POVZETEK

Mikroalge so enostavni, hitro rastoči mikroorganizmi, ki tekom procesa fotosinteze vežejo ogljikov dioksid in tvorijo energijo v obliki biomase. Predstavljajo alternativno, obnovljivo in ogljično nevtralno surovino za proizvodnjo različnih vrst biogoriv in proizvodov visokih tržnih vrednosti. Lipidi mikroalg so zelo zanimiva sestavina le-teh, tako z energetskega kot s prehranskega stališča. Produkcijo lipidov v mikroalgah lahko uravnavamo s spreminjanjem nekaterih rastnih pogojev, kot sta razpoložljivost hranil (dušika) in osvetlitev.

V doktorski disertaciji smo se ukvarjali z gojenjem mikroalge *Chlorella vulgaris* in s prenosom procesa gojenja v večje merilo, z namenom pridobiti čim več z lipidi bogate algne biomase. Sestavili smo laboratorijski fotobioreaktor in ugotavljali primernost različnih rastnih medijev, vpliv koncentracije in oblike dušikovih hranil v rastnem mediju ter vpliv svetlobnega režima na rast mikroalge, donos algne biomase in kakovost le-te, glede na vsebnost lipidov in sestavo maščobnih kislin. Na pilotni napravi pa smo ugotavljali vpliv pH vrednosti procesne brozge, pretoka brozge in pretoka zraka na donos in kakovost algne biomase. Preizkušali smo tudi različne metode za ekstrakcijo lipidov.

Na laboratorijskem nivoju raziskav smo določili optimalen svetlobni režim s 16-urno osvetljenostjo fotobioreaktorja na dan, v katerem smo za gojenje izbrane vrste mikroalge uporabili nizkodušični rastni medij. Z naslednjo kombinacijo dušikovih hranil v rastnem mediju, 123,986 mg/L NaNO3 in 31,461 mg/L (NH4)2HPO4, smo določili največji delež lipidov (37 ut. %). Na pilotni napravi pa smo določili največje število celic mikroalg (3,7×107 celic/mL) in delež lipidov v njih (43 ut. %), s prevladujočimi nasičenimi (C16:0) in enkrat nenasičenimi maščobnimi kislinami (C18:1), pri pH vrednosti procesne brozge v območju 6,9-7,1, pri pretoku brozge s 1000 mL/min in pretoku zraka s 1000 L/h pri nespremenjenih ostalih procesnih pogojih. Metoda ekstrakcije lipidov s pulzirajočim električnim poljem se je izkazala za obetavno, predvsem zaradi možnosti uporabe sveže procesne brozge in možnosti vračanja brozge po ekstrakciji nazaj v proces gojenja. Za obdelavo večjih količin procesne brozge bo treba metodo optimizirati in preučiti njeno ekonomsko upravičenost.

ABSTRACT

Microalgae are simple, fast growing microorganisms, which during the process of photosynthesis fix carbon dioxide and produce energy in the form of biomass. They represent an alternative, renewable and carbon-neutral raw material for the production of different types of biofuels and products of high commercial value. Microalgae lipids are very interesting cell components from both, an energetic and nutritional point of view. Production of lipids in microalgae can be adjusted by changing certain growth conditions, such as the nutrient (*e.g.*nitrogen) availability and lighting.

In my PhD thesis, the cultivation of microalga *Chlorella vulgaris* and the potential of scaling-up of the cultivation process were investigated in order to obtain a high amount of lipid-rich algae biomass. For this purpose, a laboratory photobioreactor was constructed. The suitability of different culture media, the effect of the concentration and the form of nitrogen compounds in the culture medium, and the effect of light regime were studied with respect to microalgae growth, algae biomass yield and quality of the latter, considering the lipid content and the fatty acid composition as well. To perform the scale-up procedure, a tubular photobioreactor was designed and set up in series with a well-mixed vessel. The effect of different pH values of cultivation broth, its flow rates and air flow rates were varied, while the yield and quality of algae biomass were examined. A variety of methods for the extraction of microalgae lipids were tested.

On laboratory scale, the optimal light regime with the 16-hour illumination period of the photobioreactor per day during the cultivation of the selected microalga species using low-nitrogen culture medium was determined. The maximal lipid content (37 wt. %) was obtained with the following combination of nitrogen compounds in culture medium: 123.986 mg/L NaNO3 and 31.461 mg/L (NH4)2HPO4. On intermediate scale, the maximal cell number (3,7×107 cells/mL) and maximal lipid content (43 wt. %), with a predominant content of saturated (C16:0) and monounsaturated (C18:1) fatty acids, were determined in the pH range of 6.9–7.1, at the 1000 mL/min flow rate of cultivation broth, and at the 1000 L/h air flow rate, while other growth conditions were constant. The extraction of the microalgae lipids by means of pulsed electric field has proven to be promising, primarily due to the possibility of applying fresh cultivation broth and the possibility of returning the broth back into the cultivation process after the treatment. For processing large quantities of cultivation broth, the method is to be optimized and assessed with regard to its economic viability.