SUSTAINABLE MATERIALS, PROCESSES AND SYSTEMS FOR ENERGY TRANSITION

IIT - Innovative approaches for the production from renewable sources of high-quality bioactive fractions

Funded By	FONDAZIONE ISTITUTO ITALIANO DI TECNOLOGIA [P.iva/CF:09198791007]
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Context of the research activity	Growing demographic pressure is leading to a scarcity of water resources and available arable land. Hence, there is an urgent need to develop innovative and sustainable technological approaches based on renewable resources towards satisfying the increasing demand for plant biomass destined for food, feed, and energy production. Conventional agricultural practices have heavily relied on non-renewable inputs of chemical fertilisers and pesticides. In addition to posing a serious threat to human health and the environment, their supply and application is becoming increasingly expensive. A promising alternative is the use of biostimulants, which can play a key role in addressing sustainability challenges by improving the efficiency of nutrient uptake by plants, enhancing crop yield and stability under environmental stress, and boosting product quality, thus reducing dependence on chemical fertilisers. Microalgae, simple unicellular photosynthetic organisms, are attracting growing interest from both academia and industry because of their versatile nature: faster growth rates and higher photosynthetic and CO2 fixation efficiency compared to terrestrial plants, ability to grow on organic carbon sources and recover nutrients from waste and wastewater and possibility to yield valuable co-products. Microalgae are renewable feedstock with high biostimulant potential as algal extracts are characterised by a wide range of biostimulating compounds, including amino acids, polysaccharides, vitamins, fatty acids, mineral elements, phenols and hormone-like compounds. To date, several biostimulant compounds based on algal biomass have already reached the market, however based on the few species that can be cultivated on a large scale, against a genetic variability ranging from 50,000 to 1 million. In order to reduce production costs, the two key factors are the optimization of bioreactors for their production and the streamlining of downstream processes (e.g. cell disruption, extraction and fractionation), greater efforts should be directed towards: - the search for species with bioactive fractions with superior biostimulant potential;

	- the efficiencyisation of innovative photo-bioreactor systems; - the development and optimization of efficient and environmentally friendly extraction methods for the recovery of bioactive fractions of high quantity and quality.

Objectives	The main research objectives of this PhD thesis include (not necessarily all): • Optimization of biotechnological processes based on autotrophic and mixotrophic cultivation of non-model microalgae species for efficient recovery of CO2 and nutrients from waste coupled with the production of bioactive fraction to be valorized as biostimulants/soil amendment for sustainable agriculture; • Set-up and optimization of innovative and eco-friendly extraction techniques (e.g. Three phase partitioning -TPP- and microwave extraction) aimed at improving the quantity and preserve the quality of bioactive compounds; • Set up and implementation of efficient analytical techniques for the characterization of bioactive fractions; • Design of porous materials for the separation of bioactive molecules; • Drawing, design and implementation of innovative photo-bioreactor systems to increase process productivity and efficiency; • Study of mass balances for determining process efficiency and techno-economic sustainability; • Life Cycle Assessment, economic and environmental assessment analysis.

Skills and competencies for the development of the activity	Candidates should have a good background in industrial biotechnology and biochemistry and strong motivation to learn through advanced research in engineering, analytical, materials science and process areas. Direct experience in microbiology laboratories is preferred. Problem solving ability, strong communication, time-management skills, and commitment to innovation for sustainability is preferred