Valuable Products from Algae Using New Magnetic Cultivation and Extraction Techniques

Rendicontazione

Informazioni relative al progetto

VALUEMAG

ID dell'accordo di sovvenzione: 745695

Sito web del progetto

DOI
10.3030/745695

Progetto chiuso

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31 Luglio 2020

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SOCIETAL CHALLENGES - Food security, sustainable agriculture and forestry, marine, maritime and inland water research, and the bioeconomy

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Greece

Periodic Reporting for period 2 - VALUEMAG (Valuable Products from Algae Using New Magnetic Cultivation and Extraction Techniques)

Periodo di rendicontazione: 2018-04-01 al 2020-07-31

Sintesi del contesto e degli obiettivi generali del progetto

The VALUEMAG project aims to provide ground-breaking solutions for microalgae production and harvesting as well as scaling up biomass transformation systems in order to provide new technologies for aquatic biomass integrated bio-refineries. The main objective of the project is to develop an advanced magnetic method for micro-algae cultivation and to produce micro-algae for food, cosmetic, and nutraceutical use at the minimum possible cost. The specific objectives of the project are:
Micro-algae cultivation - Cost reduction
- Set up a method to produce microalgae cells with magnetic properties;
- Immobilization of magnetic microalgae using a magnetic conical surface;
- Develop economic & viable magnetic Photo-BioReactors (mPBR) for fast-growing and easy harvesting of biomass, using the above mentioned magnetic microalgae and magnetic surface.
Production of added-value products from harvested micro-algae
- Implement methods for holistic food production from microalgae biomass;
- Extraction of commercially valuable products (nutraceutical, cosmetics) from micro-algae biomass, with standard and with and new methods such a selective magnetic separation for better, faster, and cheaper extraction process;
- Develop CO2 capturing and water re-cycling methodologies based on mPBR.
VALUEMAG will demonstrate the pilot production and harvesting of integrated algae products and bring them nearer to the market in an economically, environmentally, and socially sustainable manner. The project will contribute to several areas of technology including:
- Development of magnetic nanoparticles;
- Uptake of magnetic nanoparticles by microalgal cell and their consequent magnetic activation;
- Magnetic cone with the ability of trapping magnetically activated microalgae;
- Production of valuable products from micro-algae cells, such as cosmetics, nutraceuticals, food etc;
- Sustainable water re-cycling;
- Sustainable CO2 capture;

Lavoro eseguito dall'inizio del progetto fino alla fine del periodo coperto dalla relazione e principali risultati finora ottenuti

Magnetic microalgae have been obtained via continuous electroporation method. This method was established thanks to a new device that allowed continuous electroporation. The device has been design, constructed and used at NTUA and presence of magnetic nanoparticles inside cells has been confirmed via Prussian blue test. Viability of magnetic cells reached 50+ days without any particular issue on their reproduction (growth) achieving 20-25% of cells that uptake the right amount of nanoparticles and a viability >70%.
Magnetization of microalgae cells has been achieved. Indeed, after electroporation microalgae cells can be attracted via permanent magnet. The presence of magnetic nanoparticles inside cells was proved by staining cells with Prussian blue reagent that in presence of iron gives to cells a blue colour. All subparts of the magnetic cone and the cultivation chamber have been studied and developed and the integration of the system and the initial operation have been done. The entire pilot installation has been completed. SOMAC, cultivation chamber, dewatering system, piping network, and electronic/control systems were successfully integrated creating the mPBR. Microalgae cells have

been used along with growth media to test and adjust all control and regulation modules. The operation of the plant using magnet cells has been performed proving the proper implementation of the proposed innovative technology. However, the biomass production was lower than the expected. Improvements and recommendations were proposed based on the process simulations and energy/exergy calculations, while the sustainability of the process has been proved by the Life Cycle Assessment (LCA) that was carried out.
Several microalgae species were chosen for characterization, on the basis of their potential industrial application in food, nutraceutical & cosmetics sectors. Experimental investigations have been focused on the extraction of bioactive compounds using accelerated solvent extraction and supercritical carbon dioxide. Furthermore, species were selected to check the antimicrobial activity of their extracts on fungal and bacterial plant pathogens under in-vitro and in-vivo conditions with very interesting results.
CO2 sequestration and water recycling experiments on a lab scale were carried out. Achievements highlighted that membrane technology is an effective and valuable de-watering technology, allowing to achieve a high percentage concentration of biomass (i.e. 27%). Investigations were performed by using two microalgae species.
Regarding dissemination and exploitation, several activities have been carried out. Project Identity, Project website, Social Media (Twitter, LinkedIn), Dissemination and Communication material, 1 Project Video, 7 Newsletters, 9 Presentations in Conferences, 32 Scientific Publications, 4 Non-Scientific Publications, Identification of 38 most active stakeholders in microalgae area, 5 interviews with the most important stakeholders in microalgae area.

