BIVALIA
BIORREFINERÍAS INTEGRADAS



CIRCULAR ECONOMY IN FOOD INDUSTRY WASTE MANAGEMENT

Book of Abstracts

BIVALIA-CM [TEC-2024/BIO-177]

WORKSHOP 2026

BIVALIA
BIORREFINERÍAS INTEGRADAS

Comunidad de Madrid

CIRCULAR ECONOMY IN FOOD INDUSTRY WASTE MANAGEMENT

2 Workshop - BIVALIA-CM

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WS2. Circular Economy in Food Industry Waste Management, the second workshop of the BIVALIA-CM network, is organized by W2V-UAM and TEC4E-UAM (Local Organizers, Universidad Autónoma de Madrid) together with CIBER-URJC (Universidad Rey Juan Carlos), in charge of the communication tasks of the network.

BIVALIA-CM is coordinated by GIQA-BIO-URJC (Universidad Rey Juan Carlos) and brings together eight research groups, whose leaders contribute to the scientific coordination of this workshop: UBAB-CIEMAT, BIOREF-ICP-CSIC, W2V-UAM, GIQA-BIO-URJC, TEC4E-UAM, UPTQ-IMDEA, UAS-IME and CIBER-URJC.

The workshop brings together researchers, industry stakeholders and institutions to examine the role of biorefineries in the valorisation of agri-food industry waste, addressing pretreatment and fermentation processes, energy and material recovery strategies, and the circular economy framework within which these technologies are deployed.

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CSIC Consejo Superior de Investigaciones Científicas

Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

instituto IMDEA energía

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Foreword

The BIVALIA-CM network presents the Book of Abstracts of its second workshop, WS2. Circular Economy in Food Industry Waste Management, held at the Faculty of Sciences of the Universidad Autónoma de Madrid on 16 October 2026.

This second meeting is devoted to recent advances in the circular economy applied to food industry waste management and brings together the research being carried out across the eight groups of the network on the valorisation of biogenic residues. The programme combines two plenary lectures, [15] oral presentations and [19] posters, organised around three thematic areas: pretreatment technologies and fermentation processes, energy and material recovery strategies, and the circular economy framework within which this work takes place.

Beyond presenting results, the workshop is intended as a working meeting. It seeks to strengthen collaboration between the network's groups and to open that conversation to industry, to institutions and to researchers from outside BIVALIA-CM, in the conviction that aligning scientific and industrial efforts is what turns laboratory results into deployed technology.

We thank all authors for their contributions, the Scientific Committee for its work in reviewing them, and the Comunidad de Madrid for funding the network.

The Organising Committee

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INVITED SPEAKERS

WS2. Circular Economy in Food Industry Waste Management

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Invited Speakers #1

Valorization of food waste into carbon-based materials and bio-based chemicals and fuels

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Keywords: *Integrated catalytic process; Waste-derived carbons; Carbohydrate valorization; Renewable platform molecules; Hydrogenative upgrading; C–C coupling; Sustainable aviation fuels*

Food waste is an abundant renewable carbon resource with considerable potential for the production of functional materials, platform chemicals, and sustainable fuels. This work presents an integrated valorization strategy in which food residues are used both as feedstocks for catalytic conversion and as precursors for carbon materials and catalysts.

Glucose-derived and food waste-derived catalytic materials were developed and applied to the conversion of cellulose and carbohydrate-rich food residues into ethylene glycol (EG), demonstrating the feasibility of coupling renewable feedstocks with carbon-based catalytic materials. Within this integrated framework, food residues were also converted into carbonaceous materials through hydrothermal carbonization, followed by carbonization/activation treatment, with the resulting materials applied to the production of biomass-derived value-added chemicals, including EG and furfural.

Low-cost Ni–W catalysts supported on glucose-derived carbons were developed for the one-pot conversion of cellulose into EG, achieving complete cellulose conversion and EG yields of 60–62 % [1-2]. The optimized glucose-derived catalysts were also applied to real waste, producing EG yields of around 40 % from cellulosic urban wastes and up to 21 % through the direct conversion of banana peel, orange peel, and spent coffee grounds [1]. To further integrate waste into catalyst synthesis, orange- and banana-peel-derived carbons were used as Ni–W catalyst supports, yielding 34.7 and 44.3 % EG from cellulose, respectively [3]. Additionally, preliminary results obtained with activated carbon derived from orange peel showed a highly developed porous structure and effective catalytic performance in xylose dehydration, reaching 98 % conversion and a furfural yield of 30.4 %.

The approach further integrates the production of furfural and levulinic acid from carbohydrate-rich feedstocks with their subsequent upgrading into sustainable aviation fuel precursors. These oxygenated platform molecules then undergo carbon–carbon coupling reactions, followed by hydrodeoxygenation, to produce hydrocarbons within the carbon-number range relevant for aviation fuels (C_8-C_{16}).

Overall, this strategy combines waste-derived material synthesis, carbohydrate conversion, and catalytic upgrading within a unified framework, demonstrating the versatility of food waste as both a source of catalytic materials and a renewable feedstock for chemicals and fuels.

Acknowledgements

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Invited Speakers #2

Technological advances in methane emission monitoring

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Keywords: *Biomethane; Methane leak detection; Fugitive emissions; Continuous emissions monitoring; Life Cycle Assessment; Optical Gas Imaging*

Biomethane is a cornerstone of the circular economy through the energy recovery of agrifood waste. However, because methane has a Global Warming Potential (GWP) 80–86 times greater than CO_2 over a 20-year horizon, its classification as a "sustainable" fuel holds true only if biomethane remains entirely contained within the pipeline.

Recently, studies revealed that average methane loss across biomethane plants ranges between 4-6% of total production (with extreme outliers reaching up to 21%). Rigorous Life Cycle Assessment (LCA) demonstrates that even a 2-3% fugitive leak rate can erode more than 50% of the net greenhouse gas reduction benefits expected from replacing natural gas. Driven by the EU Methane Regulation (Directive 2024/1787), operators are now legally mandated to maintain transparent, quantifiable, and proactive emissions management.

Unmonitored leaks create a persistent blind spot, often representing an unmeasured loss of around €100,000 annually per facility. It is crucial to differentiate between methane slip (operational losses during upgrading, typically 0.5–2% of throughput) and fugitive emissions (leaks from valves, flanges, membrane seals, and digestate storage, which account for ~70% of a facility's total unmetered losses).

This technological review presents the spectrum of techniques for methane leak detection and quantification, spanning

1. close-proximity inspection,
2. fenceline monitoring,
3. aerial surveys, and
4. satellite tracking

alongside key technological advancements underpinning methane monitoring:

1. NDIR,
2. TDLAS, and
3. Optical Gas Imaging (OGI)

The combination of these technologies with machine learning models, digital twins, and computer vision is rapidly transforming environmental monitoring from a manual, labour-intensive task into an automated, unmanned operation. Implementing continuous and automated workflow monitoring routinely enables biomethane operators to pinpoint super-emitters and eliminate 45–60% of fugitive losses, yielding a typical payback period of under 12 months. Ultimately, this shift not only empowers operators to certify verified emission reductions for high-value carbon markets and regulatory compliance, but also delivers a direct boost to Return on Investment (ROI) by preventing the loss of valuable gas.

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ORAL PRESENTATIONS

WS2. Circular Economy in Food Industry Waste Management

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Oral Presentations #3

Integrated green extraction strategies for the valorization of agro-industrial residues into value-added products

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Keywords: *Brewer's spent grain (BSG); Enzyme-assisted extraction (EAE); Deep eutectic solvents (DES); Protein recovery; Phenolic compounds; Biorefinery*

Agro-industrial by-products are promising feedstocks for integrated biorefineries, although their efficient valorization requires extraction strategies tailored to the physicochemical characteristics of each biomass. Within this framework, the present work focuses on destarched brewer's spent grain (d-BSG), a protein-rich lignocellulosic residue. Due to the strong association of proteins and phenolic compounds with the cell wall structure, efficient and sustainable extraction approaches are required to maximize the recovery of high-value compounds while improving the downstream valorization of the residual biomass.

Enzyme-assisted extraction (EAE) was investigated as the first step towards the development of tailored green extraction strategies for d-BSG valorization. A screening of commercial proteases with different catalytic specificities was performed under mild processing conditions. In parallel, a choline chloride:trehalose deep eutectic solvent (DES) was evaluated as an alternative green extraction medium for protein and phenolic recovery. Extraction performance was assessed through soluble protein recovery (BCA assay), residual protein in the solid fraction (Kjeldahl), total phenolic content (TPC) and antioxidant activity.

Alkaline proteases exhibited the highest extraction performance, achieving approximately 35% soluble protein recovery and 37% TPC recovery. Protein solubilization reached a plateau after approximately 1 h, whereas phenolic extraction continued to increase up to 6 h, indicating different extraction kinetics for both fractions. Kjeldahl analysis of the residual solids revealed a substantial decrease in protein content, from 22.6 g/100 g in the initial d-BSG to 4.3–6.8 g/100 g dry solid after 24 h using the most effective proteases, demonstrating their potential for d-BSG deproteinization. In contrast, the evaluated DES showed limited extraction efficiency, highlighting the recalcitrant nature of the d-BSG matrix and the need for complementary extraction strategies. Based on these results, three commercial proteases were selected for further physicochemical and bioactivity characterization.

The selected enzymatic conditions establish a robust benchmark for the rational evaluation of complementary green extraction strategies. Future work will investigate protein-compatible and disruptive DES formulations, together with process intensification technologies such as microwave-assisted extraction (MAE) and ultrasound-assisted extraction (UAE), either as pretreatments or in combination with DES, to enhance mass transfer and maximize the recovery of proteins, peptides and phenolic compounds from d-BSG.

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Oral Presentations #4

Scaling up organosolv fractionation processes to improve the utilization of lignocellulosic food industry waste

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Keywords: *biomass, fractionation, furfural, cellulose, lignin*

The transition towards a renewable resource-based economy requires technologies capable of fully valorizing lignocellulosic biomass and agro-industrial residues while producing compounds that can compete with petroleum-derived products. This work presents a biorefinery platform based on the use of gamma-valerolactone (GVL) as an organosolv solvent for the efficient fractionation of biomass and agro-food industry residues. The technology enables the selective separation of cellulose, hemicellulose, and lignin under mild operating conditions, preserving the quality of each fraction while reducing process-related costs. Thanks to the high solubilization capacity of GVL, more than 90% of both hemicellulose and lignin can be extracted, while simultaneously obtaining a solid cellulose stream with purities exceeding 90%.

The versatility of the process has been demonstrated using a wide range of feedstocks, including eucalyptus, birch, sugarcane bagasse, pruning residues, grape rachis, grapevine canes, and brewer's spent grain. In addition, the co-processing of materials with different characteristics and particle sizes, ranging from fine powders to wood chips, has been successfully evaluated while maintaining high fractionation yields. Results obtained using fresh and recycled solvent showed equivalent performance, highlighting the feasibility of GVL recovery and reuse.

The cellulose obtained can be directed toward high-value applications such as fiber and textile production or converted directly into fermentable sugars, ethanol, levulinic acid, or 5-hydroxymethylfurfural without additional purification steps. In parallel, the lignin retains much of its native structure, exhibiting high purity, low ash content, and high molecular weight, characteristics that make it suitable for the production of carbon foams, phenolic resins, and polyurethanes. Likewise, the hemicellulose fraction can be directly converted into furfural with yields close to 80%.

Overall, this technology enables the conversion of up to 80% of the biomass into high-value products, generating attractive economic returns while providing a sustainable and scalable pathway for the development of advanced biorefineries. Experiments conducted at the hundreds-of-grams scale further support future industrial scale-up and comprehensive technology validation.

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Oral Presentations #5

High-value VFAs production from sewage sludge by acidogenic fermentation using food industry waste and organic compounds

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Keywords: *Chain elongation; Electron donors; Hydrothermal carbonization; Waste management*

Hydrothermal carbonization (HTC) is an efficient technology for sewage sludge valorization, producing a solid fraction (hydrochar) and a liquid by-product labeled as process water (PW). While hydrochar has been investigated for energy and agricultural applications, PW remains underutilized despite its high content of soluble organic compounds and nutrients. This study evaluates the potential use of PW derived from secondary sewage sludge as a substrate for acidogenic fermentation. This work focuses on volatile fatty acid (VFA) production, studying the influence of pH and the effect of different electron donors' addition on VFA yield and selectivity.

Batch fermentation assays were performed under mesophilic conditions (35 °C) using a thermally pretreated inoculum obtained from an industrial anaerobic digester. The effect of pH (5.5, 7.2 and 9.0) and PW solid content, after two different filtration degrees, was initially assessed. Subsequently, chain elongation potential was evaluated by supplementing the reactors with different electron donors (ethanol and lactic acid) at concentrations of 5, 10 and 15 g/L. Thereafter, wine lees and cheese whey were also assessed as electron donors at the same concentrations to substitute the pure compounds. Process evolution was analyzed, monitoring also VFA production and composition.

Results demonstrated that acidic conditions severely limited VFA production regardless of filtration level of PW. In contrast, neutral and alkaline conditions enhanced acidogenic activity, with acetic acid being the predominant product. The highest VFA concentration was achieved using PW filtrated through 0.45 µm at neutral pH. The addition of external electron donors significantly increased VFA production compared with the control. Ethanol addition at 15 g/L resulted in the highest VFA concentration (21.2 g COD/L) and promoted chain elongation towards butyric and caproic acids. Lactic acid addition (15 g/L) achieved similar VFA levels (23.1 g COD/L), favoring propionic and butyric acid formation, likely through the acrylate pathway. Wine lees, despite their ethanol content, showed limited effectiveness and did not promote chain elongation. Conversely, cheese whey increased VFA production to 25.7 g COD/L, with extremely high selectivity to butyric acid, representing 67.8% of the total VFA profile.

These findings demonstrate that HTC integrated with acidogenic fermentation offers a sustainable resource recovery pathway.

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Oral Presentations #6

Purple photobiorefineries for greener valorization of food industry waste

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Keywords: *Nutrient recovery, Waste valorization, Purple phototrophic bacteria, Photobiorefinery, Circular bioeconomy*

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According to the latest 2025 agri-food sector report from CaixaBank Research, Spain's agri-food sector continues to expand due to increasing production, exports, and food demand. However, this growth also increases the generation of biogenic residues such as livestock manure and nutrient-rich agro-industrial effluents. Conventional management strategies often lead to greenhouse gas emissions, nutrient losses, and inefficient resource recovery. In this context, integrated biorefineries emerge as sustainable platforms to transform these residues into bioenergy, fertilizers, microbial protein, and other high-value bioproducts through the integration of thermochemical, biological, and electrochemical technologies.

