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Abstract

Using Forest Biomass to Contribute to Population Health and Ensuring a Sustainable Environment †

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† Presented at the 19th International Symposium "Priorities of Chemistry for a Sustainable Development", Bucharest, Romania, 11–13 October 2023.

Keywords: bioproducts; bioactive extracts; energy and mobility vectors

Current societal challenges include the transition to a circular bioeconomy, with the cascade exploitation of natural resources through the superior valorization of by-products and waste from the agro-industrial sector in bioproducts and, at the same time, the transition to an energy and mobility system that ensure climate neutrality and resilience [1]. Forest biomass in the form of primary feedstocks removed from forests or secondary feedstocks as by-products from forest industry represents the most important source of biomass [2].

This study proposes the valorization of primary coniferous biomass by obtaining bioactive extracts with antioxidant and wound healing potential, intending to contribute to the health of the population [3], and also reviews the main transformation routes of forest biomass as renewable resources with a low carbon footprint into energy and mobility vectors (biohydrogen, biomethane, and bioethanol). Response surface methodology with the Box–Behnken design was used to optimize the microwave assisted extraction parameters (ethanol concentration, microwave power, extraction time, and ratio of solvent to biomass) in order to maximize the polyphenol yield. The resulting extracts were characterized for total polyphenols, total flavonoids and antioxidant activity by UV–Vis methods and by UHPLC-MS/MS. The bibliometric studies included a descriptive analysis of papers from the Web of Science database associated with the keywords forest biomass, forest biomass AND energy, forest biomass AND biofuels, forest biomass AND bioactive compounds, and included documents published from 2014 to 2023. Bibliometric analysis was carried out using VOSviewer 1.6.19. software (Leiden University, The Netherlands).

The optimal extraction conditions that enable obtaining a high total polyphenol content (mg GAE/g) were as follows: 50% ethanol extraction solvent, 10 min ramp to 50 °C. Flavonoids represent the most dominant bioactive compounds in spruce and fir biomass (bark and needles), with (+)-catechin being the representative compound of coniferous biomass. Astringin, piceatannol glucoside, t-piceid, combretastatin A-4, t-isorhapontin, t-isorhapontigenin, and piceatannol represent the main stilbenes identified in the coniferous biomass, which exert numerous biological activities, including antioxidant, anti-inflammatory, and antimicrobial (Figure 1).

Lignocellulosic biomass has considerable potential to solve environmental and energy crises through the efficient use of forest biomass to obtain biofuels (bioethanol, biohydrogen, and biomethane) in order to replace fossil fuels, which are the main cause of global warming. In this context, forest biomass represents an important source of bioactive compounds with antioxidant and antimicrobial properties and also an alternative renewable energy source for a clean environment due to its great potential for biofuel production, mainly bioethanol,

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Citation: Geana, E.-I.; Ciucure, C.T.; Tamaian, R.; Man, G.; Ionete, R.E. Using Forest Biomass to Contribute to Population Health and Ensuring a Sustainable Environment. *Proceedings* **2023**, *90*, 39. https://doi.org/10.3390/proceedings2023090039

Academic Editors: Mihaela Doni, Florin Oancea and Radu Claudiu Fierăscu

Published: 19 December 2023

through fermentation processes of lignocellulosic material after appropriate pretreatment procedures (physical, chemical, biological, and thermal) (Figure 2).

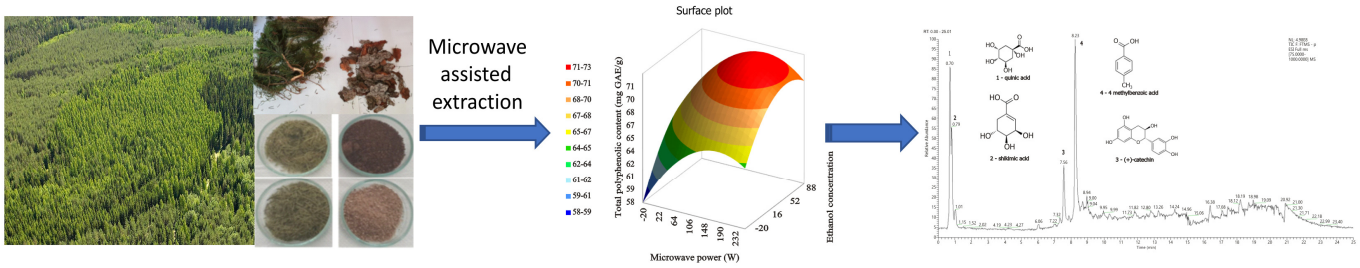

Figure 1. Extraction and characterization of bioactive compounds from spruce needle biomass.

