Microalgae as the source of biomass for energy purposes

Izabela KRZEMIŃSKA, Jerzy TYS – Bohdan Dobrzański Institute of Agrophysics, Polish Academy of Science (PAS) in Lublin

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In recent years, the potential and perspective on using microalgae for energy sustainable development has been broadly analysed. Microalgae-based biofuels have become one of the main research trends whose results may benefit both the environment and human beings.

Microalgae are regarded as one of the oldest microorganisms present on the Earth (Song et al., 2008). The growth rate of microalgae is very fast. They proliferate 100 times quicker than the land plants and are able to double their biomass within the period from 1 to 10 days (Schenk et al., 2008, Tredici, 2010). The additional feature of single-celled algae is their ability to accumulate lipids (Tab.1) which can be converted into biofuels (Chisti, 2007).The research results show that the production of microalgae biomass may amount from 15 to 25 t $ha^{-1}year^{-1}$ (Tsukahara and Sawayama, 2005). Assuming that lipid content in the microalgae cell is 30% (without the optimisation of growth conditions), the lipid production can reach 4.5 t ha^{-1} $year^{-1}$ (Chisti, 2007). Microalgae cultures do not compete with the agriculture production intended for food purposes and they occupy considerably smaller area than plant crops (Tab.2) (Li et al., 2010).

Table 1

Lipid content in selected microalgae (Chisti Y., 2007)

Microalgae species	Lipid content, % DM
Botryococcus braunii	25-75
Chlorella sp.	28-32
Crypthecodinium cohnii	20
Cylindrotheca sp.	16-37
Dunaliella primolecta	23
Isochrysis sp.	25-33
Monallanthus salina	>20
Nannochloris sp.	20-35
Nannochloropsis sp.	31-68
Neochloris oleoabundans	35-54
Nitzschia sp.	45-47
Phaeodactylum tricornutum	20-30
Schizochytrium sp.	50-77
Tetraselmis sueica	15-23

Table 2

Comparison of oil produced from selected energy crops (Chisti 2007)

Crop	Essential area to satisfy a 50% demand for transportation fuels in the USA, M ha
Maize	1 540
Soya	594
Coconut palm	99
Palm oil	45
Microalgae (70% of oil in biomass)	2
Microalgae (30% of oil in biomass)	4.5

The attractiveness of the microalgal biomass results from a wide range of its applications. A selection of species with a suitable chemical composition for cultivation is the key element in biofuel production. Depending on the species or cultivation conditions, the algae may demonstrate a high content of lipids or hydrocarbons that can be converted into different forms of energy. The conversion can be conducted by thermochemical, biochemical, and chemical processes as well as by direct combustion (Wang et al., 2008).

The microalgae proliferate quickly under the optimal cultivation conditions, but they accumulate few reserve substances. Under unfavourable conditions (stress), the metabolism of microalgae fatty acids changes to biosynthesis and accumulation of triacylglycerides. Due to the changes in lipid metabolism, triacylglycerides may constitute as many as 80% of lipid total content in the cell and they can be converted into biodiesel (Miao and Wu, 2006). The research shows that the reduced availability of nitrogen is one of the main factors influencing the lipid metabolism in microalgae cells (Hu et al., 2008, Tang et al., 2011). Biohydrogen and biogas are among other forms of fuels produced from biomass (Fig.1). The microalgae species with a high content of hydrocarbons can be used as the substrate in bioethanol production (Oilage Report 2009).

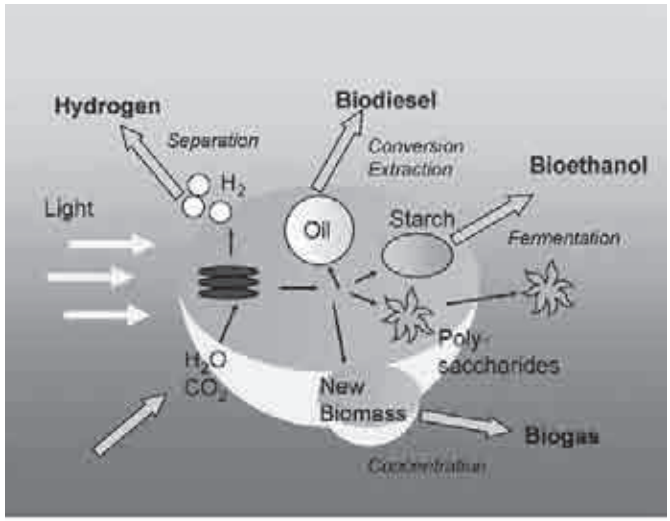

Fig. 1. Possibilities of using algae (Posten and Shaub, 2009)