Progressi oltre lo stato dell'arte e potenziale impatto previsto (incluso l'impatto socioeconomico e le implicazioni sociali più ampie del progetto fino ad ora)

VALUEMAG aims to address two main challenges. The first is improve cultivation of microalgae, by proposing ground-braking solutions (magnetic cells and magnetic cultivation), whereas the second is to optimize and scale up biomass transformation processes and methods. The new integrated production system has the potential to increase the efficiency and the environmental sustainability of modern bio-refineries through lowering the cost of securing cleaner energy and sustain food security. Furthermore, new job positions can be created as the running of such systems requires skilled personal and high educated technicians.
Most significant exploitable results:
•Development of magnetic algae cells
The first innovation of the project was the feeding of micro-algae cells with core-shell magnetic nanoparticles (MN). The significant milestone has been that these magnetic microalgae cells are alive for long periods of time. This way, the magnetic algae could be driven-navigated by magnetic field gradient. Insertion of MNs in algae cells was achieved by electroporation. New electroporation device was developed during the project. The main reason for developing magnetic algae cells was to cultivate algae in the magnetic cone. Apparently, another use of these cells was determined (byproduct), the so called magnetically targeted drug delivery, with the advantage that the algae cells are biocompatible but also foreign bodies with respect to the human tissues. Thus, this type of drug

carrier (microalgae cells) does not suffer the possibility of phase transformation, like other cells (e.g. stem cells) do

• Selective magnetic separation

The selective magnetic separation (SMS) has been developed during Valuemag. The method consists of a novel and innovative principle: covering magnetic nanoparticles (MNs) by a proper ligand able to trap a certain molecule, protein, peptide etc. it is possible to trap and extract with high speed ingredients of high purity. As an example, astaxanthin has been extracted by algae cells, using the SMS technique, obtaining 95% pure astaxanthin within 15 minutes. The method is extendable to other techniques, like heavy ion trapping, like Cr6+, or ingredients selection from bio-products, such as polyphenols, proteins and peptides. The point is that the SMS method is faster (15 minutes compared to hours of membrane separation), better (95% purity instead of 60-70% by other methods) and cheaper (one order of magnitude cheaper) than the existing state of the art.

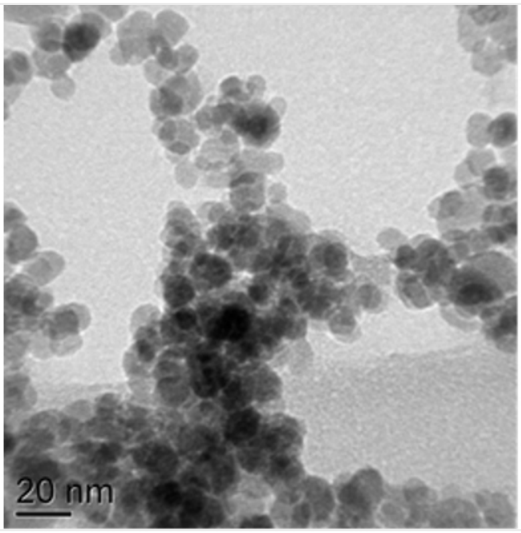

Fig5. TEM image of lipid-coated magnetic nanoparticles

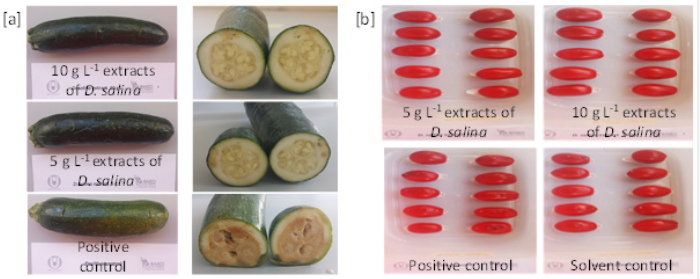

Fig10. Effect of microalgae extracts against P. carotovorum subsp carotovorum on vegetables

