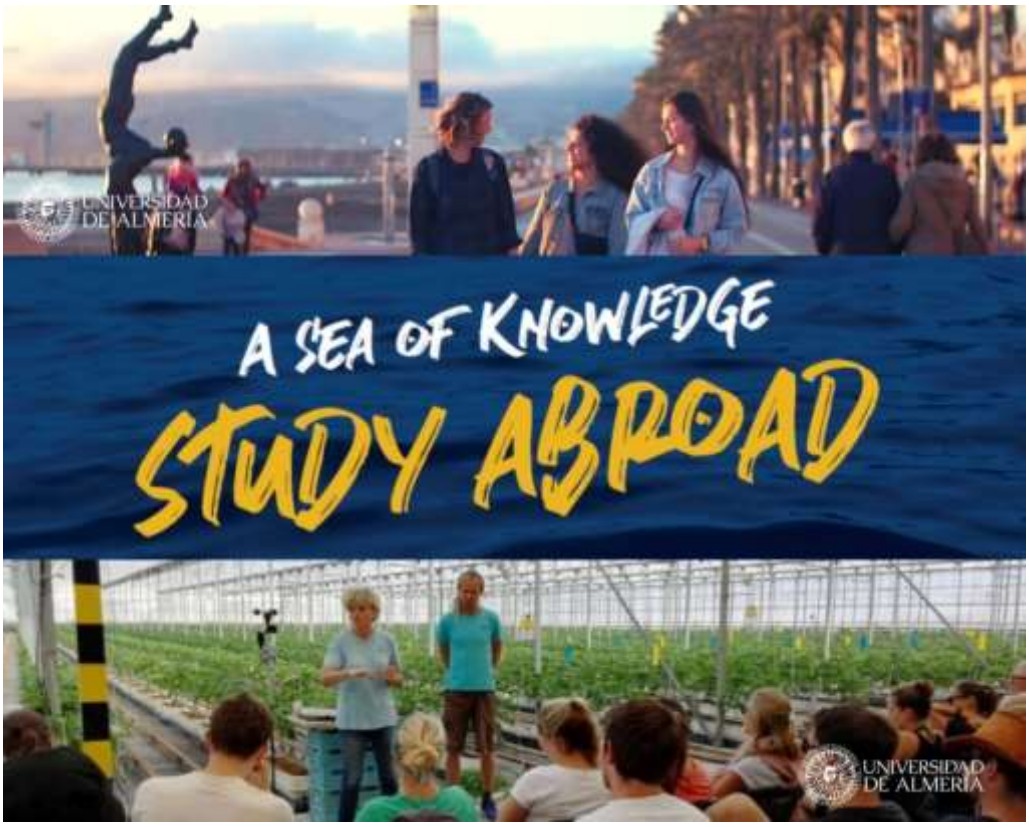

[TRAINING IN MICROALGAE-RELATED INDUSTRIAL PROCESSES]

Dates: July 3rd – 7th 2023

Teaching hours: 20h (2.6ECTS)

Area of knowledge: Chemical Engineering and Biotechnology

Academic coordinator: Francisco Gabriel Acién Fernández & Tomás Lafarga Poyo

INTRODUCTION

This is an intensive course about microalgae-based processes, on which expertise from academia and industry explain the major aspects of these processes. The course will cover all the aspects related with microalgae-based processes, from (i) the modelling of strains and light utilization, to (ii) the design and operation of photobioreactors, (iii) harvesting and processing of the biomass to achieve reliable and high-value products, and (iv) scale-up to commercial size. Fundamental and practical aspects will be covered always including the participation of internationally recognised researchers, young researchers and the exchange of experiences between the assistants. Lecturers have extensive experience in bioeconomy, climate change, and in the development of processes that will make industrial production more sustainable in the future.

The course is oriented towards PhD students or equivalent experience students in microalgae biotechnology and chemical engineering fields from whatever fundamental area as microbiology, biology or biological/ biochemical engineering, chemistry and biochemistry.

The course is also intended to give those working in the industry an opportunity to upgrade their knowledge in microalgae biotechnology.

