# Biotech and non-thermal treatments to upgrade value of crop and herbal residues

A.P. Djukić-Vuković[1], J. Grbić[2], M. Bogdanović[1], S. Lazović[3], A.Žugić[4], V. Tadić[4], D. Mladenović[2]

[1]Department of Biochemical Engineering and Biotechnology, University of Belgrade, Belgrade, 11120, Serbia
[2]Innovation Center Faculty of Technology and Metallurgy University of Belgrade, Belgrade, 11120, Serbia
[3] Institute of physics Belgrade, University of Belgrade, Zemun, 11000 Serbia
[4] Department for Pharmaceutical Research and Development, Institute for Medicinal Plant Research "Dr Josif Pančić", Belgrade, 11000, Serbia
Keywords: cold plasma, agri-food residues, lignin, biorefinery, biotransformation
Presenting author email: adjukic@tmf.bg.ac.rs

With the growing trend for valorization of agri-food industry residues, by-products and wastes, in order to follow bioeconomy principles, novel approaches are being developed. Herbal dust, grounded fine powder which remains after processing of medicinal herbs for tea bags remains in huge amounts and depending on the herb, could be around 15% of total mass. This is a huge loss for industry and also significant wasting of resources if not used properly. It is either landfilled which poses a significant risk to generate gaseous emissions in uncontrolled conditions or it is used for composting. However, significant amount of phenolics in these residues could negatively affect soil microbiome. Similar is the case with residues remaining after harvesting of corn or wheat, like corn stalks which are high in lignocellulose and still often burned. Conventional strategies for fractionation have high environmental impact, involving acid/alkaline treatment and usually low recovery rate, favouring cellulose fraction.

Aim of our work was to study strategies to exploit herbal and crop residues, with higher recovery rate by means of combined biotech methods, e.g. fermentation, and non-thermal technologies.

Extraction of phenolics from selected herbal residues was performed with green solvents, water and ethanol, in different ratios. Depending on the extraction conditions, solvents were evaporated to remove ethanol as an antimicrobial solvent and reconstituted with water. This way obtained extracts were subjected to lactic acid fermentation with selected lactic acid bacteria and antioxidant activity, microbial growth and chemical compositions were monitored. For corn stalks, predominantly lignocellulosic substrate, we studied role of cold plasma treatment on fractionation and characteristics of recovered lignin and cellulose. Cold plasma was combined with alkaline hydrogen peroxide treatment to estimate the possibility of treatment's improvement in terms of delignification and further valorization of treated biomass (Grbić et al., 2024).

Fermentation of common nettle's extract with *L. salivarius* has shown potential to increase the content of caffeic acid (73%), rutin (99%) and caffeic acid derivatives (65%) during 48h while also achieving a high number of viable cells (7,5 log CFU/ml). Since *L. salivarius* has a probiotic potential, this way extracts with increased bioactivity and fortified with potentially probiotic and GRAS microorganisms were obtained. This simple method can be adapted and exploited for different herbal residues, enabling recovery of phenolics and their upgrade toward more potent extracts.

Lignocellulosic crop residues subjected to cold plasma in the alkaline environment were richer in cellulose content (69%) than the raw biomass (40%), with an overall recovery rate of 84%. The crystallinity index increased from 50% to 59% after applied treatment. SEM micrographs confirmed that cold plasma induced significantly higher porosity of treated residues than alkaline treatment solely. Increased porosity eventually led to enhanced enzymatic digestibility, resulting in an overall conversion rate of around 91%. This unlocks new possibilities for lignocellulosic biomass valorization towards platform chemicals production through fermentation processes. At the same time, the lignin fraction could be successfully separated and tested for potential high-value applications.

This study offers perspectives, highlighting low-energy methods for efficient agro-food waste management. Future research will focus on optimizing these valorization processes. Fermentation with probiotic bacteria cold plasma treatment can be further optimized and integrated into industrial biomass processing for the production of high-value products such as postbiotic extracts, biofuels and platform chemicals. In additional future research will focus on process optimization, techno-economic and environmental impact to ensure the sustainable application of these innovative valorization strategies.

## Acknowledgments

This work was supported by the Ministry of Science, Technological Development, and Innovation of the Republic of Serbia (Contract No. 451-03-65/2024-03/200135 and 451-03-66/2024-03/200287) and by the Alliance of International Science Organizations, project SparkGREEN (ANSO-CR-PP-2022-08).

## References

Grbić, J. Z., Mladenović, D. D., Veljković, M. B., Lazarević, S. S., Lević, S. M., Lazović, S. S., & Djukić-Vuković, A. P. (2024). Cold plasma/alkaline pretreatment facilitates corn stalk fractionation and valorization towards zero-waste approach. *Industrial Crops and Products*, *222*, 119498. https://doi.org/10.1016/j.indcrop.2024.119498