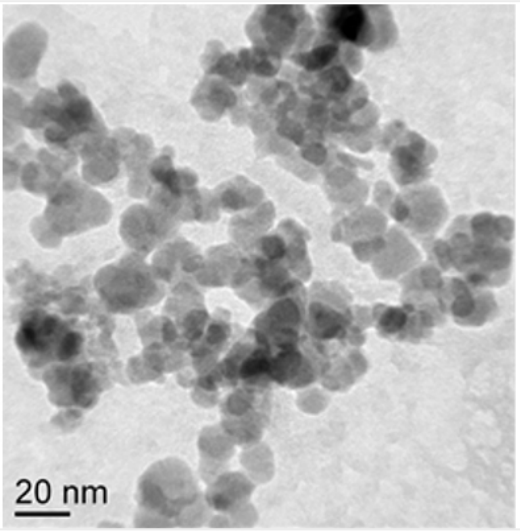

Fig4. TEM image of Dextrane-coated magnetic nanoparticles

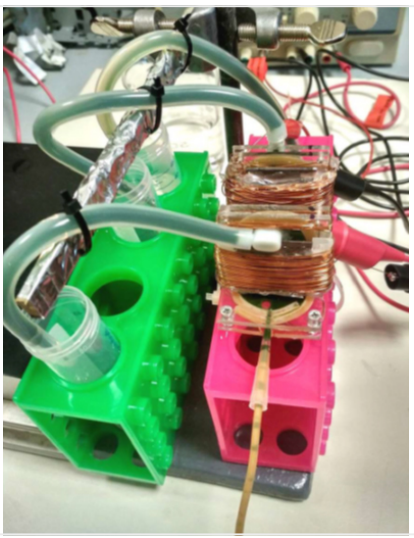

Fig7. Magnetic separation system

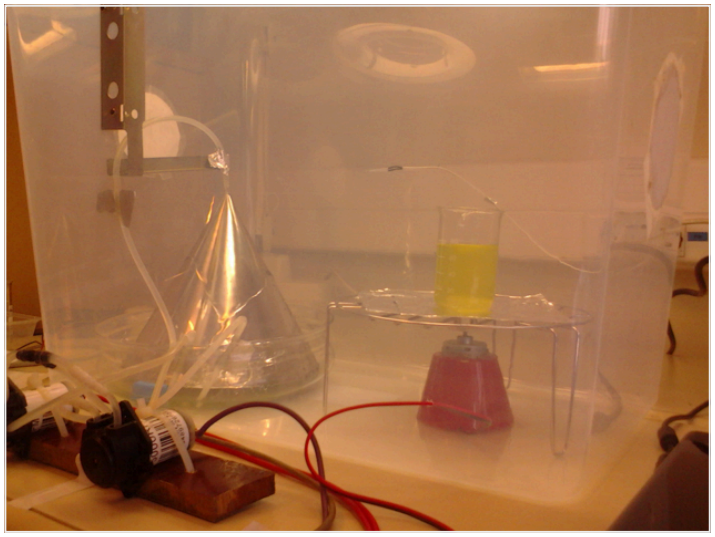

Fig2. Lab-scale cone prototype used to perform fluidodynamics experiments

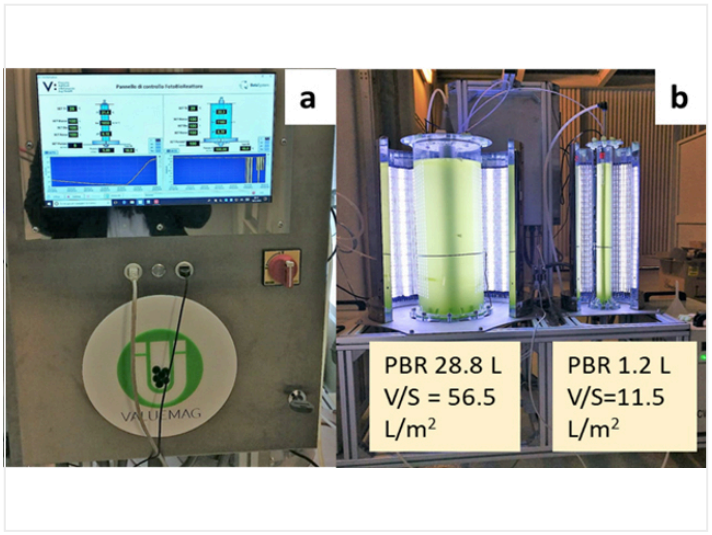

Fig9. Bench-scale microalgal cultivation system

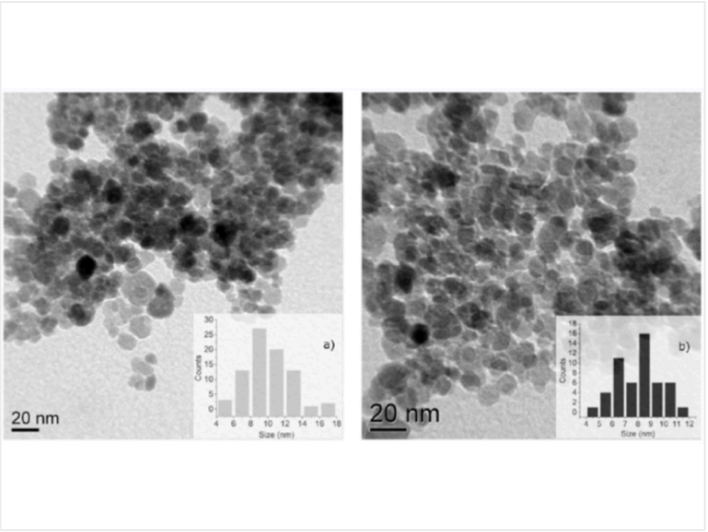

