Journal of
Oceanography and Marine Research

Anthony and Runge, Oceanography 2014, 2:1
DOI: 10.4172/2332-2632.1000116

Short Communication Open Access

An Approach to Microalgal Production Systems for Commodities

Renil Anthony and Troy Runge*

Department of Biological Systems Engineering, University of Wisconsin-Madison, Madison, Wisconsin 53706, United States

Microalgae have been actively researched in recent years as a feedstock for commodities such as fuels, biosolvents [1], animal feed [2], and bio-based plastics and polymers [3]. Microalgae are a promising biomass feedstock due to a wide range of product possibilities, high growth rates, and low resource demands. Although there are small to mid-size commercial microalgae production systems for high value human nutritional supplements worldwide, large-scale commercialization of microalgal systems for commodities are limited by the low economic returns on the products generated. Continuing research and testing of different production strategies and scenarios represents the best path to achieve technical and economic feasibility of microalgae to bioproducts.

Currently, commercial production of microalgae totals nearly 15,000 t/y with the majority of the material produced for human consumption, and almost all cultivated in outdoor open ponds [2]. Microalgae *Spirulina, Chlorella, Dunaliella*, and *Haematoccocus* are few of the commercially produced strains with major production facilities in China, Japan, USA, India, and Australia [2]. High value nutritional and pharmaceutical products such as ω-3 fatty acids, antioxidants, vitamins, and proteins derived from these strains justify the economics of commercial production and processing. Unfortunately, the economic viability of microalgae for lower margin commodities needs to be improved considerably. Since commodity prices are unlikely to rise significantly, the best strategy is to lower algal feedstock production costs by improving cultivation and harvesting practices.

Commercial cultivation of microalgae in outdoor open ponds or raceways is considered to have lower costs and thus more economically attractive than closed system photobioreactors [2]. Such open ponds systems can be built upstream of wastewater treatment plants or beside agricultural facilities. Nutrient growth media requirements in these ponds can be fulfilled using municipal wastewater or agricultural residue [4]. Additionally, waste streams of carbon dioxide from flue gas or fermenters can be utilized as a source of inorganic carbon for enhanced growth [5]. However, a considerable challenge faced by open pond systems is to constantly maintain the desired strain cultures. Such contamination problems can be overcome by carefully selecting microalgae strains that thrive in adverse conditions such as marine algae, thermophilic algae, and algae that can grow in extreme pH conditions and then simulating those conditions to inhibit wild type algae growth.

Facile harvesting of microalgae represents a significant technical challenge and is one of the key processing steps that impact production economics. Simple harvesting methods need to be developed to concentrate microalgae to greater than 3% solids prior to using conventional dewatering methods such as centrifugation or filtration to allow for sufficient equipment throughput to minimize drying costs. Microalgae can be agglomerated by bioflocculation or by pH adjustment of growth media through control of the CO_2 supply [6,7]. The use of coagulant or flocculant additives should be avoided as much as possible to support downstream processes and keep processing costs low.

Based on the desired bioproduct from microalgae, decisions should be made regarding drying, pretreatment, and biomass conversion. Drying requirements for products such as animal feed or fertilizer should be met with waste heat sources or solar energy whenever possible, taking advantage of local resources and geographical location of the facility. For other products that require further processing and conversion of the biomass, the goal should be to utilize a biorefinery platform to produce several products by fractionating the algal biomass without drying [8]. To this effect, recent studies employing subcritical co-solvent extraction [9], *in situ* transesterification [10], acid-base hydrolysis [11], and polymeric membranes [12] have been successful at laboratory scale. To be acceptable as a sustainable feedstock, the economics of low value products from microalgae should be credited with the offset costs of wastewater remediation and CO_2 capture, with these credits and processing costs allocated to all the products generated by fractionating microalgae.

Finally, genetic engineering of microalgae is another path towards lower processing costs by achieving superior biochemical composition or in some instances by the direct secretion of products desired [13]. Similarly, heterotrophic and mixotrophic microalgae are also being tested to utilize carbohydrate feedstocks to produce lipid content as high as 60% dry weight [14,15]. Although these systems incorporate carefully controlled closed systems, such as photobioreactors, the experience gained is invaluable in developing commercial-scale microalgal systems.

