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):
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 digestion. They contain a high amount of carbohydrates (>60%) making them suitable for cellulosic ethanol fermentation. The yeast *Saccharomyces cerevisiae* was used for ethanol fermentation after the enzymatic hydrolysis of the macerated algal biomass, and the effect of alkaline pre-treatment was also investigated in regard to the potential ethanol production. In this study, both species showed potential as candidates for future algal biorefineries using diluted DPM as nutrient source for biomass production and the biomass utilized for biofuels. *Ulva lactuca* had significantly higher growth rates compared to *U. splendens*. However, washed *U. splendens* had significantly higher biogas potential than *U. lactuca*. Results on ethanol concentrations showed that pretreatment of biomass was not necessary prior to fermentation.

**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 NO-3 (6/2), NH4+ (standard algal medium) and diluted (1:200) digested pig manure (mainly NH4+) as nitrogen source corresponding to 12.35 mg N/L. Light was provided 24 hours daily with intensity of 48umol photons/um²/second, temperature of 15°C, and experiment duration was 21 d. For experiments of biogas potential 550 mL bottles were used with organic loading of 1, 2, and 4 g VS/L macerated algal biomass (washed with fresh seawater or left with sea water on surface), water and inoculated with digested pig manure to volume of 200 mL. 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 Mg2SO4 (1g/L), H2O2 (1% V/V) and buffer (pH=4.8) and incubation (50°C, 120 rpm, 24h) and fermentation by yeast *Saccharomyces cerevisiae*.

**Results**

- *Ulva lactuca* and *U. splendens* could both be cultivated on diluted DPM as growth medium, with *U. lactuca* reaching the highest growth rates. The high carbohydrate content of especially *U. lactuca* makes this species particular interesting for biofuels production. Higher biogas potentials were reached in the washed *U. splendens* compared to *U. lactuca*.

- Literature study showed high market potential of carbohydrates (>60% of dry weight including ulvan) derived from especially *U. lactuca* for various products e.g. cosmetics.

- *U. lactuca* had significantly higher concentration of ethanol compared to *U. splendens*.

- The Na+ and K+ concentrations of < 1 g/L should not be inhibiting the biogas process.

- Alkaline/oxidative pretreatment of *U. splendens* decreased the ethanol production significantly, and this species had a significantly lower concentration of ethanol compared to *U. lactuca*.

- Both *U. lactuca* and *U. splendens* could be used for biogas production with a yield of approx. 0.2 L CH4/gVS. The CH4 yields were 21-29% higher when the macroalgae was washed.

**Conclusions**

*Ulva lactuca* and *Ulvaria splendens* could both be cultivated on diluted DPM as growth medium, with *U. lactuca* reaching the highest growth rates. The high carbohydrate content of especially *U. lactuca* makes this species particular interesting for biofuels production. Higher biogas potentials were reached in the washed *U. splendens* compared to *U. lactuca*. These results make both species candidates for future algal biorefineries.