Within the BIVALIA-CM framework, our research line develops purple phototrophic bacteria (PPB)-based photobiorefineries for the valorization of pig slurry as a model agro-industrial residue. PPB are highly versatile microorganisms capable of growing under photoheterotrophic, photohydrogenotrophic, and photoelectrotrophic conditions, enabling simultaneous nutrient recovery, CO_2 fixation, and production of value-added biomolecules.



Figure 1. Conceptual scheme of the BIVALIA-CM purple photobiorefinery platform for pig slurry valorization

First, we demonstrated the feasibility of coupling steam explosion pretreatment, gas-permeable membrane ammonia recovery, anaerobic digestion, and PPB cultivation within a single integrated photobiorefinery. Thermal hydrolysis enhanced organic matter solubilization by up to 57%, while more than 99% of ammoniacal nitrogen was recovered in less than 3 h. Anaerobic digestion increased methane production up to 3.5-fold, and recovered ammonium was successfully reused as nutrient source for PPB cultures growing under photohydrogenotrophic conditions, where CO_2 from biogas was converted into microbial protein-rich biomass [1].

Second, we explored sequential PPB–microalgae photobiorefineries inspired by raceway systems for comprehensive carbon and nutrient recovery from pig slurry. PPB assimilated organic matter and ammonium into bioactive biomass, while subsequent microalgae cultivation enabled tertiary treatment and

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additional CO_2 assimilation. The integrated system achieved up to 85% COD removal and 86% NH_4^+ recovery, demonstrating the potential of phototrophic consortia for sustainable pig-waste treatment and nutrient circularity [2].

Finally, PPB-based photo-electro-biorefineries using polarized cathodes demonstrated that PPB can directly uptake extracellular electrons supplied by an electrode to drive CO_2 fixation. This extracellular electron flux can modulate cellular redox metabolism, redirecting intracellular electron sinks toward biomass formation, carotenoid accumulation, and coenzyme Q10 biosynthesis, thereby opening new opportunities for renewable electricity-driven production of food-grade biomolecules within circular agri-food systems.

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Oral Presentations #7

Dairy by-product valorisation for carotenoid production by *Rhodosporidium toruloides*

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Keywords: *Cheese whey; Microbial carotenoids; red yeast;* Rhodosporidium toruloides

The management of agri-food residues and by-products represents a major environmental and economic challenge, particularly in the context of increasing food demand and population growth. Currently, many of these residues are still treated through low-value routes, such as composting, anaerobic digestion or energy recovery, while a significant fraction is disposed of without effective valorisation. These strategies do not fully exploit the potential of agri-food waste as renewable feedstock for the production of high-value bioproducts, resulting in limited circularity and inefficient use of carbon and nutrients. In this context, the production of high-value bioproducts such as carotenoids represents a promising strategy, since they are gaining increasing attention in the food, nutraceutical and health-related industries as natural alternatives to synthetic additives. Their applications as natural colorants, vitamin supplements and anti-ageing ingredients, together with their reported antimicrobial properties, are driving the expansion of the global carotenoid market, which is expected to reach USD 2.9 billion by 2029 [1].

In this work, the valorisation of dairy industry by-products for carotenoid production using the oleaginous red yeast Rhodosporidium toruloides ATCC 204091 was evaluated. Cheese whey was utilized as a low-cost substrate. Prior to fermentation, the whey was pasteurized at 90 °C for 30 minutes. Since this yeast cannot assimilate lactose, a preliminary hydrolysis step was performed using beta-galactosidase. To identify the most favourable cultivation conditions for carotenoid production by R. toruloides, a design of experiments (DOE) approach was applied using synthetic media representative of the composition of two types of whey, primary and concentrated whey. The optimal conditions identified were then used with the corresponding real whey substrates in a 0.5-L bioreactor under aeration, at pH 6 and 30ºC. The total carotenoid concentration ranged from 28 to 42 mg/L, with a carotenoid content of 800 µg/g dry cell weight. Torulen was the predominant compound, reaching an accumulation of 289 µg/g of cells.

Acknowledgements

This work was carried out within the framework of the BIVALIA-CM project [TEC-2024/BIO-177], funded by the Technology Networks call of the Community of Madrid. Authors thanks to Lácteas del Jarama for providing the raw material used in this study.

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Oral Presentations #8

Valorization of agri-food industry residues through photoheterotrophic fermentation by purple phototrophic bacteria

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Keywords: *Agri-food residues; Purple phototrophic bacteria; Photoheterotrophic fermentation; Biorefinery; Carotenoids*

The transition towards sustainable biorefineries requires integrated strategies capable of converting residual streams into valuable bioproducts while reducing their environmental impact. In this context, the present work aims to evaluate the potential of purple phototrophic bacteria (PPB) for the valorization of pretreated agri-food liquid streams generated within biorefinery schemes.

PPB represent a versatile microbial platform due to their ability to grow under anaerobic photoheterotrophic conditions, assimilate a wide range of organic carbon sources, and produce compounds of industrial interest. Their capacity to use near-infrared light provides an additional advantage for selective cultivation in complex residual matrices, enabling the coupling of wastewater treatment with the production of microbial biomass and added-value intracellular metabolites.

The experimental approach will focus on different liquid streams obtained after upstream pretreatment or fermentation processes, including mixed carboxylic acid streams, exhausted fermentation effluents, and washing fractions. Key operational and biological parameters will be evaluated, including irradiance, initial chemical oxygen demand (COD), and culture configuration using axenic cultures and mixed cultures enriched in PPB. Process performance will be assessed in terms of microbial growth, COD removal, substrate conversion, single-cell protein production, and carotenoid accumulation.

Once the most suitable operating conditions are identified, the process will be applied to selected residual streams to assess the feasibility of a cascade valorization strategy. This approach is expected to contribute to the development of integrated biorefinery schemes in which pretreated agri-food residues are sequentially transformed into added-value products. Overall, the proposed strategy combines residual stream treatment with the production of microbial biomass and carotenoids, supporting circular and sustainable alternatives for agri-food and biobased industries.

Acknowledgements

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Oral Presentations #9

Rhodobacter capsulatus as a genetically engineered platform for converting waste into high-value compounds

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Keywords: *Biohydrogen production, Nitrogenase-driven hydrogen production, Photofermentation, Purple non-sulfur bacteria*

Rhodobacter capsulatus is a purple non-sulfur photosynthetic bacterium with remarkable potential for waste valorization owing to its metabolic versatility and its ability to produce hydrogen through nitrogenase activity. However, photofermentative H_2 production is constrained by physiological and regulatory mechanisms that limit both H_2 yields and the range of waste streams that can be exploited. Genetic engineering offers an effective strategy to overcome these limitations and develop strains adapted to specific residual feedstocks.

As a first approach, a Δ*hupAB* mutant was constructed by deleting the genes encoding the uptake hydrogenase, an enzyme responsible for consuming part of the H_2 produced by nitrogenase. Elimination of this competing pathway generated a H_2-overproducing strain capable of producing up to ten-fold more H_2 than the wild-type strain under diazotrophic conditions (Barahona et al., 2016).

The biotechnological potential of this engineered strain was evaluated using process water generated during the hydrothermal carbonization (HTC) of food waste (Díez et al., 2024). This effluent is characterized by a high organic load and represents an important environmental challenge. Photofermentation assays demonstrated that the Δ*hupAB* mutant efficiently utilized HTC process water as its primary carbon source while simultaneously producing H_2 and reducing the organic load of the effluent. Moreover, continuous operation for more than 600 h confirmed the long-term stability of the process and sustained H_2 production from this complex waste stream.

To further expand the applicability of this platform to ammonium-rich agro-industrial waste streams, a Δ*hupAB* Δ*draTG* mutant is currently being developed. The DraT/DraG system controls the post-translational regulation of nitrogenase through reversible ADP-ribosylation of dinitrogenase reductase in response to ammonium availability (Masepohl et al., 2013). Disruption of this regulatory circuit is expected to maintain nitrogenase activity under ammonium-rich conditions, thereby extending photofermentative H_2 production to a broader range of agro-industrial effluents.

Overall, these results highlight the potential of *R. capsulatus* as a genetically engineered platform for waste valorization, where targeted modifications can be used to tailor cellular metabolism to diverse residual feedstocks and enhance sustainable biohydrogen production.

Acknowledgements

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Oral Presentations #10

Hydrothermal carbonization–anaerobic processes integration for improved valorization of wine and brewery by-products

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Keywords: *Anaerobic digestion; Acidogenic Fermentation; Hydrothermal Carbonization; Brewery Spent Grain; Winery residues*

An integrated process based on hydrothermal carbonization (HTC) and anaerobic treatment of brewery spent grain (BSG) and winery residues (grape skins, GS, and stems, S) was investigated. HTC of BSG was carried out at 180, 210, and 240 ºC (1 h), while winery residues were subjected to HTC and co-HTC at 180 ºC and 1 h. Furthermore, the generated process waters (PW) were evaluated through acidogenic fermentation (AF) and anaerobic digestion (AD).

For BSG, hydrochar yield remained stable (55–60%) across HTC temperatures, although carbon content and HHV increased up to 210 ºC. However, their nitrogen content limits their use as biofuels, although they comply with regulations for soil amendment. All hydrochars from winery residues showed potential as both biofuels and soil amendments, although increasing stem content in co-HTC reduced hydrochar yield, carbon content, and HHV.

Acidogenic fermentation was performed at an SIR of 1.6 and pH 5.5 under mesophilic and thermophilic conditions. The maximum hydrogen yields for BSG's PWs were reached for PW240 with 20.8 mL H_2/gCOD under thermophilic conditions, and for PW180 with 17.5 mL H_2/gCOD under mesophilic conditions. All assays generated similar volatile fatty acids (VFA) concentrations (5–6 gCOD/L). For winery residues, thermophilic AF of PW led to clear inhibition. Under mesophilic conditions, GS and GS:S PWs also showed inhibition, while stem PW obtained a production of 40.2 mL H_2/gCOD. Moreover, final VFAs concentration of stem PW was comparable to those obtained from BSG PWs, but with a higher content of caproic acid, up to 0.8 gCOD/L.

In AD, methane yields from BSG derived PW decreased from 175 to 71 mL CH_4/gCOD as HTC temperature increased from 180 to 240 ºC, indicating higher methane potential at lower carbonization temperatures. For winery residues PWs, methane production was similar (230–240 mL CH_4/gCOD), with the highest value reached for stem PW.

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Oral Presentations #11

Aqueous-phase reforming for simultaneous hydrogen production and waste treatment: insights from the BIVALIA project

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Keywords: *aqueous phase reforming, bio-hydrogen, circular economy*

Biohydrogen derived from residual biomass (WBM) plays a pivotal role in the transition toward a circular economy and a sustainable energy model. Aqueous phase reforming (APR) offers a route for converting organic matter present in dilute aqueous solutions into a hydrogen-rich gas that also contains CO_2 and small amounts of light alkanes. APR operates under relatively mild conditions (200-250°C and 15-50 bar) [1], with Pt/C being the most used catalysts due to their high stability under the hydrothermal conditions typical of APR process. While APR was initially developed and studied using model compounds such as glycerol or sugar alcohols as feedstocks, recent studies have shown that its economic viability relies on the use of low-cost feedstocks [2]. Consequently, waste streams containing organic matter from diverse industries such as brewing, fish canning, or juice production have been also explored as feedstocks [3].

The APR process has been integrated into the biorefinery schemes proposed within BIVALIA project, with the aim of recovering both mass and energy from high water content waste streams generated in other stages of the BIVALIA framework. The waste streams identified as having potential for APR include aqueous fractions of bio-oil, washing streams generated during the treatment of brewery bagasse and grape stalks, and effluents from hydrothermal carbonization, steam explosion and enzymatic hydrolysis, among others. Several challenges associated with the application of APR will be assessed as part of BIVALIA work plan, including catalyst deactivation and the enhancement of some feedstocks processability by chemical pretreatment. Finally, different alternatives for the utilization of the hydrogen-rich gas stream produced will be evaluated, including its use as fuel-gas, its recycling as hydrogen source to other biorefinery processes (e.g. hydropyrolysis or phototrophic fermentation), or its export from the BIVALIA scheme as crude hydrogen product stream.

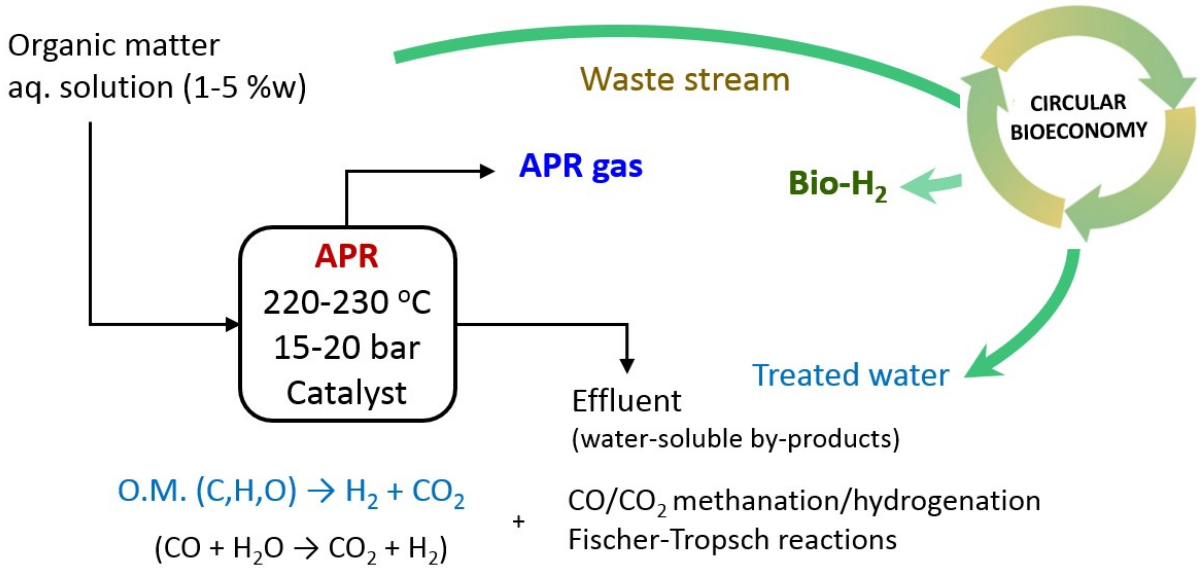


Figure 1. Fundamentals of Aqueous Phase Reforming and integration in BIVALIA-CM scheme

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Oral Presentations #12

Advances in the hydrogen valorization of different biorefinery waste streams derived from food industry residues

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Keywords: *aqueous phase reforming, hydrogen, biomass*

Within the BIVALIA-CM research network, experimental studies have been conducted using representative streams derived from dairy processing, enzymatic treatments of biomass residues, and thermochemical conversion processes. This contribution presents the main results obtained to date, with emphasis on the influence of feedstock composition on process performance and the challenges associated with the valorization of real waste streams for hydrogen production

The first group of studies focused on raw and concentrated whey from dairy industries. APR experiments were carried out at different feed concentrations using Pt/C catalyst loadings of 3 and 5 wt.%. The results revealed a strong influence of both substrate concentration and catalyst loading on process performance. Maximum carbon conversion to gas (CCgas) values of 76.9 % and hydrogen yields up to 67.6 mmol H_2 $gTOC^{-1}$ were obtained under the most optimal conditions. Gas composition was dominated by H_2 and CO_2, with a maximum H_2 composition of 56%.

