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Editorial: Non-conventional organisms and methods for bioenergy production processes

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Editorial on the Research Topic
Non-conventional organisms and methods for bioenergy production processes

This Research Topic brings together five contributions, three review articles and two brief research reports, focusing on the utilization of non-conventional organisms, environmental modulation strategies, and advanced analysis methods for improving the feasibility and efficiency of microbial bioenergy processes from over 20 international authors. Considering the urgent need to transition toward sustainable and renewable energy sources the search for novel biological systems and methods in bioenergy production has intensified. Thus, with an emphasis on the use of non-conventional microorganisms, stress-responsive microbial systems, and novel analytical or monitoring approaches, the collected works aim to expand the current toolbox for developing more resilient, efficient, and scalable bioenergy processes.

In this Research Topic, two of the articles address the use of indigenous and stress-tolerant microalgae for lipid-rich biomass production. In their brief report, Andrew et al. evaluated eight tropical microalgae strains from Sabah, Malaysia, identifying *Chaetoceros muelleri* as a promising biodiesel candidate due to its high lipid content and favorable fatty acid profile, particularly its oleic acid concentration. This work highlights the importance of strain-level screening under local conditions for biodiesel feedstock development. Do et al. focused on *Graesiella emersonii* KNUA204, isolated from Ulleungdo Island, South Korea. They explored the effect of $MgCl_2$ and NaCl-induced salt stress on biomass productivity, pigment composition, and fuel quality. Notably, treatment with 75 mM $MgCl_2$ led to increased biomass and energy content while improving the biodiesel characteristics of the fatty acid methyl esters. The results underscore the role of salt stress as a process parameter to modulate biochemical composition in microalgal cultivation. In the domain of electroactive microorganisms, Scarabotti et al. introduced a microfluidic electrochemical flow-cell system combined with optical microscopy for real-time observation of early-stage biofilm growth. The system enabled *in vivo* quantification of growth dynamics, latency times, and yield coefficients, providing a valuable analytical platform for future microbial electrochemical technology development. The findings also point to oxygen intrusion as a key limitation, offering direction for technical refinement.

The Research Topic also covers review papers from a broader technological perspective. Subramanian and Sayre provided an in-depth review of biomass enhancement strategies in microalgae, spanning strain selection, photosynthetic engineering, and breeding approaches. Their report shows that biomass yields can be significantly increased, potentially up to fivefold, through molecular-assisted breeding and optimization of photosynthetic capacity. The review also draws connections between enhanced carbon fixation, open-pond system feasibility, and cost-competitive bioproduct generation. The next review in the Research Topic by Al-Hammadi et al. centered on non-conventional ethanol production using extremophiles and engineered microbial systems together with immobilization. It covers the challenges of feedstock availability, pretreatment costs, and inhibitor formation, while highlighting the advantages of co-cultures, methods for whole cell immobilization, and consolidated bioprocessing. Importantly, the paper links recent policy developments in Europe with commercialization potential, and provides insights into pilot-scale implementations.

Collectively, these studies contribute to a deeper understanding of how biological and environmental diversity can be harnessed in bioenergy systems with a non-conventional point of view. By examining underutilized organisms and novel methods, this Research Topic offers new directions for overcoming the limitations of conventional bioenergy production and supports the broader transition to a circular and sustainable bioeconomy.

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