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New Strains and the Future of Microalgae Production

Leonardo Brantes Bacellar Mendes & Heraldo Namorato de Souza

Petrobras Research and Development Center, Biotechnology Sector, Cenpes

***Corresponding author:** *Leonardo Brantes Bacellar Mendes, Petrobras Research and Development Center, Biotechnology Sector, Cenpes*

ABSTRACT

Over the last decades the development of microalgae biotechnology has provided the commercial scale with a focus on few species grown in open ponds.

Nowadays new equipment and methodologies of genetic manipulation are being applied to the agricultural processes with success, having increased the productivity and the environmental sustainability of the plantations of soybean and corn.

As in agriculture since 2000, the prospection of new strains of microalgae and their genetic manipulation may contribute to raising crop productivity in the near future.

INTRODUCTION

Similar to agriculture, aquaculture destined to the cultivation of microalgae counts on multiple factors so that it reaches high stability, a primordial condition to obtain high productivity for the generation of biomass that can be commercialized at regional and global level. Abiotic factors present in the cropping locations such as temperature, light intensity, rainfall and water quality are fundamental to achieve high yields (above 15g /m2/day) capable of justifying scale up to the commercial scale.

However other equally important factors for the production of large-scale microalgae biomass can be highlighted and illustrate the complexity involved in the universe of micro-algal biotechnology. An important aspect to achieve high efficiency in the photosynthetic process is the correct hydrodynamic movement applied to the cropping systems - in both open and closed systems. The efficiency obtained in practice depends on a suitable design of the photobioreactor in order to avoid regions of recirculation (short circuits) and stagnation where undesirable deposition of cells occurs collaborating for the inhibition of productivity.

Special mechanical pumping systems have been developed to agitate microalgae without damaging their cellular structures, avoiding the collapse of the cultures in the photo bioreactors currently used (*Figure 1*). Other equipment such as blowers for air-lifts and paddle wheels are also designed specifically for each situation and have been used successfully.

Figure1 - *Closed photobioreactor currently used for advanced experiments in microalgae biotechnology at the Petrobras Research and Development Center*

Another important factor is the biotechnology involved in the harvesting of cultivated microalgae because the success of a cultivation cycle depends in general terms on an efficient harvesting process with the lowest possible energy expenditure.

Different equipment and collection methodologies can be applied depending on the product to be obtained and the species of microalgae to be cultivated. In general, smaller cells with low mucilage secretion require a more intense harvesting effort than larger cells.

Fine chemicals such as astaxanthin and beta carotene have high added value and justify high investment costs in industrial centrifuges for microalgae harvesting, while obtaining microalgae from domestic sewage treatment does not justify the use of sophisticated machinery due to its low value added.

The aspects mentioned above highlight the application of an aquaculture engineering closely linked to the machinery and the photo bioreactors specially developed for the cultivation of microalgae, having an analogy with the agriculture practiced in the 70's that obtained productivity in the crops through techniques of revolving and decompression for the preparation of the soil with the use of heavy and powerful machinery with high consumption of diesel.

During the 1980s, other less harmful planting methods (no-tillage) were developed that increased productivity and crop sustainability until the year 2000, when the new transgenic cultivars became indispensable to the corn and soybean crops that in this way acquired resistance to the herbicides used in the realization of the no-tillage system.

Large-scale microalgae production has been carried out since the 70's and currently has three genera of microalgae (*Dunaliella*, *Chlorella* and *Haematococcus*) and a genus of cyanobacteria (*Arthrospira*) grown on a commercial scale, although there is a universe that exceeds 30,000 species of microalgae present in the most diverse environments of the planet.

Much of the biotechnological potential of microalgae and cyanobacteria still depends on the detailed knowledge of the genetic constitution present in the strains and that may be one of the great factors of innovation in the projects aimed at the commercial production of microalgae in the coming years.

Over the past decade several companies (Aurora, Solazyme, Algenol, Synthetic Genomics) have reported advances in genetic manipulation of microalgae and cyanobacteria that include the excretion of target compounds (ethanol from cyanobacteria) into the extracellular medium and elevation of biosynthesis of molecules of economic interest in the cells (80% of lipids in the dry biomass).

The intellectual protection of the specifically developed genetic manipulation methodologies and the previously obtained results indicate that the importance of the genetic composition of microalgae strains to be inoculated in photo bioreactors and open ponds may be increasing in the near future.

Microalgae strains containing special characteristics could increase crop productivity. Some interesting properties among many others can be highlighted below:

- Thermophilic microalgae capable of growing at temperatures above 40 oC can be grown in closed systems dispensing refrigerators and also in open systems with low occurrence of predators due to this "thermal barrier".
- Special strains could synthesize cell walls less resistant to breakdown facilitating the extraction processes of the target compounds from the humid biomass.
- Microalgae capable of producing allelopathic compounds - also known as info chemicals could have this property intensified in order to increase the protection of open culture systems by increasing their stability over time.

The trajectory of modern agriculture shows that the recent biotechnology of production of transgenic cultivars using new techniques of genetic manipulation collaborated to establish a new level of productivity and environmental sustainability in the corn and soybean crops.

Prospecting for new strains and the genetic manipulation of microalgae is also likely to play an equally important role in significantly increasing productivity and environmental sustainability in open systems - the main scientific issue of microalgae biotechnology to be debated in the 21st century.

Conclusion

Significant advances were obtained for the production of microalgae biomass since the 1970s. These include the improvement of photo bioreactors and equipment used in the agitation, collection and drying processes of the obtained biomass.

However, the prospection of new strains from a great universe of species allied to the genetic manipulation can cause increase in the productivity of the cultures and improve the processes of extraction of target compounds. Both are key factors for the economic viability of future developments in the field of micro-algal biotechnology.

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