In parallel, aqueous streams generated during the enzymatic processing of brewery bagasse and grape stalk residues were evaluated under a common set of APR conditions. Preliminary results demonstrated the suitability of these streams as feedstocks for hydrogen production, reaching carbon conversions of 81.4 % and hydrogen yields of 52.4 mmol H_2 $gTOC^{-1}$. Significant differences were observed among the type of enzymatic treatment used.

Additionally, aqueous fractions of bio-oils obtained from pyrolysis and hydropyrolysis processes are currently being investigated, building upon previous experience within the research group [1]. Owing to their high chemical complexity and broad distribution of oxygenated compounds, these streams represent a challenging substrate for APR.

Overall, the results obtained to date confirm the versatility of APR for the valorization of diverse aqueous waste streams generated in food-based biorefineries. Furthermore, they highlight the importance of feedstock composition in determining hydrogen production, carbon conversion and gaseous product distribution.

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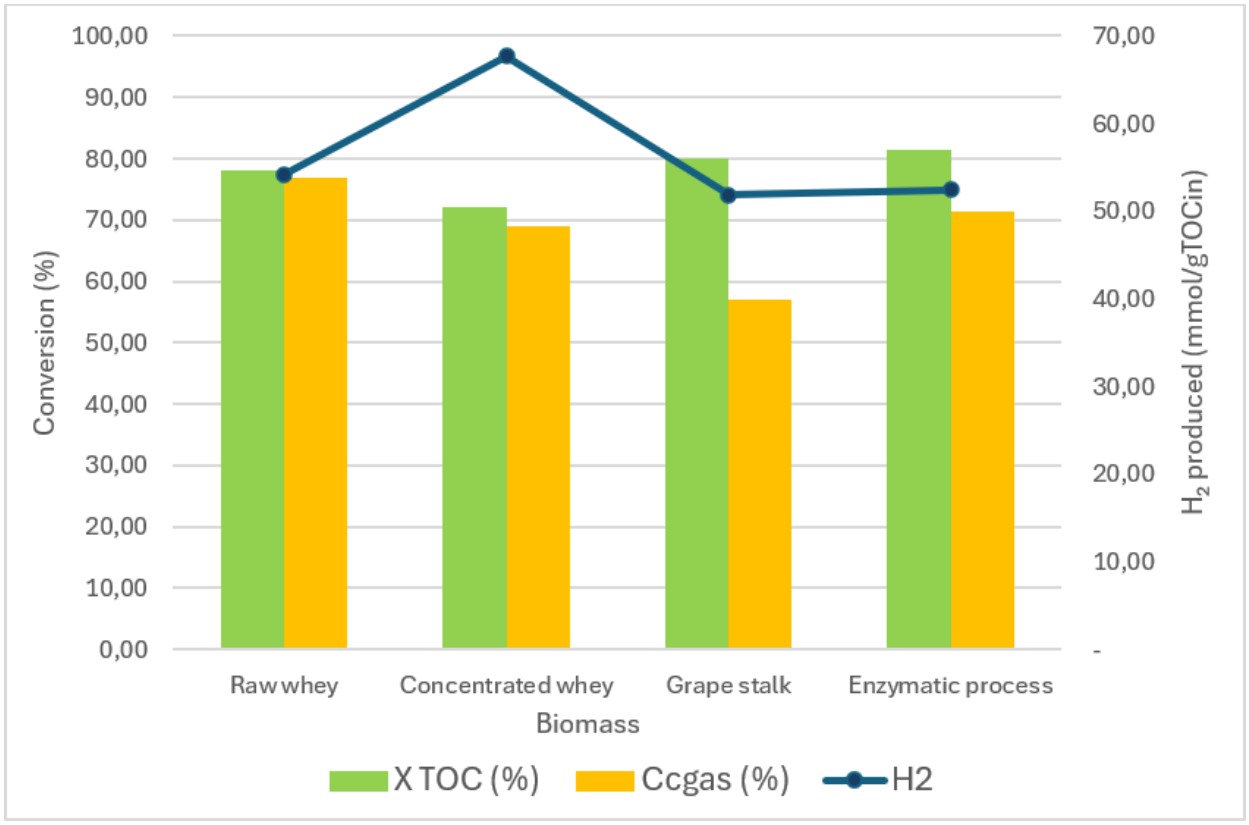


Figure 1. Preliminary results obtained for the different types of biomasses (5 wt.%, 1500 ppm).

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Oral Presentations #13

Hydrotreatment of technical lignins

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Keywords: *Lignin hydrotreatment, Hydrodeoxygenation (HDO), Depolymerization*

The catalytic upgrading of lignin into fuels and value-added chemicals is a key challenge for the development of sustainable biorefineries due to lignin's structural complexity, high oxygen content, and resistance to depolymerization. In this work, silica-supported metal phosphide catalysts (Ni_2P, MoP, and CoP) were synthesized and evaluated for the hydrotreatment of two commercial lignins with different structures: organosolv lignin and enzymatic hydrolysis lignin. The influence of catalyst composition, reaction temperature, residence time, and solvent on lignin conversion, product selectivity, and molecular weight evolution was investigated. Reactions were carried out in a stirred batch reactor under 10 bar of hydrogen. Product distributions were analyzed by gas chromatography (GC), while molecular weight changes were monitored using gel permeation/size exclusion chromatography (GPC/SEC).

The results showed that lignin type strongly affects catalytic behavior. Organosolv lignin exhibited significantly higher reactivity than enzymatic hydrolysis lignin, owing to its greater content of cleavable β-O-4 linkages and lower degree of condensation. GPC/SEC analyses revealed substantial reductions in both number-average and weight-average molecular weights, confirming effective depolymerization. The decrease was more pronounced for organosolv lignin, indicating its higher susceptibility to catalytic upgrading under relatively mild conditions.

Among the catalysts studied, Ni_2P/SiO_2 displayed the highest activity for lignin depolymerization and hydrodeoxygenation, promoting extensive ether bond cleavage and hydrogenation of reactive intermediates, which resulted in higher yields of stabilized monomeric products. MoP/SiO_2 showed intermediate activity and favored partial hydrodeoxygenation while preserving aromaticity. CoP/SiO_2 exhibited lower overall activity but greater selectivity toward aromatic-ring hydrogenation. GC analysis identified phenolic monomers such as guaiacol, syringol derivatives, alkylphenols, and partially hydrogenated cyclohexanol-type compounds.

Reaction temperature and residence time had a significant impact on conversion and selectivity. Increasing temperature enhanced lignin solubilization and monomer formation; however, temperatures above 325 °C promoted secondary condensation reactions and the formation of heavier fractions. An optimum temperature near 300 °C provided the best balance between depolymerization and product stabilization. Overall, silica-supported metal phosphides, particularly Ni_2P/SiO_2, showed strong potential for lignin valorization, highlighting the importance of matching catalyst and operating conditions to the characteristics of the lignin feedstock.

Acknowledgements

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Oral Presentations #14

Overcoming major challenges in lignocellulose catalytic pyrolysis by combination of low-temperature thermal decomposition and co-processing with vegetable oils over ZSM-5 zeolite: boosted production of aromatic hydrocarbons and prolonged catalyst lifetime

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Keywords: *Catalytic co-pyrolysis, ZSM-5 zeolite,Lignocellulosic biomass, Camelina oil, Monoaromatic hydrocarbons, Catalyst deactivation*

Catalytic pyrolysis of lignocellulosic biomass is a promising route for producing renewable fuels and chemicals, monoaromatic hydrocarbons (MAHs), key petrochemical intermediates, and fuel components. ZSM-5 zeolites are widely used due to their Brønsted acidity and shape selectivity, which promote deoxygenation and aromatization. However, scale-up is limited by low MAH yields and rapid catalyst deactivation caused by coke formation. This study investigates the co-processing of oak biomass and camelina oil over nanocrystalline ZSM-5 zeolite, emphasizing the effect of thermal pyrolysis temperature on catalyst stability.

Experiments were performed in an ex-situ fixed-bed reactor with two reaction zones and continuous feeding systems for oak and camelina oil, allowing catalyst performance and deactivation to be monitored along time on stream. Camelina oil was used as a hydrogen-rich co-feed to compensate the hydrogen deficiency of lignocellulosic vapours and mitigate catalyst deactivation. As shown in Figure 1, operating the thermal pyrolysis zone at 350 °C and co-feeding camelina oil improved MAH production and extended catalyst lifetime compared with conventional catalytic pyrolysis of oak alone and with high-temperature co-processing. Although MAH yields decreased and oxygen content increased with time on stream due to progressive deactivation, this effect was sharply mitigated when oak pyrolysis was carried out at 350 °C.

The improved performance is attributed to the influence of thermal pyrolysis temperature on oak-derived vapours. At 500 °C, the vapour stream becomes enriched in deactivating species, particularly aromatic oxygenates from lignin decomposition, which act as coke precursors. In contrast, low-temperature oak pyrolysis limits the release of heavy oxygenated compounds while increasing char formation at the expense of gas production, without affecting bio-oil yield. Camelina oil co-feeding promotes synergistic aromatization over ZSM-5, through Diels-Alder reactions between oak-derived furans and olefins from camelina oil cracking.

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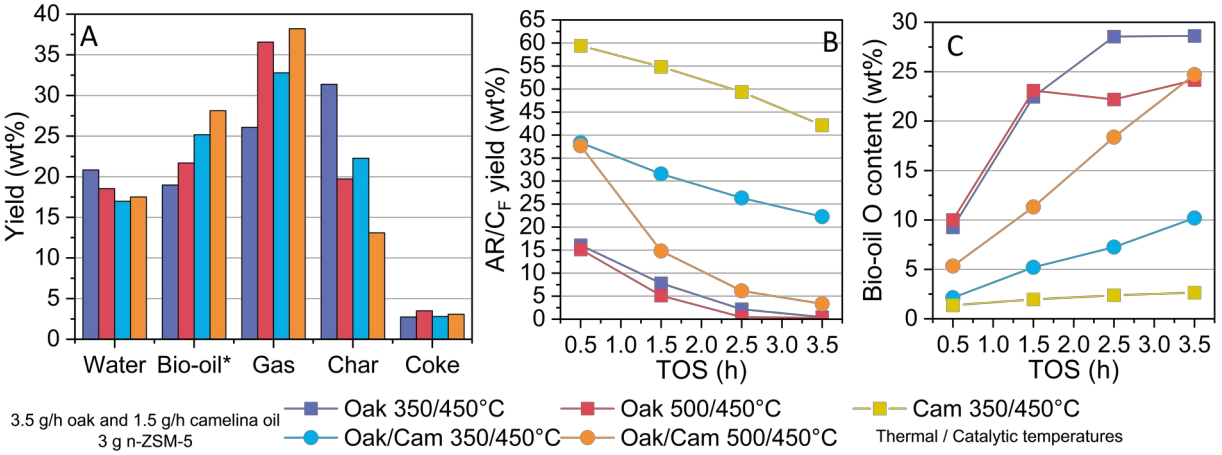


Figure 1. (A) Global and (B) carbon-to-aromatic hydrocarbons yields and (C) bio-oil* O content.

Post-reaction and regenerated catalyst characterization showed that the zeolite preserved its crystalline and textural properties. In conclusion, low-temperature oak pyrolysis coupled with camelina oil co-processing enhances MAH production and mitigates deactivation.

Acknowledgements

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Oral Presentations #15

Insights on the acetic acid pretreatment of wheat straw: changes induced in the biomass properties and benefits for the bio-oil production by pyrolysis

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Keywords: *Acetic acid washing, Selective demineralization, AAEM removal, Biomass pretreatment, Fast pyrolysis*

Agricultural lignocellulosic residues, such as wheat straw, are abundant renewable feedstocks for biofuels and chemicals. Nevertheless, their direct pyrolysis is hindered by ash, particularly alkali and alkaline-earth metals (AAEMs), which catalyze dehydration, cracking, gas and char formation, lowering bio-oil yield. Sustainable pretreatments to remove these species are essential.

This work investigates acetic acid washing as a green pretreatment for wheat straw, benchmarking it against water and ammonia washing. Each pretreatment was assessed by combining biomass characterization, including AAEM removal, holocellulose enrichment and thermal stability, with pyrolysis under nitrogen in a downflow fixed-bed reactor with two zones at 550 and 450 °C.

Acetic acid washing selectively removed the most catalytically active species, almost eliminating potassium and sodium and reducing magnesium and calcium. Unlike ammonia, which increased demineralization through silica removal, acetic acid targeted AAEMs involved in secondary reactions. It also extracted soluble lignin, extractives and acetyl-rich compounds, increasing holocellulose content and shifting cellulose decomposition to higher temperatures. Consequently, bio-oil* yield increased from 35 wt % for raw wheat straw to 53 wt% after acetic acid pretreatment, while water, gas and char decreased.

As shown in Figure 1, bio-oil* yield increases when total AAEM content decreases and holocellulose content increases. Thus, suppressing AAEM-catalyzed fragmentation, decarboxylation and condensation, while preserving holocellulose, is crucial for maximizing liquid production. Bio-oil* quality improved, with lower acids, ketones and ethers, and higher furans and anhydrosugars. Levoglucosan became the dominant valuable compound, reaching yields close to 10 wt%, due to inhibition of cellulose ring-scission reactions. Conversely, extracted matter samples mainly promoted char and gas.

