

# **Integrated Platform for Agro-Industrial Waste Valorization: From Functional Food Ingredients to Sustainable Packaging and Thermochemical Products**

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The growing generation of agro-industrial waste poses significant environmental and economic challenges while simultaneously offering a sustainable source of bioactive compounds and functional materials. The presentation deals with the development of an integrated platform for the valorization of plant residues from the agro-industry, such as stalks, corn cobs, husks, brewer's spent grain, and pomaces (grape, apple, beetroot), as well as related agro-residues and food industry by-products.

The proposed approach is based on a stepwise utilization strategy to maximize resource efficiency. In the first stage, waste biomass allocation is guided by chemical composition, safety profiles, and functional properties. Plant residues that meet food safety requirements and exhibit suitable nutritional and techno-functional characteristics are incorporated into food systems to develop fortified food products, thereby improving nutritional value and functional performance. Residual biomass unsuitable for food applications is subsequently used to produce bio-based materials, including green composites for sustainable food packaging.

In the final stage, residues unsuitable for food and material applications undergo thermochemical conversion processes, such as pyrolysis and co-pyrolysis with other waste materials, yielding value-added products including (bio)oil, (bio)char, and syngas. This integrated cascade approach ensures optimal utilization of residual biomass, minimizes waste streams, and supports the transition to circular, sustainable production systems.

The proposed platform is demonstrated through experimental results and analytical characterization, emphasizing its applicability across food systems, sustainable materials, and environmentally responsible waste management strategies.