Algae are cultured in the aquatic environment. Natural or artificial ponds or closed photobioreactors can be used as tools for algae cultivation. The algae cultivation in the open systems is cheap and technologically simple. On the other hand, it has many disadvantages, such as low efficiency, high evaporation, lack of possibilities of controlling the cultivation process and high risk of contaminating the culture. The closed photobioreactors can result in achieving higher productivity and biomass density. They also provide the control of culture conditions and its additional exposure to light. High costs of photobioreactors are the main disadvantage of this cultivation system (Mata et al., 2010).

So far, the methods of microalgae-based biofuel production have not been commercialised on a large scale. Very high costs of cultivation are the main limitation for the production of microalgal biomass on an industrial scale. The algae production based on wastewater being a source of water and nutrients for algae can be a profitable and environmentally friendly system of biofuel production (Pittman et al., 2011).

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Izabela KRZEMIŃSKA, PhD *[Dr]*., graduated from the Faculty of Biology and Earth Sciences at Maria-Curie Skłodowska University (Pl abbr.: UMCS) in Lublin. She did her doctoral research at the Polish Academy of Sciences (Pl abbr.: PAN) in Lublin where she obtained the degree of Doctor of Agricultural Sciences in agronomy-agrophysics. She is currently working in the Laboratory of New Technologies of Renewable Energy and Biomass Acquiring at Bohdan Dobrzański Institute of Agrophysics at PAN in Lublin. Research interests: production of microalgae biomass; microbiology. The grant holder of the Project "Grants for young scientists – an opportunity for Lublin agro-development" financed from the European Funds 2006-2007 and of the Project "Scholarships for PhD students" of the Marshall Office of the Lubelskie Voivodeship within the Human Capital Operational Programme 2007-2013 co-financed from the European Social Fund.

e-mail: i.krzeminska@ipan.lublin.pl

Professor Jerzy TYS, DSc *[Prof. dr hab.]* is the head of the "Regional Laboratory of the Renewable Energy" at the Institute of Agrophysics at PAN in Lublin and the leader of the following projects: development of physiological and technical assumptions for producing algae for energy purposes; a pilot line for production of eco-rapeseed oil with unique health-promoting properties. Operational Programme: Innovative Economy. Priority Axis 1. Research and development of modern technologies. Action 1.3. Support for R&D projects for entrepreneurs carried out by scientific entities. Sub-action 1.3.1. Development projects. Sub-action 1.3.2. Support for the protection of industrial property generated in scientific entities as result of R&D works.

Obtained academic degrees: MSc Eng. *[mgr inż.]* in agriculture at the Faculty of Agriculture at the Academy of Agriculture in Lublin (1975 r.); PhD *[Dr]* in Agricultural Sciences at the Faculty of Agriculture at the Academy of Agriculture in Lublin, "Assessing the mechanical properties of rapeseed regarding the cracking susceptibility of siliquae (1983 r.); DSc *[Dr hab.]*in Agricultural Sciences in agronomy-agrophysics at Bohdan Dobrzański Institute of Agrophysics at PAN in Lublin, "The factors determining agro-physical properties of rapeseed" (1997); Professor of Agricultural Sciences at Bohdan Dobrzański Institute of Agrophysics at PAN in Lublin (2004). Research interests: mechanical and biological properties of plants determining the quantitative and qualitative losses of seeds; the impact of harvesting, drying and storage conditions on the quality features of rape seeds: physical, biological, microbiological and chemical; characteristic and technology for biofuels production and use; quality of vegetable oils; farm-scale biogas farms; technological and economic terms of the biogas production; biotechnology algae production for energy purposes.

Research achievements: 136 original scientific papers, 16 patents + 3 patent applications (including 1 European patent); 4 industrial designs; 11 textbooks and monographs; 16 implementations; 98 other publications; 8 scientific expertise opinions; PhD supervisor for 5 completed theses; leader in 7 and contractor in 5 research projects. Membership in organisations: Polish Society of Agrophysics; Polish Society of Agricultural Engineering; Polish Association of Oil Producers; Scientific Society of Lublin; Reserve Officers' Club; Chairman of the Public Science Advisory Board at the Centre of Agricultural Advisory in Końskowola. Scholarships and fellowships: Upssala, Svalof, Sweden (1998).

e-mail: j.tys@ipan.lublin.pl