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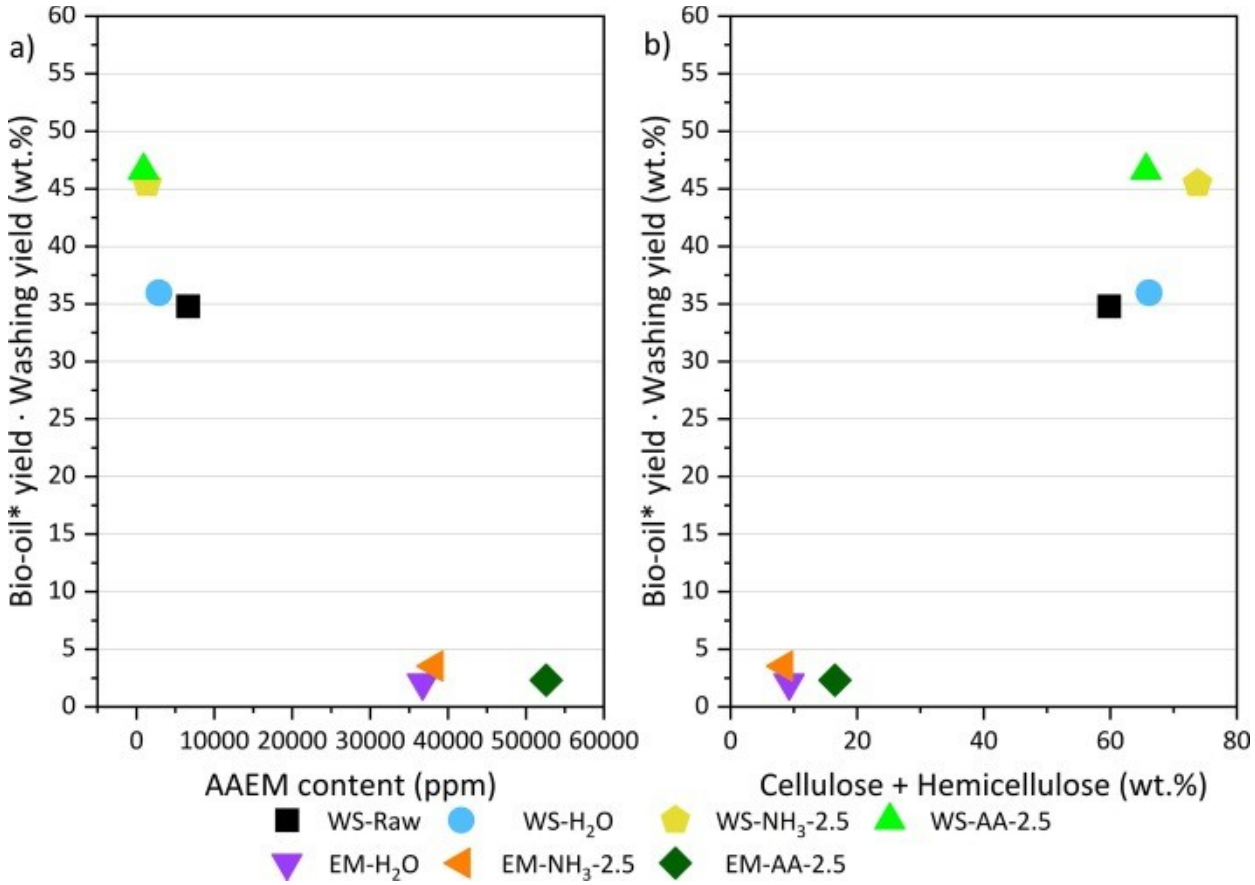


Figure 1. Bio-oil* yield versus (a) total AAEM content and (b) holocellulose content of raw WS, washed WS and EM samples. Bio-oil yields are calculated considering the washing yields of every WS and EM sample.

Acetic acid pretreatment improves wheat straw pyrolysis by separating holocellulose from catalytic inorganic species. Preliminary techno-economic analysis indicates that higher bio-oil* and levoglucosan revenues can offset acid, energy, and equipment costs, supporting its potential as a sustainable pretreatment for biorefineries.

Acknowledgements

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Oral Presentations #16

Evaluation of food waste hydrothermal carbonisation through process simulation and environmental life cycle assessment

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Keywords: *hydrothermal carbonisation; food waste; process simulation; life cycle assessment*

Hydrothermal carbonisation (HTC) has been widely investigated as a potential route for the valorisation of wet organic residues, since it enables the conversion of high-moisture feedstocks into hydrochar. In the case of food waste, previous studies have shown that HTC can support energy and nutrient recovery, but its environmental performance depends on process conditions, energy requirements, hydrochar use, and the management of the liquid phase [1,2]. These aspects make HTC a process in which experimental data, process simulation, and life cycle assessment need to be consistently integrated. Brewer's spent grain is particularly relevant in this context because it is generated as a wet by-product of beer production, typically with a moisture content of around 70 – 80 % [3]. In this context, Spanish beer production reached approximately 41.3 million hectolitres in 2024, with an estimated generation of 0.83 Mt of wet brewer's spent grain annually.

In order to advance towards a circular economy in Spain, this work presents a combined process simulation and environmental life cycle assessment of HTC of brewer's spent grain. The simulation model was developed to represent the main mass and energy flows of the system, including HTC, solid–liquid separation, and energy integration. The resulting life cycle inventory was incorporated into an environmental assessment to estimate the potential impacts associated with the process and to identify the main contributors to its environmental profile. Furthermore, the analysis studies the influence of process yields, energy demand, and hydrochar and liquid phase valorisation. In this regard, potential extension of the system to include fermentation of the liquid phase is explored. Overall, the study shows that the environmental suitability of the system is highly conditioned by the specific process design, e.g. in terms of the involved energy and end-of-life strategies.

Acknowledgements

This work was carried out within the framework of the BIVALIA-CM project [TEC-2024/BIO-177], funded by the Technology Networks call of the Community of Madrid.

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Oral Presentations #17

Communication and dissemination strategies in circular economy projects: BIVALIA as a case study

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Keywords: *Circular Economy; Agri-food Waste Management; Open Science; Responsible Research and Innovation (RRI); Strategic Science Communication*

The development of circular economy solutions in agri-food waste management requires not only technological innovation but also effective communication strategies that foster understanding, acceptance, and adoption among diverse stakeholders [1]. In this context, the BIVALIA-CM project implements an integrated communication and dissemination system aligned with the principles of Open Science [2] and Responsible Research and Innovation (RRI), aimed at maximizing its scientific, social, and economic impact [3].

This paper presents the project's communication architecture, structured around a multichannel strategy that combines digital environments, in-person actions, and multimedia production. The project website functions as a central open-access hub for information, results, and resources, complemented by an active social media strategy (LinkedIn, X, Bluesky) designed to engage both specialized and general audiences. At the same time, email marketing campaigns—via quarterly newsletters—foster stakeholder engagement and ensure the regular dissemination of project updates.

In terms of audiovisual communication, the project includes the production of dissemination-oriented content such as videos, infographics, interviews, and recordings with companies in real operational environments. These are distributed through dedicated video channels and podcast formats, facilitating knowledge transfer through accessible and engaging narratives. These actions are reinforced by the organization of scientific workshops, participation in conferences, and the development of training activities, thus creating a dynamic interaction ecosystem among academia, industry, policymakers, and citizens.

The system is supported by a structured activity plan and strategic collaborations with sectoral associations and specialized media, enhancing both visibility and credibility. Finally, a robust monitoring and evaluation framework is presented, based on key performance indicators (KPIs), including metrics related to scientific dissemination (publications, conference participation), digital communication (social media interactions, website traffic, multimedia outputs), and media impact and stakeholder engagement. This framework enables both performance assessment and iterative optimization of communication strategies.

Overall, BIVALIA proposes a replicable model for strategic communication in circular economy projects, integrating dissemination, participation, and systematic impact evaluation.

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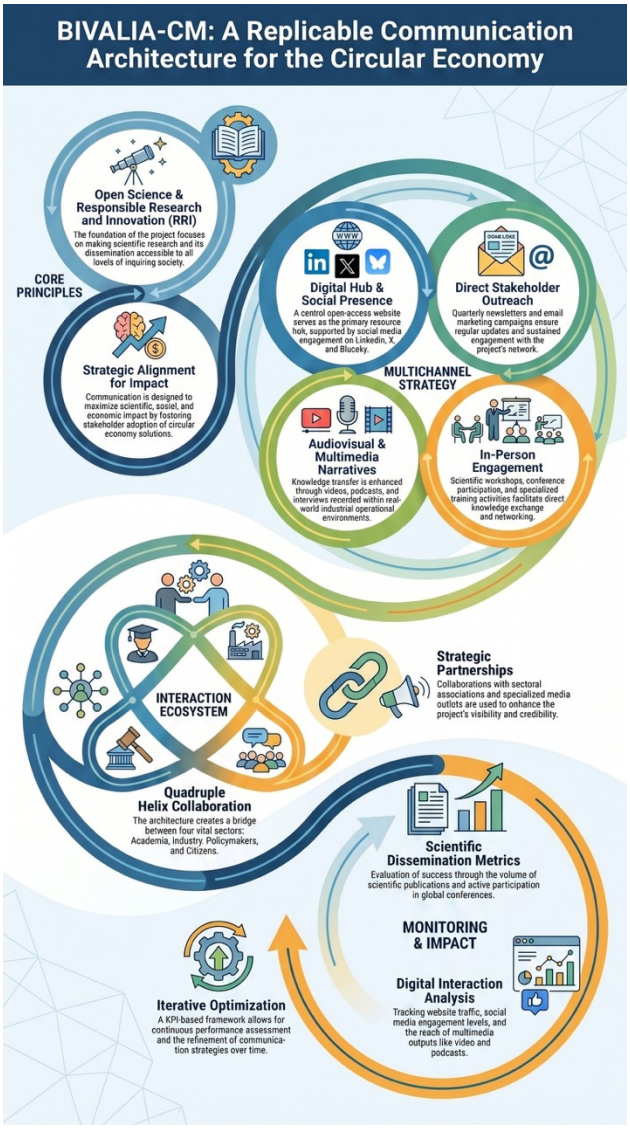


Figure 1. Replicable Communication Architecture for the Circular Economy

Acknowledgements

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POSTER PRESENTATIONS

WS2. Circular Economy in Food Industry Waste Management

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Poster Presentations #18

P.I.1 — Thermal hydrolysis pretreatment to enhance anaerobic digestion performance of the organic fraction from municipal solid waste

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Keywords: *Anaerobic degradability; Biochemical methane potential; Biogas yield; Substrate improvement; Waste degradation*

Municipal solid waste generation is increasing worldwide, while source separation remains limited and landfilling continues despite European circular-economy targets. Mechanical biological treatment enables the recovery of materials and energy from unsorted municipal solid waste, producing a mechanically separated organic fraction (MS-OFMSW) that can be valorized through anaerobic digestion. However, its low biodegradability often limits methane production and overall digestion performance. This study evaluates the application of Econward's BIOMAK® thermal hydrolysis technology as a pretreatment strategy to improve the anaerobic digestion of MS-OFMSW [2].

MS-OFMSW, from a mechanical biological treatment (Madrid), was thermally hydrolyzed at 152 °C - 4 barG for 20 min. The thermally hydrolyzed organic fraction (THOF) was screened through 40 mm sieve and subsequently cleaned using a pulper-hydrocyclone-rejector system to produce a diluted Biopulp. The BIOMAK® outflow mix (BO-Mix) was prepared by combining THOF with the condensate and the process water generated during the process (96:16:1, mass balance ratio). Biochemical methane potential tests were conducted at 36 °C for 29 days, using anaerobic digestate sourced from a mesophilic anaerobic reactor as inoculum with an inoculum-to-substrate ratio of 2 on a volatile solids (VS) basis [2]. Total solids (TS), VS, soluble chemical oxygen demand (SCOD), alkalinity, pH, ammonia nitrogen, and volatile fatty acids (VFA) were monitored, as well as biogas generation and composition,

Thermal hydrolysis modified the substrate characteristics by lowering pH and improving C:N and VS/TS ratios, indicating enhanced biodegradability. During assays, pH remained within the optimal range, with enough alkalinity and non-inhibitory ammonia concentrations. Pretreated substrates showed higher solubilization and VFA formation during the first days, followed by efficient conversion during methanogenesis stage (Figure 1a). Figure 1b shows the cumulative specific methane production. The highest methane yields were obtained for Biopulp and THOF, reaching 346 and 332 mL STP CH_4/g VS_{added}, respectively, compared with 275 mL STP CH_4/g VS_{added} for untreated MS-OFMSW. In contrast, BO-Mix presented limited improvement, likely due to inhibitory aromatic compounds present in the condensate.

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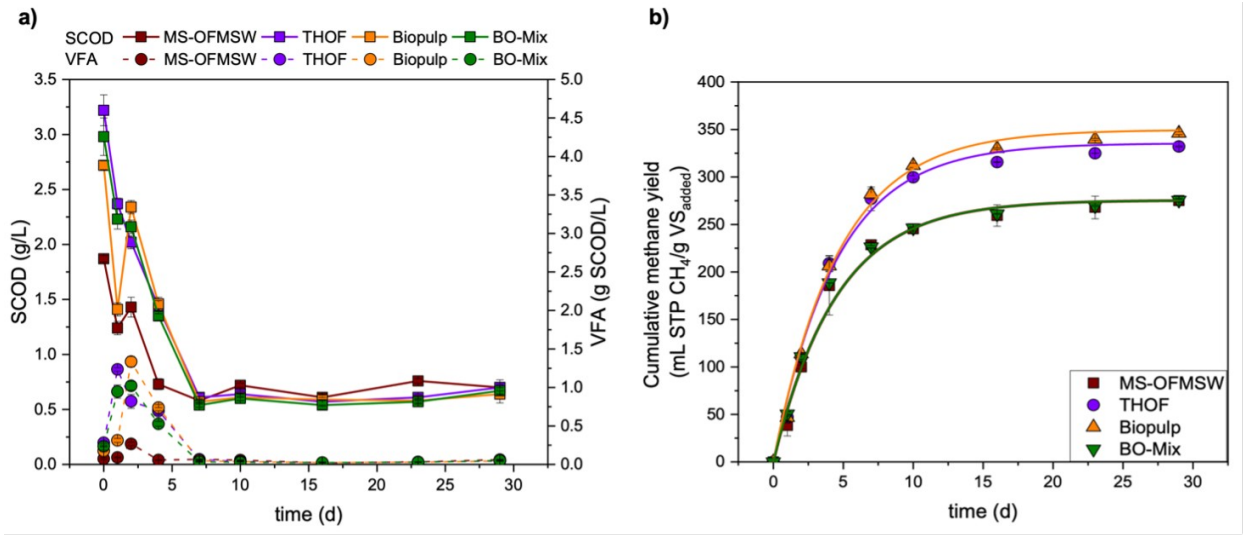


Figure 1. SCOD and VFA evolution (a); Cumulative methane yield per g VSadded (b)

BIOMAK® thermal hydrolysis enhanced MS-OFMSW biodegradability and anaerobic digestion performance, supporting its potential for biowaste valorization within circular-economy strategies.