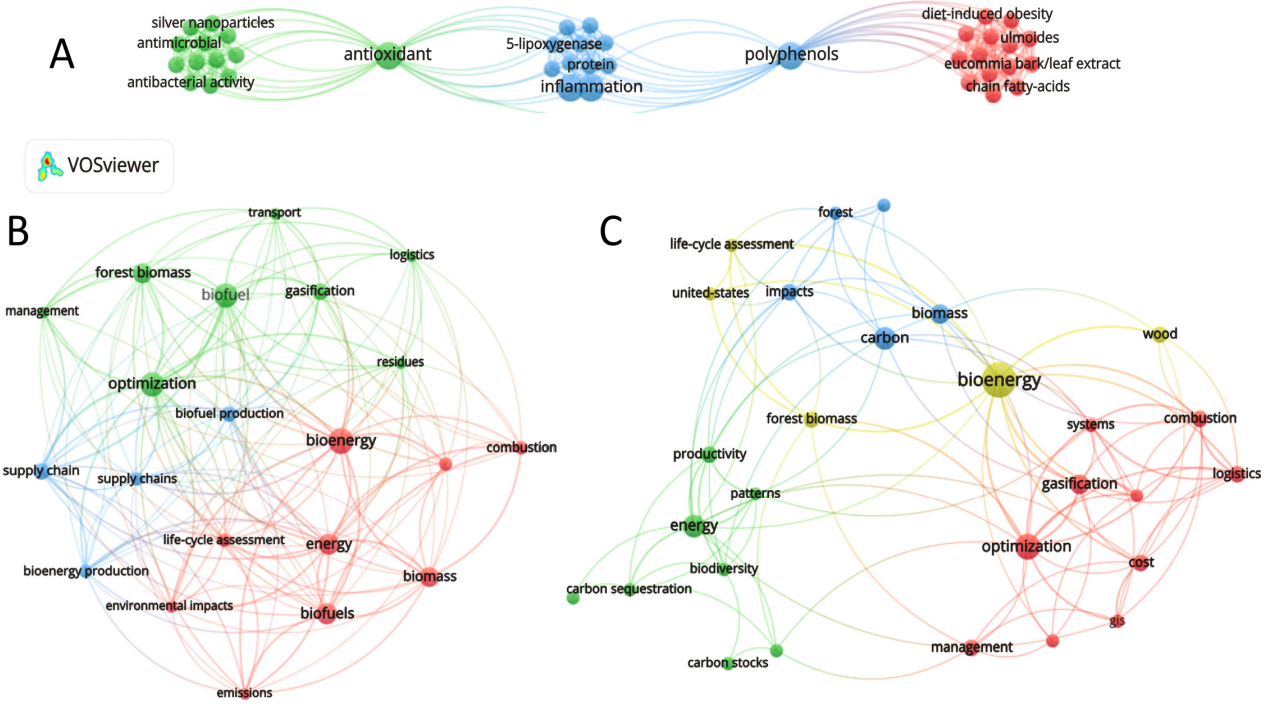

Figure 2. Co-occurrence network plots (by keywords) for: (**A**) Forest biomass to bioactive compounds; (**B**) Forest biomass to biofuels; (**C**) Forest biomass to bioenergy.

The intelligent exploitation of forest biomass by obtaining bioproducts in the circular bioeconomy system intended to ensure the health and safety of the population and the environment represents an important step towards achieving climate neutrality.

Author Contributions: Conceptualization, E.-I.G.; methodology, E.-I.G.; software, E.-I.G. and C.T.C.; validation, E.-I.G. and C.T.C.; formal analysis, R.T.; investigation, C.T.C. and R.T.; resources, E.-I.G. and G.M.; data curation, E.-I.G.; writing—E.-I.G. and R.T.; writing—review and editing, R.E.I.; visualization, R.E.I.; supervision, E.-I.G.; project administration, E.-I.G.; funding acquisition, E.-I.G. and G.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Research, Innovation and Digitization through the Core Program, grant 20N/2023, project PN 23 15 04 01, "The cascade valorization of agro-industrial waste of plant biomass type in bioproducts with added value in the circular bioeconomy system".

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data are not publicly available due to privacy restrictions.

Acknowledgments: The authors acknowledge the support received through Program 1—Development of the national research and development system, Subprogram 1.1. Institutional performance—Projects to finance excellence in RDI, Contract No. 19PFE/30.12.2021.

Conflicts of Interest: The authors declare no conflict of interest.

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