Summary of thesis

EFFECT OF SPECTRAL COMPOSITION OF LIGHT ON THE PHOTOSYNTHESIS, THE METABOLIC ACTIVITY AND CHEMICAL COMPOSITION OF BIOMASS IN SELECTED SPECIES OF ALGAE

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Algae are a very diverse group of photosynthetic organisms, from unicellular microalgae of microscopic sizes to enormous macroalgae reaching the length of 65 m. Currently, the group has 50,000 species, of which approximately 30,000 has been studied. This group of lower plants proved to be very attractive from an economic point of view and has been already applied in various industries, e.g., chemical, food or pharmaceutical industries as well as biofuel production. The potential of algae lies in the growth rate of the biomass and the relatively small culture space, as compared to the conventional energy crops such as rapeseed or maize. Algae are able to produce a large amount of biomass in a very short time, when provided with the optimal light intensity, temperature and the proper concentration of mineral salts, carbon dioxide, oxygen and pH. Light of sufficient intensity and spectral composition is one of the most important factors determining the growth of algae biomass. In the natural conditions, sunlight intensity, its spectral composition and the length of the day are specific for the region of culture and change in the diurnal and annual cycle independently of man. In artificial conditions (photobioreactors) all these factors can be controlled to optimize the quantity and quality of the biomass produced.

The primary objective of the doctoral thesis was to investigate the physiological conditions of algae culture in closed systems (photobioreactors) through the development of a light source with optimal spectral composition (white light, blue – red LED light or blue – red LED light with the addition of far red) for the production of algae biomass of different industrial purpose. In addition, the aim of the work was the attempt to reduce the content of unsaturated fatty acids in algae oil in order to improve the primary raw material for biofuel production. Additionally, simple indicator methods were sought allowing for rapid assessment of physiological state and prediction of algae biomass increase in order to facilitate the control of culture in photobioreactors. The experiments focused on the effect of the spectral

composition of light on: dynamics of biomass increase (weighing method), photochemical efficiency of PSII (measurement of chlorophyll *a* fluorescence kinetics parameters), metabolic activity (isothermal calorimetry), chemical composition of biomass in the content of chlorophyll, phenols and carotenoids (UV-Vis spectrophotometry, FT-Raman and FT-IR spectroscopy and gas chromatography) as well as the cell fluorescent emission spectra in the range of blue – green and red – far red (spectrofluorimetry) in three different algae strains. Moreover, the effect of the light pulse and the temperature of the culture on biomass productivity was studied as well as the possibility to culture algae in municipal wastewater.

Based on these results, it was found that the spectral composition of light affected the growth and selected physiological parameters in all strains. However, the scale of this effect was strongly dependent on the strain. Spectral composition of light affected the efficiency of the photosynthetic apparatus of *Chlorella vulgaris*. In *Chlorella emersonii* and *Botryococcus braunii,* light with the addition of far red increased photochemical activity of PSII.

The cells of strains studied differed in fluorescent emission spectra in the range of blue – green, and additionally these spectra were dependent in individual strains on the spectral composition of light. These differences resulted from changes in the chemical composition of phenolic compounds present in the algae under the influence of the spectral composition of light. Changes in fluorescence intensity in the range of red – far red (F690/F735) characterized changes of chlorophyll content resulting from increasing number of cells in culture. Numeric values have been proposed to assess the degree of stress of the algae for the fluorescence coefficients of blue – green (F450/F530), blue – red (F450/F690) and blue to far red (F450/F735). Thus, respectively, the value of F450/F530 should be less than or equal to 1.0; F450/F690 less than 0.1, while the F450/F735 less than 0.5.

It has been shown that algae cultured in the light rich in far red component had the highest content of phenols and chlorophyll. It was found that the best thermal parameters for *Botyococcus braunii* culture were 25°C to 30°C. Evaluation of light pulsation on the growth of the cultures demonstrated that the pulsed light caused a faster and greater increase in biomass of the culture, despite lower efficiency of the photosynthetic apparatus.

During the algae culture in municipal wastewater, it was expectedly found that it had markedly lower biomass increments than the algae growing in the medium. However, there were significant differences between successive cultures, related to the chemical composition of wastewater, which in turn was dependent on the date of their acquisition from the plant. Wastewater cultures with a lower content of nitrate nitrogen had better biomass increase and comparable chemical composition to the algae growing in the medium.

Analysis of the fatty acid composition showed that increasing the temperature of the culture to 30°C greatly reduced the unsaturated fatty acid content, which may be important in the fuel industry. The doctoral thesis demonstrates that appropriate selection of the spectral composition of light and the temperature of the culture allows for both better biomass increase and change of its chemical composition.