Acknowledgements

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Poster Presentations #19

P.I.2 — From residual municipal waste to high value products: volatile fatty acids and biohydrogen

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Keywords: *Waste management; acidogenic fermentation; biomass*

Acidogenic fermentation (AF) represents a sustainable pathway for biohydrogen generation from the residual fraction of municipal waste (RFMW). This study evaluated the AF of thermo-hydrolyzed RFMW under batch and semicontinuous regimes, analyzing hydrogen yields, fermentation kinetics, volatile fatty acids (VFA) production, and microbial community shifts. Batch assays tested mixed stabilized sludge (MSS) and digested sewage sludge (SSD) as inocula under different substrate-to-inoculum ratios (SIR). MSS was identified as the superior inoculum, achieving maximum hydrogen yields of 19.4 mL H_2/g volatile solids (VS) at an SIR of 1.5. In these assays, kinetics for MSS were best described by a modified logistic model, favoring the enrichment of hydrogen-producing taxa such as Bacillus and Caloramator, while end-point VFAs showed a high correlation with butyrate prevalence. Semicontinuous trials were conducted in continuously stirred tank reactors (CSTR) using MSS at hydraulic retention times (HRT) of 3, 5, and 8 days. Semicontinuous operation initially favored fermentative pathways, reaching a peak hydrogen production rate of 19.6 mL H_2/g VS·d at an HRT of 3 days. However, operating at longer retention times induced a progressive metabolic shift from hydrogenogenesis toward methanogenesis, accompanied by moderate acidification, a substantial accumulation of intermediates (VFAs up to 8.4 g/L), and a decline in stability. Microbial community dynamics reflected these functional changes: hydrogenogenic consortia dominated the initial H_2-producing stages, but extended HRTs caused a transition where *Caproiciproducens* shifted toward *Thermoclostridium* and *Defluviitoga*, allowing low-abundance hydrogenotrophic methanogens to establish. In conclusion, while batch operation optimized hydrogen production via specific inoculum selection, semicontinuous operation revealed that short retention times enhance initial hydrogen yields but compromise system stability. These findings highlight that maintaining long-term acidogenic performance requires strict operational control, particularly pH regulation, to avoid the metabolic diversion of intermediates toward methanogenesis during the valorization of municipal organic waste.

Acknowledgements

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Poster Presentations #20

P.I.3 — Environmental stress as a driver of pigment modulation in *Rhodobacter capsulatus*

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Keywords: Rhodobacter capsulatus*; Carotenoid production; Oxidative stress; Pigment regulation*

The transition toward circular bioprocessing requires sustainable microbial platforms capable of converting residual streams into valuable bioproducts. Purple phototrophic bacteria (PPB), such as *Rhodobacter capsulatus*, are promising candidates due to their metabolic versatility and their capacity to produce microbial protein and carotenoids with antioxidant and photoprotective functions. This study evaluates how environmental stressors, specifically oxygen availability and UV-C exposure, regulate carotenoid biosynthesis and pigment composition in *R. capsulatus*.

Pigments were extracted using organic solvents and analyzed by UV–Vis spectrophotometry and high-performance liquid chromatography (HPLC). UV-C irradiation reduced cell viability, reflecting its damaging effect on microbial populations, but surviving cultures showed an increase in total carotenoid accumulation of approximately 10–20%. This response suggests the activation of photoprotective and oxidative-stress defense mechanisms. In addition, UV-C exposure induced a temporary delay in growth that progressively decreased over successive cycles, indicating an adaptive response to repeated stress. However, carotenoid accumulation was not strictly proportional to exposure intensity or cycle number, suggesting the existence of regulatory limits in pigment overproduction (Figure 1). Oxygen availability strongly influenced carotenoid composition and culture pigmentation. Under aerobic conditions, cultures shifted toward reddish coloration, while anaerobic cultures remained more yellowish. Spectrophotometric and HPLC analyses confirmed that oxygen promoted the CrtA-mediated oxidation of spheroidene into spheroidenone, a ketocarotenoid associated with enhanced oxidative-stress quenching and photoprotective capacity.

Overall, these results demonstrate that controlled environmental stress can modulate carotenoid biosynthesis in *R. capsulatus*. Oxygen acts as a key regulator of pigment composition, while repeated UV-C exposure promotes carotenoid accumulation and physiological adaptation. These findings highlight the potential of stress-based cultivation strategies to enhance carotenoid production in PPB systems and support their integration into scalable bioprocesses for the sustainable production of high-value compounds.

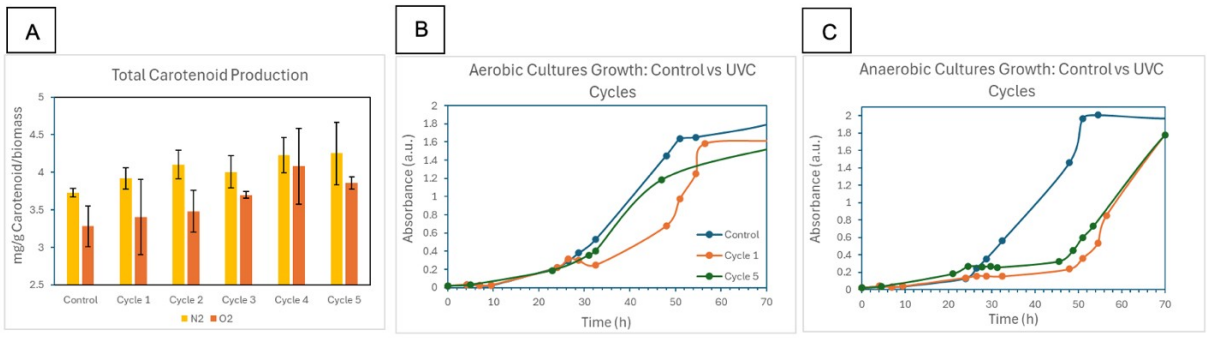


Fig 1. (A) Total carotenoid production (mg carotenoids/g biomass) per cycle under UV-C irradiation compared to non-irradiated controls (N_2 and O_2). (B) Growth curves (absorbance, a.u.) of aerobic cultures for selected cycles vs control. (C) Growth curves (absorbance, a.u.) of anaerobic cultures for selected cycles vs control.

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Poster Presentations #21

P.I.4 — Sequential enzymatic and hydrothermal fractionation of brewer's spent grain for selective prebiotic XOS production

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Keywords: *Xylooligosaccharides; Agro-industrial residues; Biorefinery*

The growing interest in functional food ingredients has intensified the search for sustainable sources of prebiotic xylooligosaccharides (XOS) with a low degree of polymerization (DP2–DP5). These compounds are particularly attractive due to their selective stimulation of beneficial gut microorganisms and their associated health benefits [1]. Yet, producing these compounds efficiently remains challenging, especially when working with complex lignocellulosic residues. Among agro-industrial residues, brewer's spent grain (BSG) is one of the most relevant. It accounts for approximately 85% of the total solid waste generated during beer production [2]—specifically during the mashing stage—and represents an abundant but underexploited feedstock. Although rich in hemicellulose, proteins, and phenolic compounds, its heterogeneous composition often limits its direct conversion into high-value fractions.

This study addresses these limitations by implementing a two-stage valorisation strategy designed to enhance BSG processability and maximise the selective release of XOS. First, a tailored enzymatic sequence—combining amylase, glucoamylase, and protease—was applied to remove starch and proteins, mitigating issues such as gel formation and Maillard-type reactions during thermal processing, and also allowing for the recovery of the protein. This step substantially increased the relative xylan content of the solid residue, creating a more suitable substrate for subsequent fractionation. The pretreated biomass was then subjected to liquid hot water processing at 185 °C, a catalyst-free approach that promotes controlled solubilisation and depolymerisation of arabinoxylans.

The integrated process yielded 13.8 g/L of XOS, corresponding to 8.7 g per 100 g of dry BSG, with nearly half of the recovered oligosaccharides falling within the low-DP range associated with enhanced prebiotic functionality. Degradation products remained minimal, highlighting the selectivity of the method. Beyond XOS, the process generated additional streams of biotechnological interest, including protein- and sugar-rich liquors and a cellulose-enriched solid fraction with improved digestibility.

Overall, this work demonstrates that BSG can be transformed from a low-value residue into a versatile feedstock for producing high-quality prebiotic ingredients, reinforcing its role within advanced biorefinery and circular-economy strategies.

Acknowledgements

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Poster Presentations #22

P.I.5 — Growth and tolerance screening of engineered *Shimwellia blattae* and *Escherichia coli* on agro-industrial residues for isobutanol production

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Keywords: *Isobutanol production; Agro-industrial residues; Engineered bacteria; Growth and tolerance screening*

Biorefineries are driving interest in transforming agro-industrial residues into valuable products and biofuels. Among these, isobutanol has emerged as a particularly attractive alternative to ethanol due to its higher energy density, lower hygroscopicity, and improved compatibility with existing fuel infrastructure. The sustainable production of biofuels from agro-industrial residues therefore represents a promising strategy to reduce reliance on fossil resources while valorizing waste streams. In this study, the potential of two genetically engineered bacterial strains, *Shimwellia blattae* p424IbPSO and *Escherichia coli* W pIZIbPSO [1, 2], for isobutanol production using agro-industrial residues was evaluated. A preliminary screening was performed to assess microbial growth and tolerance to different waste-derived substrates. The tested feedstocks included cheese whey from the dairy industry, brewer's spent grain (BSG) from the brewing process, and a hot water extract of sugars obtained from grape stems generated in the wine industry. These residues were incorporated at different concentrations into a defined minimal salts medium (M92X), which served as the base culture medium. Growth performance and substrate compatibility were compared against control cultures grown in standard M92X medium. Cultures were conducted in multiwell plates under controlled conditions in a plate reader CLARIOstar (BMG Labtech), with the addition of selective antibiotics (gentamicin and streptomycin) to ensure plasmid maintenance. The screening results demonstrated that both strains were capable of growing on tested residues, although growth profiles and tolerance thresholds varied depending on the substrate type and concentration. Cheese whey and grape stem extracts supported robust growth at moderate concentrations, while higher loadings of brewer's spent grain-derived substrates showed inhibitory effects, likely due to complex matrix components. These findings highlight the adaptability of the engineered strains to heterogeneous, low-cost substrates and provide key insights into optimal substrate concentrations for subsequent fermentation processes. The results will guide future optimization of isobutanol production using agro-industrial waste streams as feedstock.

Acknowledgements

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Poster Presentations #23

P.I.6 — Development of fermentable streams from dehesa pruning residues for biotechnological production of sustainable aviation fuel precursors

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Keywords: *steam explosion; inhibitors; single cell oil; oleaginous yeast*

The decarbonization of the aviation sector requires sustainable alternatives to fossil-derived fuels, with microbial oils emerging as promising precursors for Sustainable Aviation Fuels (SAFs). Mediterranean dehesa systems generate large amounts of lignocellulosic pruning residues despite their potential as renewable feedstocks for integrated biorefineries. In this context, the BIODESOIL project aims to develop biotechnological strategies for converting these residues into microbial oils and high-value bioproducts. This study aimed to develop fermentable lignocellulosic streams from dehesa pruning residues through an integrated biomass preparation and pretreatment strategy, and to evaluate their suitability for microbial conversion using the oleaginous yeast *Rhodotorula toruloides*.

Biomass preparation, including milling and aqueous extraction, was combined with dilute acid-catalysed steam explosion (SE) to enhance biomass fractionation. Pretreated solids were enzymatically hydrolysed while pretreatment liquors were characterized for sugars, organic acids, phenolics and furans. The compatibility of the preferred pretreatment liquor with *R. toruloides* ATCC 204091 was evaluated by assessing cell viability, biomass formation, sugar utilization and detoxification capacity using untreated, different pretreatment liquor-to-medium ratios, and activated carbon-treated liquors.

Biomass preparation prior to SE significantly enhanced pretreatment efficiency, with aqueous extraction followed by SE at 190 °C providing the highest overall sugar recovery (≈ 45 g/100 g extracted biomass). Although pretreatment generated inhibitory compounds, *R. toruloides* maintained high cell viability (≈85–90%) in media containing up to 50% pretreatment liquor. Sequential sugar utilization was observed, with arabinose consumed after xylose depletion. Moreover, furfural was efficiently converted into furoic acid, demonstrating the yeast's intrinsic detoxification capacity. Among the cultivation conditions evaluated, a pretreatment liquor-to-medium ratio of 1:2 provided the most favourable biological performance, combining high cell viability with the highest biomass formation and enhanced carotenoid production. Although activated carbon efficiently reduced furans and phenolic compounds, the treated liquor supported lower biomass formation, suggesting that detoxification may also affect the nutritional quality of the fermentation stream.

Overall, these results demonstrate that integrating biomass preparation with SE pretreatment enables the generation of fermentable streams compatible with microbial conversion, supporting the valorisation of dehesa pruning residues as feedstocks for biotechnological production of sustainable aviation fuel precursors within an integrated biorefinery.

Acknowledgements

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Poster Presentations #24

P.I.7 — Fermentable sugars recovery from agro-food by-product for bioethanol production

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Keywords: *Sugars, Agro-food waste, Fermentation*

The treatment of waste from the agri-food supply chain is expected to intensify with global population growth. A major challenge in using food waste as a biorefinery feedstock is sample heterogeneity. The food manufacturing industry offers more homogeneous materials, which is key to the optimal valorisation of these residues, since variations in feedstock lead to differences in the chemical composition of the wastes [1].

