0.5 M NaOH for pH adjustment to pH:11.5.

Results

- Literature study showed high market potential of carbohydrates (>60% of dry weight including ulvan) derived from especially Ulva spp. for various products e.g. cosmetics.
- High growth rates (0.22 d⁻¹ with NO₃ culture medium) and high yields (10 x corn yield).
- Ulva lactuca had higher growth rates for all treatments compared to Ulvaria splendens (p<0.05).
- Diluted DPM was suitable as nutrient source, however growth rate 27% lower (0.16 d⁻¹) than the maximum achieved.
- Both Ulva lactuca and Ulvaria splendens could be used for biogas production with a yield of approx. 0.21 CH4/g VS. The CH4 yields were 21-29% higher when the macroalga was washed.
- The Na⁺ and K⁺ concentrations of < 1 g/L should not be inhibiting the biogas process.
- Alkaline/oxidative pretreatment of Ulva splendens decreased the ethanol production significantly, and this species had a significantly lower concentration of ethanol than Ulva lactuca.

Conclusions

Ulva lactuca and Ulvaria splendens could both be cultivated on diluted DPM as growth medium, with Ulva lactuca reaching the highest growth rates. The high carbohydrate content of especially Ulva lactuca makes this candidate for ulvan extraction and ethanol fermentation. Pretreatment of biomass was not necessary for biomass fermentation. Higher biogas potentials were reached in the washed Ulvaria splendens compared to Ulva lactuca. These results make both species candidates for future algal biorefineries.