In summary, microalgae are organisms with high photosynthetic efficiency that can utilize and remediate waste streams and have the potential to generate an array of important commodities. However, this potential can only be unlocked by developing effective low cost production systems. The attainment of sustainable bioenergy from microalgae requires significant R&D to develop simple and efficient processes. Although the establishment of commercial microalgal systems is a complex task, a concerted effort will ensure feedstock sustainability stimulating local and regional development.

References

1. Ellis JT, Hengge NN, Sims RC, Miller CD (2012) Acetone, Butanol, and Ethanol Production from Wastewater Algae. Bioresour Technol 111: 491-495.
2. Benemann J (2013) Microalgae for Biofuels and Animal Feeds. Energies 6: 5869-5886.
3. Rahman A, Anthony RJ, Sathish A, Sims RC, Miller CD (2014) Effects of Wastewater Microalgae Harvesting Methods on Polyhydroxybutyrate Production. Bioresour Technol.

***Corresponding author:** Troy Runge, Department of Biological Systems Engineering, University of Wisconsin-Madison, Madison, Wisconsin 53706, USA, Tel: 608-890-3143; E-mail: trunge@wisc.edu

Received January 14, 2014; **Accepted** Februay 12, 2014; **Published** Februay 14, 2014

Citation: Anthony R, Runge T (2014) An Approach to Microalgal Production Systems for Commodities. Oceanography 2: 116. doi:10.4172/2332-2632.1000116

4. Hoffmann JP (1998) Wastewater Treatment with Suspended and Nonsuspended Algae. J Phycol 34: 757-763.

5. Lam MK, Lee KT, Mohamed AR (2012) Current Status and Challenges on Microalgae-Based Carbon Capture. International Journal of Greenhouse Gas Control 10: 456-469.

6. Liu J, Zhu Y, Tao Y, Zhang Y, Li A, et al. (2013) Freshwater Microalgae Harvested via Flocculation Induced by pH Decrease. Biotechnol Biofuels 6: 98.

7. Wu Z, Zhu Y, Huang W, Zhang C, Li T, et al. (2012) Evaluation of Flocculation Induced by pH Increase for Harvesting Microalgae and Reuse of Flocculated Medium. Bioresour Technol 110: 496-502.

8. Anthony RJ, Ellis JT, Sathish A, Rahman A, Miller CD, et al. (2013) Effect of Coagulant/flocculants on Bioproducts from Microalgae. Bioresour Technol 149: 65-70.

9. Chen M, Liu T, Chen X, Chen L, Zhang W, et al. (2012) Subcritical Co-Solvents Extraction of Lipid from Wet Microalgae Pastes of *Nannochloropsis* sp. Eur J Lipid Sci Technol 114: 205-212.

10. Cao H, Zhang Z, Wu X, Miao X (2013) Direct Biodiesel Production from Wet Microalgae Biomass of *Chlorella pyrenoidosa* through *In Situ* Transesterification. BioMed Research International.

11. Sathish A, Sims RC (2012) Biodiesel from Mixed Culture Algae via a Wet Lipid Extraction Procedure. Bioresour Technol 118: 643-647.

12. Yoo G, Yoo Y, Kwon J-H, Darpito C, Mishra SK, et al. (2013) An Effective, Cost-Efficient Extraction Method of Biomass from Wet Microalgae with a Functional Polymeric Membrane. Green Chemistry 16: 312-319.

13. Radakovits R, Jinkerson RE, Darzins A, Posewitz MC (2010) Genetic Engineering of Algae for Enhanced Biofuel Production. Eukaryotic Cell 9: 486-501.

14. Hu B, Min M, Zhou W, Du Z, Mohr M, et al. (2012) Enhanced Mixotrophic Growth of Microalga *Chlorella* sp. on Pretreated Swine Manure for Simultaneous Biofuel Feedstock Production and Nutrient Removal. Bioresour Technol 126: 71-79.

15. Perez-Garcia O, Escalante FM, de-Bashan LE, Bashan Y (2011) Heterotrophic Cultures of Microalgae: Metabolism and Potential Products. Water Res 45: 11-36.

This article was originally published in a special issue, **Seaweeds, Micro- and Macro-algae** handled by Editor. Dr. Jeffrey Craig Bailey, University of North Carolina, USA