This study evaluates the potential of three abundant by-products—brewer's spent grain (BSG), grape stalks, and cheese whey—for bioethanol production, comparing their characteristics, processing requirements, and fermentation performance. BSG, a by-product from the beer-brewing process, requires pretreatment to improve cellulose accessibility; steam explosion was selected because it effectively disrupts the biomass structure and partially solubilises hemicelluloses, producing a glucose- and xylose-rich prehydrolysate [2]. Grape stalks, lignocellulosic waste obtained after destemming in winemaking, were processed by aqueous extraction, yielding a solution containing mainly glucose and fructose. Cheese whey was pasteurised and then subjected to enzymatic hydrolysis.

The fermentation performance of the three sugar-rich streams was evaluated using an industrial yeast, focusing on the effects of nutrient supplementation and yeast inoculum concentration on sugar utilisation and ethanol yield. The results showed that BSG prehydrolysate required both nutrient supplementation and a higher yeast inoculum concentration (up to 1 g/L) to achieve efficient fermentation, yielding ethanol above 0.44 g/g sugar consumed. In contrast, grape stalk extract and cheese whey achieved comparable ethanol yields without nutrient supplementation and at a much lower inoculum concentration (0.2 g/L), although fermentation proceeded more slowly.

Overall, the study demonstrates that each feedstock requires a specific processing strategy determined by its chemical composition and carbohydrate profile. Steam explosion substantially enhances the digestibility of lignocellulosic biomass, whereas cheese whey offers a simpler processing route because its sugars are readily fermentable after enzymatic hydrolysis of lactose.

These findings highlight the feasibility of integrating brewery, winery, and dairy residues into regional biorefinery schemes, contributing to waste valorisation, renewable solvent production, such as bioethanol, and greenhouse gas emissions reduction while supporting the development of a sustainable circular economy.

Acknowledgements

This work was carried out within the framework of the BIVALIA-CM project [TEC-2024/BIO-177], funded by the Technology Networks call of the Community of Madrid. The authors thank Cervezas La Cibeles, Bodega Bernabeleva and Lácteas del Jarama for providing the raw materials used in this study

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Poster Presentations #25

P.I.8 — Electrochemical control of CO_2 fixation and high-value biomass production in *Rhodopseudomonas*

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Keywords: *Purple phototrophic bacteria, Photoelectroautotrophy, CO_2 fixation, Bioelectrochemical systems, CoQ10*

Purple phototrophic bacteria (PPB) are emerging as promising microbial platforms for sustainable carbon capture and resource recovery due to their exceptional metabolic versatility and capacity for extracellular electron transfer. This study aimed to isolate novel electroactive *Rhodopseudomonas* strains from pig slurry and evaluate their potential for photoelectroautotrophic CO_2 fixation, biomass production, and coenzyme Q10 (CoQ10) biosynthesis, contributing to the development of bioelectrochemical systems for biogas upgrading.

Three environmental *Rhodopseudomonas* isolates (*Rp6, Rp12, and R25*) were obtained and compared with the model electroactive strain *Rhodopseudomonas palustris TIE-1*. The strains were cultivated under photoheterotrophic conditions using acetate or butyrate and subsequently transitioned to photoelectroautotrophic growth in bioelectrochemical reactors with a cathode polarized at −0.4 V vs. Ag/AgCl as the sole electron donor and bicarbonate/CO_2 as the carbon source. Biomass production, inorganic carbon fixation, electrochemical activity, and intracellular CoQ10 accumulation were evaluated.

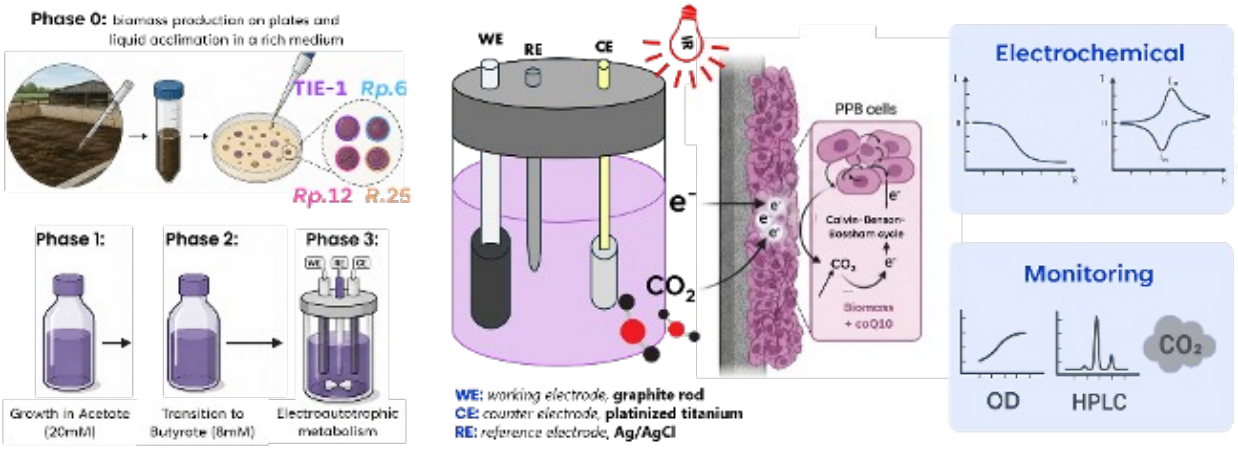


Figure 1. Experimental design for the isolation and photoelectroautotrophic evaluation of electroactive Rhodopseudomonas strains.

All four strains successfully established photoelectroautotrophic growth, demonstrating their ability to directly utilize cathode-derived electrons for CO_2 assimilation. The environmental isolates exhibited superior biomass production compared with *TIE-1*, with *Rp6* reaching up to 1.17 g dry cell weight (DCW) L^{-1}. Chronoamperometric and cyclic voltammetric analyses confirmed extracellular electron uptake in all strains, although distinct electrochemical behaviours suggested differences in electron transfer mechanisms. Cathodic current consumption was closely associated with bicarbonate availability, indicating that electron uptake was coupled to inorganic carbon fixation. Under photoelectroautotrophic conditions, *Rp6* achieved the highest CO_2 fixation, corresponding to approximately 1.18 g CO_2 L^{-1}, equivalent to the CO_2 contained in approximately 1.6 L of typical anaerobic digestion biogas.

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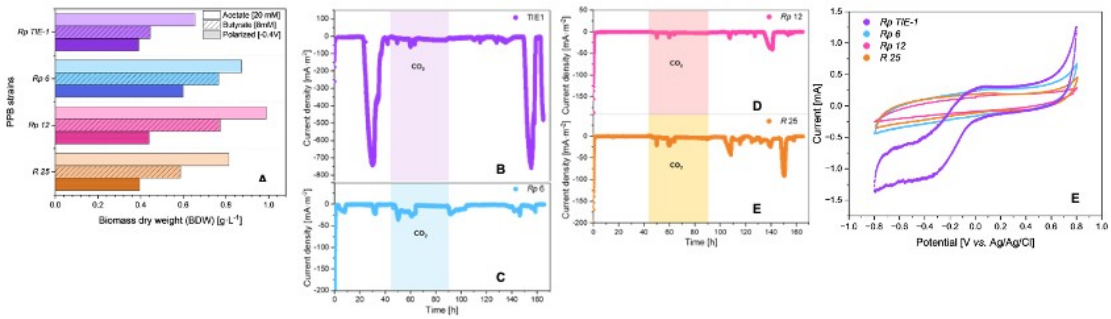


Figure 2. (A) Final biomass production, (B–E) chronoamperometric response during CO_2 feeding, and (F) cyclic voltammograms of Rhodopseudomonas strains under photoelectroautotrophic conditions.

Electrode-driven metabolism also significantly enhanced intracellular CoQ10 accumulation. Compared with photoheterotrophic cultivation, cathodic polarization increased CoQ10 content by approximately two- to three-fold in the environmental isolates, with *Rp6* reaching 7.4 mg g^{-1} DCW. These findings demonstrate that electroactivity extends beyond the model strain *TIE-1* and reveal novel *Rhodopseudomonas* isolates capable of simultaneously converting biogas-derived CO_2 into microbial biomass while enhancing the production of a high-value nutraceutical. This work establishes electroactive PPB as promising biocatalysts for integrating carbon capture, biogas upgrading, and sustainable production of food-grade biomass and valuable bioproducts within circular bioeconomy frameworks.

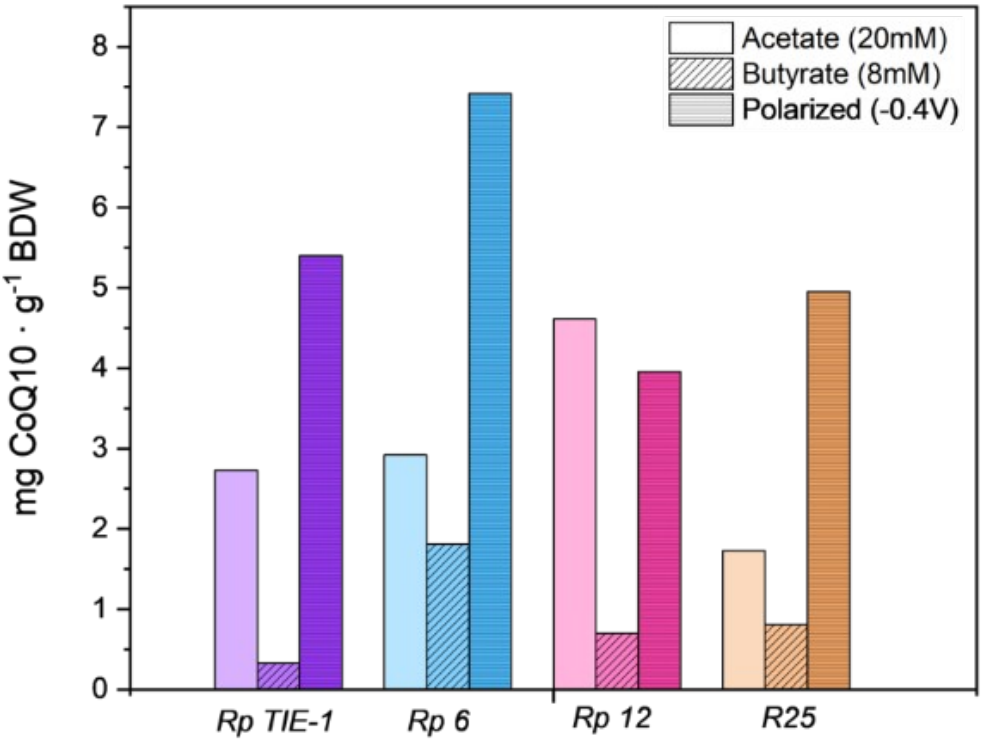


Figure 3. CoQ10 content of the Rhodopseudomonas strains under photoheterotrophic conditions (acetate 20 mM or butyrate 8 mM) and photoelectroautotrophic conditions (−0.4 V vs. Ag/AgCl).

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Poster Presentations #26

P.I.10 — Anodic polarization drives the trade-off between organic conversion and bioproduct formation in PPB photo-MECs

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Keywords: *Purple phototrophic bacteria; Wet air oxidation; Photo-bioelectrochemistry; Refinery sludge; Carotenoids*

The valorization of refinery oily sludge remains challenging due to its hazardous nature, high organic load and complex hydrocarbon-rich composition. In this work, purple phototrophic bacteria (PPB) were integrated with wet air oxidation (WAO) and photo-bioelectrochemical operation to evaluate whether anodic polarization can steer the conversion of refinery sludge-derived organics towards treatment- or valorization-oriented outputs.

WAO was first used to oxidize and solubilize high molecular weight hydrocarbons from refinery oily sludge, generating an aqueous phase suitable for PPB cultivation. This WAO effluent contained high soluble chemical oxygen demand (SCOD ≈11.4 g L^{-1}) and ammonium concentration (NH_4^+ ≈0.84 g L^{-1}) and was diluted to 33% (v/v) to reduce microbial inhibition while preserving substrate availability. The diluted stream was treated in H-type photo-microbial electrolysis cells inoculated with an enriched natural PPB culture. Graphite anodes were poised at +0.2, +0.4, +0.6 and +0.8 V vs Ag/AgCl, using platinized titanium mesh cathodes and infrared illumination. Open circuit potencial reactors (OCP) were operated as non-polarized controls.

Electrode polarization clearly modified the fate of the soluble organic fraction. After four days, SCOD removal increased from 22% in OCP to 35–43% under polarized operation. The +0.8 V condition showed the highest removal at this stage and reached the maximum overall SCOD removal of the assay at the end of the experiment (52%). In addition, final residual SCOD under polarization was 21–32% lower than in OCP, while polarized reactors maintained measurable late-stage activity after the control approached near-zero consumption. Ammonium removal was also enhanced, increasing from 12% in OCP to 27–34% under polarized conditions.

However, the potential that maximized organic conversion was not the one that maximized valorization products. Planktonic biomass reached its highest value at +0.4 V (800 ± 100 mg VSS L^{-1}), while it decreased to 660 ± 50 mg VSS L^{-1} at +0.8 V. Apparent biomass yield was 12% higher than OCP at +0.4 V but 32% lower at +0.8 V, indicating a shift from biomass formation to electrode respiration at more oxidizing potentials. Biofilm development and the carotenoid production were highest at +0.2 V.

Overall, anodic potential acted as a key operational lever in PPB photo-bioelectrochemical systems: +0.8 V promoted organic conversion and ammonium removal, whereas +0.2–+0.4 V favoured biomass formation, biofilm development and pigment-oriented valorization.

Acknowledgements

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Poster Presentations #27

P.II.1 — Hydrothermal-to-pyrolytic reconstruction of sewage sludge and garden waste-derived Fe-coupled biochar for peracetic acid activation toward sulfamethoxazole degradation

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Keywords: *Fe-coupled biochar; Hydrothermal carbonization; Pyrolysis*

Valorization of sewage sludge and garden and park waste (GPW) into functional carbonaceous materials is a promising route for coupling waste management with advanced water treatment. In this work, Fe-coupled biochars were prepared through a hydrothermal-to-pyrolytic reconstruction strategy. Sewage sludge and GPW were converted by hydrothermal carbonization at 240 °C for 1 h, with $FeCl_3 \cdot 6H_2O$ introduced as an Fe precursor under fixed input conditions. The as-recovered Fe-assisted hydrochars were subsequently pyrolyzed at 800 °C for 2 h under N_2 to preserve the real Fe-containing precursor state and promote structural reconstruction.