Fig1. Nanoparticles produced via microwave assisted coprecipitation method

Fig8. Integrated System

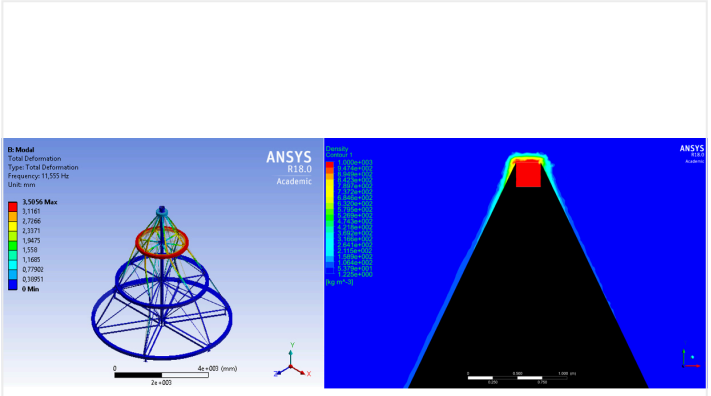

Fig3. Computational simulations for SOMAC analysis

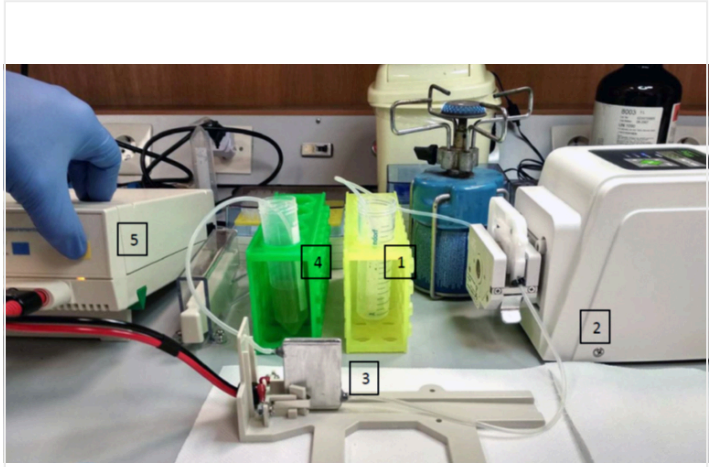

Fig6. Continuous electroporation system

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Permalink: https://cordis.europa.eu/project/id/745695/reporting/it