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Social performance of bio-based products from microbiomes: a step forward in their broader adoption and market penetration

INTRODUCTION

In recent decades, interest in bio-based products has grown significantly due to rising concerns about eco-friendly and sustainable alternatives to synthetic polymers and conventional energy sources. These bio-derived materials have the potential to substitute products obtained from fossil fuels, including plastics, additives, colourants and energy carriers like hydrogen (H_2). Additionally, within the framework of a circular bioeconomy, bio-based products can help decrease waste generation, lessen environmental harm, and enhance the efficient use of resources (Chrispim et al., 2024).

In this context, bio-based products generated by microbiomes are of considerable interest. Microbiomes demonstrate functional resilience while preserving adaptability to environmental fluctuations, exhibiting an apparent capacity for self-regulation and a reduced vulnerability to contamination by competing microbial species. These characteristics offer significant advantages for industrial applications, where maintaining strain stability remains a critical challenge.

In recent years, notable advancements have been achieved in uncovering innovative pathways for the bio-based synthesis of diverse materials, including polymers like bioplastics (e.g., Polyhydroxyalkanoates [PHA]), additives such as Exopolysaccharides (EPS), natural colourants like phycobiliproteins, and alternative energy carriers such as hydrogen. Although these developments are promising, there is still a limited level of public awareness and understanding concerning the societal impacts of these bio-based products, which may affect their wider acceptance and market integration.

Therefore, the EU Horizon 2020 PROMICON project has developed a Social Life Cycle Assessment (S-LCA) (ISO, 2024; UNEP, 2020) to evaluate the social implications along the life cycle of the studied bio-based products. In particular, the production of four bio-based products (additives, bioplastics, pigments, and hydrogen) for both food and non-food applications was examined through innovative microbiome-based approaches. A total of nine scenarios were evaluated, encompassing both individual and co-production strategies for these bio-products. The stakeholder groups included in the analysis comprised workers, consumers, the local community, value chain actors, and society.

EVIDENCE AND ANALYSIS

The PROMICON project has made significant progress in the analysis of social performance of bio-based products for both food and non-food applications (i.e. additives, bioplastics, pigments and hydrogen) by means of novel bio-based routes based on microbiomes:

- All the scenarios analysed showed good performance for workers (health and safety), consumers (quality and performance, acceptability) and the local community (number of jobs generated).
- The sole production of bioplastics and hydrogen had the best social performance. This was primarily attributed to the high level of consumer acceptance and the stronger performance regarding the presence of documentation addressing sustainability aspects within the bio-based production processes.
- The non-food products (i.e. bioplastics and hydrogen) seemed to have higher acceptability from consumers and higher interest in terms of regulation and policy development.

POLICY MPLICATIONS AND RECOMMENDATIONS

To enhance the social benefits for the different stakeholders derived from the production and marketing of the bio-based products from microbiomes, we recommend:

- To increase funding to analyse and enhance the sustainability of these ground-breaking processes;
- To boost implementation at pilot and full-scale in order to cover the technological development gap and increase awareness through demonstration;
- To develop specific regulations and policies, especially for the promotion of social responsibility for value chain actors and the public commitment to sustainability issues.

SUSTAINABILITY AND LEGACY

The analysis of the social performance of bio-based products from microbiomes aligns with key sustainability goals. It evaluates the social impacts of the studied processes on different stakeholders:

i. Workers: operators and managers of the bio-based products hypothetical plants;

ii. Consumers: final end-users of the bio-based products;

iii. Local community: people living near the hypothetical plants;

iv. Value chain actors: people and organisations directly involved in value chain activities (e.g. suppliers, hauliers, retailers);

v. Society: the society at large.

The analysis includes the evaluation by means of interviews and surveys performed with stakeholders and experts on the following aspects (impact categories) (UNEP, 2020): health and safety, quality and performance, acceptability, socio-economic repercussions, promotion of social responsibility, public commitment to sustainability issues, and technological development. Thus, this tool helps evaluate the contribution to the fulfilment of sustainable development goals (SDGs).

PROJECT OBJECTIVES AND METHODOLOGY

The PROMICON project aims to understand microbiome functionality to steer their phenotypes for producing biopolymers, energy carriers, feedstocks, and antimicrobials. The overall aim of the PROMICON project is the development of an efficient biotechnological production platform that creates a synergy between strain engineering strategies with the robustness of microbiomes and their metabolic plasticity in organic conversions. As part of that, it analyses the environmental, social and economic sustainability of the processes and technologies developed. Its outcomes align with the EU bioeconomy strategy, promoting sustainable bioproducts and the circular economy.

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