The non-Fe hydrothermal systems showed comparable feedstock-based yields of 53.3–54.0%, while Fe-assisted systems reached 48.4–56.8%, indicating feedstock-dependent redistribution of organic and inorganic fractions. Pyrolysis yields ranged from 39.2 to 52.0%, giving overall biochar yields of 21.2–29.5%. Elemental and ash analyses showed that sludge supplied mineral-rich matrices, whereas GPW contributed biomass-derived carbon. Textural characterization revealed that hydrochar precursors had very low BET surface areas (approximately 11 $m^2\ g^{-1}$), whereas SL+GPW-Fe/BC exhibited a markedly reconstructed porous structure with a BET surface area of approximately 430 $m^2\ g^{-1}$ and a pore volume of 0.352 $cm^3\ g^{-1}$. XRD and Raman analyses indicated the formation of Fe-related crystalline phases and defect-rich carbon domains after pyrolysis, while FTIR and SEM-EDS confirmed retained mineral-associated functionalities and heterogeneous C/O/Si/Al/P/S/Fe distributions. ICP further confirmed strong Fe enrichment in Fe-assisted biochars.

Pre-adsorption tests with sulfamethoxazole (SMX) identified 0.10 g L^{-1} catalyst dosage and 30 min pre-equilibration as suitable conditions for subsequent oxidation experiments. Overall, hydrothermal-to-pyrolytic reconstruction generated porous Fe-coupled carbon/mineral interfaces that provide a promising structural basis for future peracetic acid activation toward SMX degradation.

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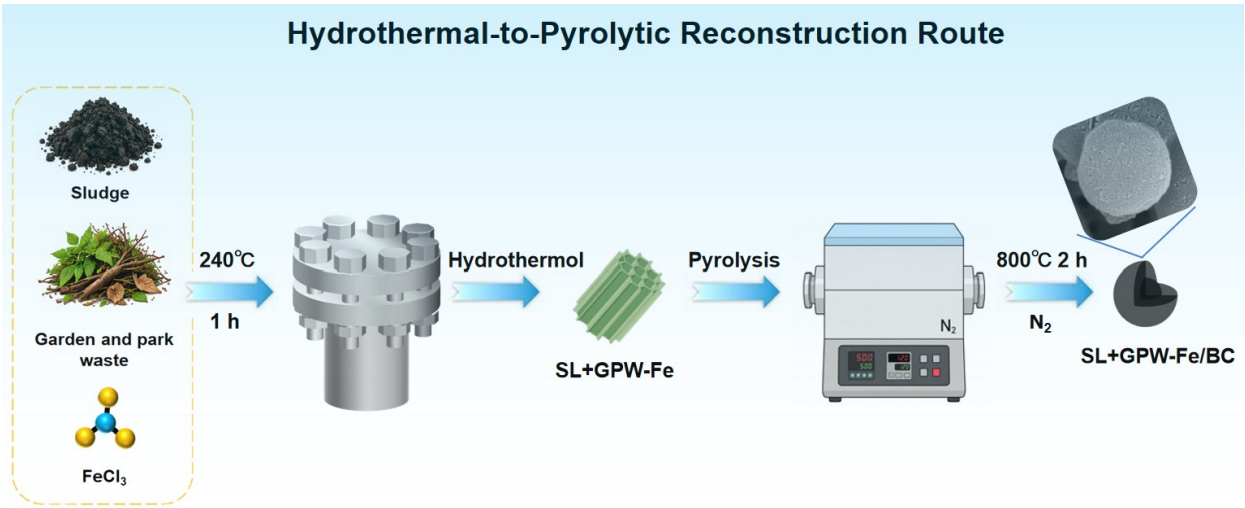


Figure 1. Material preparation process

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Poster Presentations #28

P.II.2 — Development of Ce promoted Ni/Al_2O_3 catalysts for non-thermal plasma reforming reactor

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Keywords: *ethanol, autothermal, Ni, Cerium*

Non-thermal plasma (NTP) technologies have emerged as promising alternatives for the conversion of waste-derived feedstocks into syngas under mild operating conditions. In plasma-catalytic processes, catalyst properties play a crucial role in determining product distribution, energy efficiency, and long-term stability. Within the framework of the BIVALIA project, non-thermal plasma tecnology is focused on the treatment of process streams generated during biomass valorisation. Among the different catalytic formulations, Ni-based catalysts are particularly attractive due to their high activity for hydrocarbon reforming and syngas production, as well as their relatively low cost compared with noble-metal catalysts. In this work, a series of Ni/Al_2O_3 catalysts modified with cerium were developed for application in a rotating gliding arc plasma reactor.

A first series of $Ni/CeO_2–Al_2O_3$ catalysts was prepared using γ-Al_2O_3 support modified with different ceria loadings (10 and 15 wt.% CeO_2) and a constant nickel loading of 15 wt.%. The influence of ceria content and catalyst reduction temperature (650 and 800 °C) on the physicochemical properties of the catalysts was investigated. Comprehensive characterization included X-ray fluorescence, N_2 physisorption, X-ray diffraction, temperature-programmed reduction and hydrogen chemisorption. The catalysts exhibited highly dispersed NiO and CeO_2 phases supported on mesoporous alumina, while ceria incorporation preserved the porous structure and promoted favourable metal-support interactions. Reduction studies showed the formation of metallic Ni without detectable $NiAl_2O_4$ spinel species, whereas increasing the reduction temperature slightly increased Ni particle size because of thermal sintering while decreasing metal dispersion. Catalytic performance in ethanol ATR was employed as the primary selection criterion because this reaction reproduces the key requirements expected during plasma-assisted reforming, including C–C bond cleavage, hydrogen generation, catalyst stability and resistance to carbon formation. The results demonstrated (Table 1) that the catalyst formulation containing 10 wt.% CeO_2 provided the most favourable balance between structural properties and catalytic behaviour, making it the most suitable candidate for further integration into the non-thermal plasma reactor. This screening methodology establishes a route for catalyst selection prior to plasma operation and provides the basis for the subsequent evaluation of plasma-catalytic systems dedicated to the upgrading of BIVALIA-derived process streams.

Table 1 Ethanol conversion and carbon product distribution for the autothermal etanol reforming on Ni/CeO_2-Al_2O_3 catalytsts (T=650 ºC, $EtOH/H_2O/O_2$= 1/1.8/0.6 (mol), Qt= 56.7 NmL/min, mcat=0.1 g)

	Ni/A-10Ce (R650)	Ni/A-15Ce (R650)	Ni/A-10Ce (R800)	Ni/A-15Ce (R800)
Ethanol conversion (%)	100	100	100	100
H_2 extraction (%)	66.3	66.4	62.0	65.0
	C product distribution (mol %)			
CO_2	45.0	45.7	49.2	47.6
CO	52.6	52.0	46.3	48.6
CH_4	2.3	2.4	4.5	3.8

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Poster Presentations #29

P.II.3 — Catalytic upgrading of hydrothermal liquefaction-derived biocrude from chicken carcasses and food waste for sustainable biofuel production

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Keywords: *HTL, biocrude, catalytic upgrading*

Hydrothermal liquefaction (HTL) is a promising technology for the valorization of lipid- and protein-rich residues such as chicken carcasses (CC; 52 wt.% total solids, 37 wt.% lipids and 22 wt.% protein content) or food waste (FW; 5 wt.% total solids; 18 wt.% lipids and 1 wt.% protein content) to produce a high-energy-density liquid fraction known as biocrude. HTL and co-HTL experiments were carried out in 1.8 L high-pressure batch reactor (4530 Parr, USA). HTL experiments were performed at 270-330 ºC for 60 min with 15 wt.% solids loading of CC. Co-HTL was conducted at 330 ºC for 15 and 60 min with 12.5% solids loading on a 2:3 (CC:FW) ratio on a dry basis.

Biocrude yields from HTL ranged between 62-67%, regardless of the reaction temperature. Co-HTL of FW and CC resulted in lower yields, decreasing to 40% 49% after 15 min and after 60 min of reaction. Elemental analysis revealed that the samples contained 72–75% carbon, 11.3–15.4% oxygen, and 2.2–2.7% nitrogen. Simulated fractional distillation by thermogravimetric analysis identified fuel-range fractions of interest in CC biocrudes. At 330 ºC, light fractions, primarily heavy naphtha and kerosene, accounted for up to 90% of the product distribution, whereas FW addition reduced this proportion to 75%. However, the high oxygen and nitrogen contents, together with density values of 0.943–1.013 g/mL and total acid number between 91–101 mg KOH/g, highlight the need for further upgrading before these biocrudes can be considered suitable for biofuel applications.

Therefore, catalytic upgrading is being explored as a subsequent step to promote hydrodeoxygenation (HDO) and hydrodenitrogenation (HDN) [1]. NiMo/Al_2O_3, CoMo/Al_2O_3, NiMo/n-ZSM-5, CoMo/n-ZSM-5 have been selected to assess the influence of the active metal phase on oxygen and nitrogen removal, with the aim of improving biocrude quality and compatibility with conventional refinery streams.

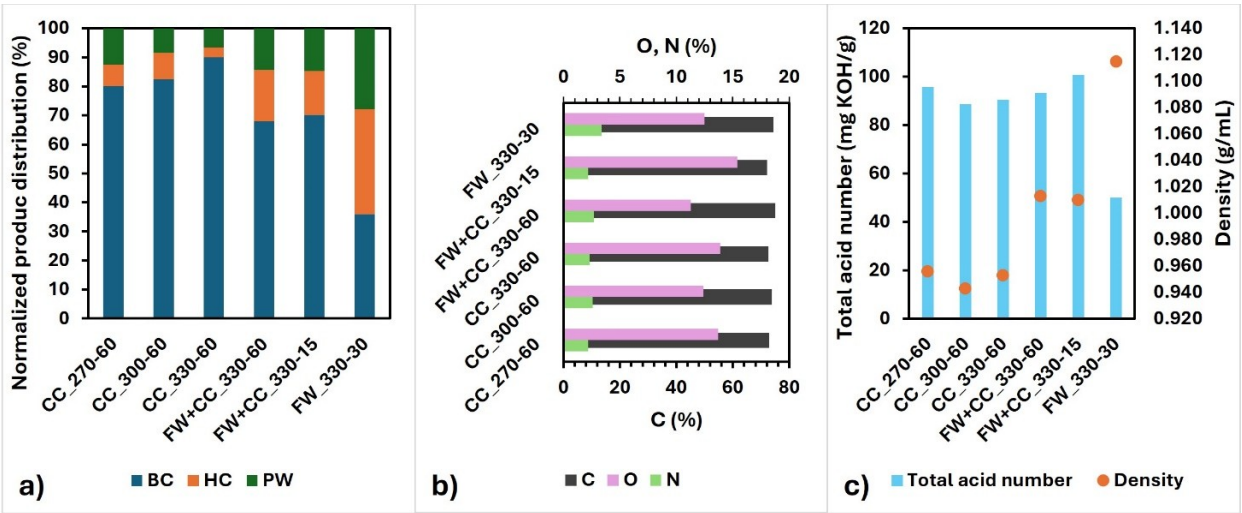


Figure 1. a) Normalized product distribution of HTL and co-HTL experiments; b) C, N and O content of biocrudes; c) physicochemical properties of the biocrudes.

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Poster Presentations #30

P.II.4 — Thermal pyrolysis of grape stalk under inert and pressurised hydrogen atmospheres: effect of reactor configuration on bio-product distribution

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Keywords: *Grape stalk; biomass valorisation; Pyrolysis; Pressurised hydrogen*

Winemaking generates 10.5-13.1 million tonnes of solid by-products worldwide each year [1]. Grape stalks are a largely underexploited lignocellulosic stream whose high lignin and cellulose content makes them an attractive renewable carbon source for the biorefineries. Pyrolysis offers a flexible, scalable route to valorise this biomass into bio-oil, gas, and biochar.

Grape stalks from a local Madrid winery (volatile matter ~65 wt.%, ash ~5 wt.%) were pyrolysed in upflow (UF) and downflow (DF) fixed-bed configurations at 550 °C, comparing two atmospheres: inert nitrogen at atmospheric pressure (1 bar/N_2) and pressurised hydrogen (6 bar/H_2).

The main product yields are presented in Figure 1A. In the UF, changing the atmosphere slightly affected the product distribution, reducing char formation in favour of gas production. Under 1 bar/N2, the DF yields ~19 wt.% bio-oil, over three times the UF value, owing to shorter vapour residence time minimising secondary cracking. Nevertheless, the undetected GC-MS fraction under DF/N2 (Figure 1B-inset), reaches the largest value across all conditions, consistent with significant lignin-derived oligomer formation. Pressurised H2 (6 bar) in DF reactor, strongly suppresses this advantage, converging bio-oil yields to ~6 wt. %, while promoting partial deoxygenation and hydrocracking of heavy oligomers into lighter detectable compounds, mainly gas. Oxygenated aromatics (O-AR), though minor, appear only in the DF, suggesting that the shorter vapour residence time preserves these primary lignin-derived products, which under the longer UF contact are likely further deoxygenated or repolymerised into heavier, GC-undetectable fractions. Overall, N2 in DF maximises bio-oil along with acids, light oxygenates, and furans, pressurised H2 shifts conversion towards lighter products and nearly eliminates furans via hydrodeoxygenation. This demonstrates that atmosphere and reactor configuration act as complementary levers for tailored bio-product distributions from grape stalks.

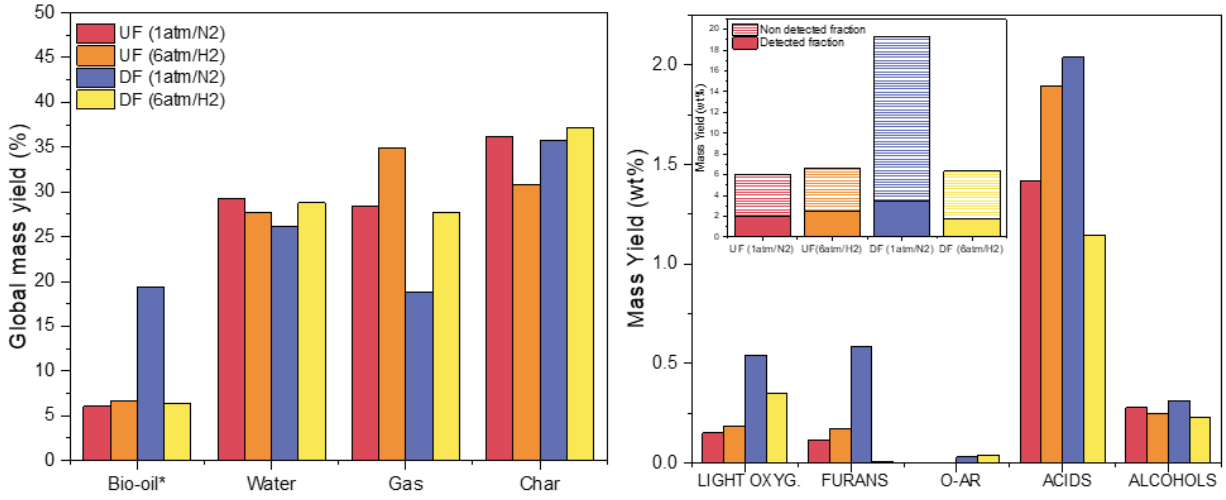


Figure 1. Global bio-oil, water, gas and char yields (a) and bio-oil fraction yields by GC-MS (b) for all four pyrolysis conditions.