MAIN GOALS

1. To provide the basic knowledge, and needed skills as well as analytical and instrumental procedures to grow microalgae, characterize the biomass and conceptualize microalgae processes.
2. To demonstrate the feasibility of microalgae-related processes and identify the markets in which these processes can be suitable
3. To provide access to real data and experience of microalgae-related industrial processes

CONTENT

Course Modules	Description
MODULE 1: Biology and basic principles of microalgae	The microalgae cell: ▪ Photosynthesis and kinetic models. ▪ Basic techniques of microalgae culture and maintenance. ▪ Stoichiometry and kinetic of microalgae cultures. ▪ Microalgae culture optimization outdoors.

cultures	In this module, the fundaments of microalgae production are reviewed. Major factors influencing the growth of microalgae in addition to modeling of this behavior are included. The module is completed with laboratory practices on light irradiance measurements, Chlorophyll fluorescence quenching measurements, photosynthesis rate and photosynthetic efficiency.
MODULE 2: Fundamentals of microalgae photobioreactors	Fundamentals of PBR design: ▪ Fluid-dynamics and mass transfer in PBR. ▪ Heat and momentum transfer in PBR. In this module, the fundamentals of the design of photobioreactors for the production of microalgae are reviewed. This includes mass and heat transfer phenomena and how mixing influences the light regime to which the cells are exposed in the culture. The module is completed with experiments in pilot-scale photobioreactors locate at IFAPA research centre as part of SABANA project. Measurement of culture conditions gradients in raceway and thin-layer reactors, and variation of those culture conditions when modifying mass transfer (air/CO_2) into the reactor.
MODULE 3: Harvesting and processing of microalgae biomass	▪ Microalgae harvesting (coagulation-flocculation, sedimentation, filtration and centrifugal recovery) ▪ Cell disruption ▪ Fundamentals of recovery, extraction, isolation and purification of microalgae products ▪ Microalgae biorefinery concept In this module, the processes required for the harvesting and processing of microalgae biomass are reviewed. The challenge is to minimize the energy and cost of these operations at the same time that maximizing the quality of end-products. The module is completed with laboratory practices on harvesting (coagulation-flocculation-sedimentation), cell disruption and extraction methods. Major aspects to be studied will involve flocculation and centrifugation experiments.
MODULE 4: Economic and sustainability analysis of microalgae	▪ Life cycle analysis ▪ Risk analysis ▪ Techno-economic analysis In this module, the sustainability of microalgae-related processes is reviewed. Both environmental and economic aspects will be studied, in addition, also social sustainability will be introduced.

processes	The module is completed with the visit and revision of the SABANA project such as the case study.
MODULE 5: Commercial application of microalgae and techno-economic assessment of microalgae processes	▪ Food ingredients from microalgae (tailored lipids, carotenoids and PUFAs) ▪ Phycobiliproteins recovery and purification. Commodities and bulk chemicals (biofuel and biofertilizer) ▪ Microalgae and Aquaculture. Wastewater treatment with microalgae cultures. In this module, a general overview of the most relevant applications of microalgae is performed. Susscessful commenrcial process in addition to potential new processes will be included. The module is completed with the revision of the BIORIZON project such as the case study.

COURSE METHODOLOGY	
In-lab sessions ☒	Company visits ☒
Academic visits ☐	Talks ☐
Lectures ☐	Others ☐
Each module will be divided into two hours of lectures and three hours of practice. Course lectures (10 hours), short lab and pilot plant practical (15 hours). The language of the course is English. On the course will participate experts from academia and private companies all of them with extensive experience in the field.	

REQUIREMENTS
Degrees in Microbiology, Biology, or in Biochemical, Chemistry and/or Biochemistry Engineering's

ACADEMIC VISITS & NETWORKING
▪ **SABANA demo facility at IFAPA research centre**: performing practices and training activities ▪ **BIORIZON BIOTECH:** Industrial facility producing biostimulants and biopesticides based on microalgae

- **FCC AQUALIA:** Industrial facility performing wastewater treatment using microalgae

ASSESSMENT

- 40% Final written exam on the contents corresponding to the course lecturers
- 40% Assessment of the reports presented by the students on lab practices
- 20% Regular attendance during the course

LECTURERS

Prof. **Francisco Gabriel Acién Fernández**

Graduated in Chemical Sciences in the brunch of Industrial Chemistry (1992) from the University of Granada, and PhD in Chemical Sciences (1996) from the University of Almeria. He began his professional career as a Research Fellow for *Plan Andaluz de Formación de Personal Investigador y Docente de la Junta de Andalucía* (the Andalusian Plan for the Training of Research and Teaching Staff of the Andalusian Government) between 1993/1996 at the University of Almeria, passing subsequently through various positions as Assistant Lecturer (LRU) (1996/1997), Associate Professor (1997/1999) and Interim Professor of University (1999/2000), until Full Professor of University (2000/2017). In May 2013, he obtained national accreditation as Catedrático de Universidad; a position he achieved in September 2017.

