

Algal Biomass for Bioenergy and Bioproducts Production in Biorefinery Concepts - DTU Orbit (09/11/2017)

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The fast population growth is increasing the demand for energy and resources. However, the reserves of oil are diminishing and greenhouse emissions associated to its combustion are affecting the global climate causing global warming. Therefore the need for alternative resources and processes is becoming impellent.

Macro- and microalgae have the ability to transform nutrients into valuable biomass. Being a good source of vitamins, minerals, lipids, proteins and pigments, they represent a promising source of various products. However these biomasses are still very little explored as biorefinery feedstocks.

Biorefinery represents an important tool towards the development of a sustainable economy. Within the biorefinery framework several bioproducts, such as food, feed and biofuels, can be produced from biomass. The specific composition of the biomass feedstock determines the potential final product that can be obtained.

In this thesis, micro- and macroalage were investigated as biorefinery feedstocks. The main aim of this work was developing different biorefinery strategies for the production of high value products, such as proteins or pigments, to be employed in the pharmaceutical or nutraceutical industry. The macroalgae used in this work were *Laminaria digitata* and *Saccharina latissima*, while the microalgae were *Chlorella sorokiniana*, *Chlorella vulgaris* and *Chlorella protothecoides*. Moreover, an evaluation of the effect of the harvesting season and location on the composition of high value products such as total phenolics and on the biogas potential for *L. digitata* and *S. latissima* was done. Both these factors had a significant impact on the accumulation of total phenolics in the algal biomass and on the biogas production. In particular, samples harvested in summer, because of the high content of sugars, showed to be the most promising feedstock in the development of biorefinery processes, containing 0.5 mgTPC gDM-1 and having a biomethane potential of 343.7 NmLCH₄ g VS-1.

Moreover, proteins being an interesting valuable product to be used as food and feed supplement, diverse industrial methods to produce amino acids and proteins were analyzed. Innovative techniques to increase the protein content in the final biomass, such as microalgae or microorganisms to be used as single cell proteins (SCP), were also investigated. The combination of phototropic growth of *C. sorokiniana* with *Methylococcus capsulatus* led to an innovative solution where two products rich in proteins (up to 43 %DM) were obtained.

Another strategy developed in this thesis work was based on the combination of micro- and macroalgae to enhance protein production. Indeed, the microalgae *C. protothecoides* was grown heterotrophically in the macroalgae *L. digitata* hydrolyzed. The final composition of the microalgal biomass showed that the protein content was increased from 0.07 ± 0.01 gProtein gDM-1 to 0.44 ± 0.04 gProtein DM-1. The results obtained show that this solution may represent an interesting strategy to be applied in a biorefinery approach.

Finally, a microalgae biorefinery strategy was developed. Lutein represents a very important pigment present in the macular region of the human eye. It is crucial in the protection against light-induced retinal damages and responsible for maintaining human bone health and preventing some diseases. Lutein and proteins were extracted by developing innovative methods specifically designed for microalgae species. From the initial algal biomass were extracted 0.8 ± 0.1 mg Lutein gDM-1 with a purity of 92.5 ± 1.2% and a calculated yield of 95%. Moreover, the final protein content in the fraction was 82.7 ± 3.1% w w-1with a protein yield of 55%. Finally, from the residues of this extraction processes, 372.7 ± 19.0 NmLCH₄ gVS-1 of biogas were produced.

The results obtained in this thesis work show that macro- and microalgae are promising biomasses for the development of the future biorefineries.

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