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Poster Presentations #31

P.II.5 — Effect of synthesis route of Mg-modified biochar from lignocellulosic residues for adsorption of nitrate in aqueous phase

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Keywords: *Biochar, lignocellulosic residue, adsorption*

The increasing presence of nitrogen and phosphorus compounds in wastewater poses a significant challenge for treatment processes and sustainable water resource management. In this context, electroadsorption processes using biochar and biochar-based electrodes derived from lignocellulosic residues emerge as a promising alternative.

Adsorbents were synthesized from pine residues and walnut shells using $MgCl_2$ and $MgCO_3$ as modifying agents. Two different synthesis routes were evaluated: (i) direct impregnation followed by thermal treatment (500–700 ºC) under an inert atmosphere, and (ii) a sequential treatment consisting of a N_2 pyrolysis at 500 ºC, followed by impregnation and subsequent thermal activation at 800 ºC under an inert atmosphere (N_2). The activating agent-to-biomass ratio ranged from 0.5:1 to 1.5:1. The resulting materials were characterized by ICP, N_2 adsorption–desorption isotherms, and TGA. The analyses confirmed the effective incorporation of Mg, the development of microporosity, and an ash content between 9.9 and 23.9 wt.%, indicating the presence of mineral species in the biochar.

The functionality of the materials was evaluated through batch adsorption experiments (24 h, 25 ºC, 180 rpm) using synthetic nitrate solutions (KNO_3) at initial concentrations of 50 and 100 mg NO_3^-/L. The first synthesis route did not show the expected performance, exhibiting negligible adsorption capacity. In contrast, the sequential route proved to be effective with the three biochars prepared from pine residues using an activating agent-to-biomass ratio of 0.5: $MgCl_2$-impregnated biochar (P_$MgCl_2$), $MgCO_3$-modified biochar (P_$MgCO_3$), and a non-modified reference biochar (P) (Figure 1).

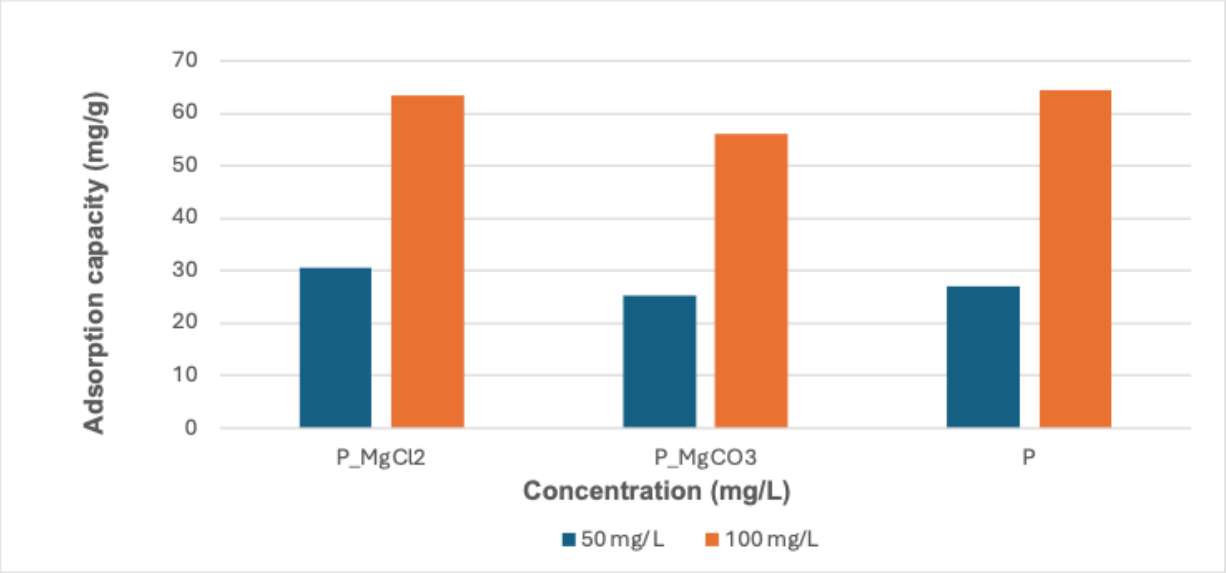


Figure 1. Adsorption capacity.

These results indicate that nitrate adsorption is not solely governed by Mg incorporation or ash content, but rather by the accessibility of active sites and the structural properties of the biochar. Although $MgCl_2$-

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modified biochar showed slightly better performance at lower concentration, the non-modified biochar exhibited comparable results at higher concentration, while the use of $MgCO_3$ precursor consistently showed lower adsorption capacity.

These findings demonstrate that optimizing synthesis and activation conditions is crucial for enhancing material performance. Furthermore, they highlight the potential of biochar derived from lignocellulosic waste as a sustainable, efficient, and low-cost solution for wastewater treatment.

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Poster Presentations #32

P.II.6 — Supercritical CO_2 extraction of astaxanthin from *Faxonius limosus* shells: a valorisation approach

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Keywords: *astaxanthin; supercritical fluid extraction;* Faxonius limosus*; valorisation*

Faxonius limosus is an invasive alien species that was first recorded in Serbia in the Danube River near Apatin in 2002 and has continued to spread rapidly since then. As it poses major invasive potential due to its ability to carry crayfish plague, which is lethal to native crayfish species, there is an urgent need for measures to control its spread. One potential approach is the valorisation of its shell through the recovery of high-value bioactive compounds such as astaxanthin. Following meat separation, a considerable amount of shell remains as a by-product, representing a potential source of valuable compounds. In this study the potential of supercritical fluid extraction (SFE) for astaxanthin recovery from *F. limosus* shell was investigated. After the meat separation, the shells were dried at 50 °C for 16 h (2 × 8 h) ground and subsequently milled. The milled material was further pretreated using a bead beater to improve astaxanthin recovery. Astaxanthin was extracted by supercritical CO_2 extraction using a laboratory-scale high-pressure extraction plant. The extraction temperature (40, 50 and 60 °C) and CO_2 flow rate (0.2, 0.3 and 0.4 kg/h) were varied, while the pressure was kept constant at 400 bar. The highest astaxanthin concentration (125.22 µg/g) was obtained at 60ºC and a CO_2 flow rate of 0.4 kg/h, while a comparable concentration (124.75 µg/g) was obtained at 60 °C and 0.2 kg/h. These results demonstrate the potential of SFE for the recovery of astaxanthin from *F. limosus* shell and support its valorisation as a valuable source of this carotenoid. Further research should focus on optimising the extraction conditions and developing an appropriate encapsulation technique to improve astaxanthin stability.

Acknowledgements

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Poster Presentations #33

P.III.1 — Techno-economic assessment of microbial oil and carotenoids production from horticultural residues

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Keywords: *oleaginous yeast; carotenoids; agri-food residues*

Intensive greenhouse horticulture generates large amounts of organic residues, mainly from vegetables that do not meet fresh market or processing industry requirements. The valorisation of these residues as feedstock for bioenergy and bioproduct production represents a promising strategy within a circular bioeconomy framework. In this context, biorefineries based on oleaginous yeasts are gaining interest for the production of microbial oils and high-value compounds [1]. However, vegetable residues usually present a low C/N ratio, which limits lipid accumulation. Therefore, the addition of an external carbon source is often required to improve lipid production. Lignocellulosic residues, such as urban pruning waste (PW), are particularly attractive due to their high carbon content, low cost and availability.

In this work, a biorefinery process for the production of microbial oils and carotenoids from vegetable residues (VR) and PW was assessed from a techno-economic perspective using the oleaginous red yeast *Rhodosporidium toruloides*. In the proposed process, VR is crushed and separated into a liquid fraction rich in glucose and fructose and a solid fraction mainly composed of glucans. In parallel, PW is pretreated by steam explosion, yielding a water-insoluble solid (WIS) fraction rich in glucan and lignin, and a xylose-rich liquid prehydrolysate. The solid fractions from both feedstocks are enzymatic hydrolysed, filtered to remove residual solids and mixed with the prehydrolysate. A pulse-feeding strategy was considered for fermentation to improve the use of sugar-rich streams. After fermentation, yeast cells are harvested, disrupted and processed through ethanolic KOH saponification, hexane extraction and evaporation to recover carotenoids, while the lipid fraction is obtained by acid neutralisation of fatty acid salts.

The process was modelled in Aspen Plus v14.0 using experimental data obtained at CIEMAT, with the aim of generating the mass and energy balances required for techno-economic evaluation. The results showed promising economic performance compared with conventional vegetable oils. Nevertheless, electricity consumption in the fermenters, mainly associated with aeration and agitation, was identified as the main contributor to operating costs. Therefore, optimisation of the fermentation stage, particularly aeration requirements and residence time, is essential to improve the overall economic viability of the process.

Acknowledgements

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Poster Presentations #34

P.III.2 — Beyond technology: how media narratives shape the social acceptance of biorefineries

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Keywords: *Social acceptance, renewable energy, energy transitions, media discourse, communication power, biorefinery, democratic legitimacy, energy policy*

The successful deployment of biorefineries depends not only on technological performance and economic feasibility but also on their social acceptance. Research on renewable energy acceptance has progressively demonstrated that public perceptions are shaped by social, institutional, and communicative factors rather than by technology alone [1]. Media narratives therefore play a central role in framing benefits, risks, and stakeholder legitimacy, influencing how citizens perceive renewable energy infrastructures [2,3].

This study examines how Spanish digital media portray biorefineries and how these narratives contribute to the construction of public acceptance or resistance. A mixed-methods approach was applied to a corpus of 350 digital news articles covering 88 biorefinery projects published between 2019 and 2024. Data were collected through the social listening platform Onclusive Social and complemented by manual validation. The analysis combined qualitative discourse analysis with statistical techniques, including logistic regression and cluster analysis, to identify relationships between media actors, narrative frames, geographical contexts, and public sentiment.

The findings reveal that media discourse is strongly influenced by the actors who dominate the communication process. Corporate and institutional actors are substantially more visible than citizen organizations, resulting in narratives that primarily emphasize economic development, technological innovation, and sustainability benefits. These frames are consistently associated with positive media coverage. Conversely, narratives centred on environmental impacts and health concerns are mainly promoted by local communities and are significantly associated with negative sentiment, particularly in rural areas where biorefinery projects are located. These results reinforce previous studies highlighting the importance of procedural justice, place attachment and community participation in renewable energy acceptance [4,5].

Building on these findings, the study proposes the Communicative Hegemony Model in Energy Transition (CHMET), a conceptual framework explaining how asymmetries in media visibility influence the social legitimacy of renewable energy infrastructures. The model integrates perspectives from the political economy of communication [6], communication power [2], and social acceptance research [1] to explain how dominant narratives and counter-publics shape public debate around biorefineries.

The results suggest that communication should be integrated into the planning and governance of circular bioeconomy initiatives from their earliest stages. Transparent communication, independent scientific information, participatory processes, and balanced media representation can strengthen trust, reduce conflict, and improve the long-term legitimacy of biorefinery projects. The proposed framework offers practical guidance for researchers, policymakers, industry, and communication professionals seeking to enhance the social sustainability of circular economy innovations.

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Poster Presentations #35

P.III.3 — De-risking investments and maximizing energy output in advanced Waste-to-Energy (WtE) and Waste-to-Hydrogen (WtH) infrastructure

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Keywords: *advanced Waste-to-Energy (WtE), Waste-to-Hydrogen (WtH), torrefaction technology, Sustainable Waste-to-Energy Solutions*

The transition to a circular economy requires technologies that can convert waste streams into reliable resources while reducing environmental impact and improving project viability. Tokef Energia develops advanced engineering and consulting solutions for waste-to-energy and biomass conversion, with a focus on gasification and torrefaction technologies. Our approach addresses one of the most persistent challenges in circular systems: how to transform heterogeneous, underutilized feedstocks into high-value energy products at industrial scale.

Our gasification expertise supports the conversion of municipal solid waste, agricultural residues, commercial biomass, and mixed plastics into synthesis gas, biohydrogen, electricity, and heat.

We will present our own Advanced Gasification with Waste-to-Hydrogen (WtH) technology, led by our business partner Dr. Hector A. Ruiz, where thermochemical conversion without complete combustion produces clean Synthetic Gas (Syngas) and Biohydrogen with zero-leaching ash and net-zero carbon footprint.

Our methodology rests on three pillars: engineering precision, vendor neutrality, and lifecycle support.1. Deep Technical Expertise Our scientific consultants are field-tested engineers, not just theorists. We design systems that bridge the gap between academic potential and commercial scale. 2. Vendor-Neutral Advice We hold no exclusive ties to specific equipment manufacturers. Our technology selection is driven solely by your unique feedstock profile and RoI goals.3. End-to-End Support From the initial concept and feasibility models to commissioning and day-to-day operations, we remain a persistent partner throughout the asset lifecycle. We are the essential bridge:

combining the rigorous expertise of elite engineers with the risk- mitigation mindset of top-tier consultants to transform global waste into guaranteed yield; thereby we help partners turn waste management challenges into sustainable infrastructure and resilient revenue streams.

In parallel, we are advancing torrefaction technology and projects that upgrade biomass into a denser, more stable, and transportable solid fuel, improving logistics and expanding its commercial use. Together, these technologies create flexible pathways for resource recovery and renewable energy generation.

We also focus on solving the operational and financial risks that often prevent successful circular economy projects. We provide vendor-neutral engineering support, detailed feedstock assessment, feasibility studies, FEED engineering, and lifecycle project assistance to help clients reduce uncertainty, avoid technology lock-in, and improve long-term performance.

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