Prof. **Luisa Gouveia**

Degree in Chemical Engineering Instituto Superior Técnico, IST, Technical University of Lisbon (1986) Master Scientific in Food Science and Technology, Technical University of Lisbon (1992) PhD in Biotechnology, IST, Technical University of Lisbon (1996).

Work experience Senior Research at GreenCoLAB – Colaborative Laboratory – Join pieces on Algal Biotechnology Senior Researcher of LNEG - National Laboratory of Energy and Geology (Bioenergy Unit), Portugal (www.lneg.pt) (1999 to present data) Head of Autotrophic Microalgae Unit at LNEG-UB. Coordinator of UB- R&D Research Program: Microalgae as an energy vector. Research Fellowship from INETI (1996-1999) PhD Fellowship from the Foundation for Science and Technology, Portugal (1991-1996) MSc Fellowship from the Foundation for Science and Technology, Portugal (1989-1991) Research Fellowship from FLAD – Luso-American Foundation for Development (1987-1989).

Prof. **Dominik Krienke**

GEA Westfalia Separator Group GmbH, Oelde. Process Technology Renewable Resources. Position: Specialist Process Technology for Industrial Biotechnology, Starch and vegetable protein processes. Planning, Excecution and Evaluation of customer trials, on-site trials, commissioning from lab to production scale for: Industrial Biotechnology Applications, Food Ingredient Processing Applications. Engineering of process lines for the mentioned applications. Optimization of process parameters after commissioning. Technical Support for Sales. Supervision of bachelor- and master students for theses

Prof. **Giuliana Dimporzano**

University of Milano, Italy. Project manager of EU Projects and contracts with companies. Agricultural ecology. Life Cycle Assessment modelling of solid waste systems. Life Cycle Assessment of Bioenergy Technologies and Energy Systems. Scientific and technical consultancy relating to the testing of the composting plant and to full operation.

Prof. **Tomás Lafarga**

Chemical Engineer from the University of Almería in 2010 and PhD in Agriculture and Food Science from University College Dublin in 2016. He began his journey in the world of research in 2010 during an Erasmus stay at the Karlsruhe Institute of Technology. In 2012 he was awarded a Leonardo scholarship to work as a researcher at the Teagasc Food Research Center Ashtown in Dublin. After 10 months in Ireland, he was awarded a Teagasc Walsh Scholarship to carry out his PhD studies between Teagasc and University College Dublin in the area of revaluation of food industry by-products. In 2017 he began working as a Researcher in the IRTA Postharvest Program in Lleida, where he obtained a Juan de la Cierva Training Grant and work in the area of revaluation of fruit and vegetable by-products, the development of functional foods and the extraction and use of proteins from vegetable origin. In 2019 he obtained a Juan de la Cierva Incorporation Grant together with the Department of Chemical Engineering of the University of Almería where he has been working as a teacher and researcher since 2020. His merits during 2020 allowed him to win a Leonardo Scholarship for Researchers and Cultural Creators financed by the BBVA Foundation.

Prof. **José María Fernández Sevilla**

Degree in Industrial Chemistry in 1990 from the University of Granada and doctorate from the University of Almería in 1995. Professor in the Department of Chemical Engineering from the University of Almería in 1999 to the present. I did my doctoral thesis in Biotechnology of Microalgae in the department of Chemical Engineering from the University of Almería. Assistant Professor in February 1996, associate a year later and Associate Professor of the University since 2000 after carry out a 3-month stay at Washington University in St. Louis, in San Luis, Missouri, USA, Department of Chemical Engineering, University of Washington

University in St. Louis, Missouri, USA) where I carried out CARPT (Computer Assisted Radioactive Particle Tracking) applied to microalgae cultures. I continued working on the cultivation of microalgae at an industrial level covering other topics such as the mixotrophic culture.

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