Tailored Technologies for Resource Recovery from Complex Streams

ReLEAF LANDFEED

ESNI-NERM
28-29 April 2026 Brussels & hybrid

Tailored Technologies for Resource Recovery from Complex Streams

This workshop will showcase innovative approaches to recovering valuable resources from complex bio-waste streams, drawing on real-world applications from the **RELEAF** and **LANDFEED** projects. Participants will explore how urban food waste, sewage sludge, fish processing residues, and other agricultural by-products as olive oil waste can be transformed into advanced bio-based fertilisers.

Technologies under discussion include enzymatic treatments, twin-screw extrusion, fermentation and hydrolysis processes. These methods enable the production of organic and inorganic fertilisers, a portfolio of different types of biostimulants and microbial biomass.

15:45-16:00	Welcome and introduction of **RELEAF** and **LANDFEED** projects: tailored technological approaches for differing secondary nutrient sources (Miriam Pinto – NEIKER and Laura Pérez – LEITAT Technological Center)
16:00 – 16:50	From Residues to Resources in practice: **RELEAF** and **LANDFEED** Case Studies in Advanced Bio-Based Fertiliser Production (8+4 mins for questions/ each) • Turning Olive Mill Waste into Resources: A Demonstration of Circular Fertiliser Production (Elli Maria Barampouti - National Technical University of Athens) - LANDFEED • Biostimulant production through solid-state fermentation: Organic waste valorisation (Jana Font i Pomarol – Autonomous University of Barcelona and AERIS) - RELEAF • Transformation of animal waste into bio-based fertilizers by twin-screw extrusion combined to enzymatic hydrolysis (Julien Lequitte – National Polytechnic Institute of Toulouse) - LANDFEED • Valorization of fish wastewaters and fish waste to produce microbial biostimulants (Francesca Patrignani - Alma Mater Studiorum-University of Bologna) - RELEAF
16:50-17:15	General discussion and wrap up: Designing and Implementing Processing for Complex Bio-Waste Feedstocks (25 mins)

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This project is supported by the *CBE JU* and its members. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the funding body. Neither the European Union nor the granting authority can be held responsible for them. Project number 10115699

LANDFEED

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Valorising waste streams to produce safe, sustainable, and efficient bio-based fertilisers.

"Tailored Technologies for resource recovery from Complex Streams"

ReLEAF project

Laura Pérez – Leitat Technological Center

ESNI-NERM 2026 Conference, 28th April 2026

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Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

This project has received funding from UK Research and Innovation (UKRI)

Project basic info

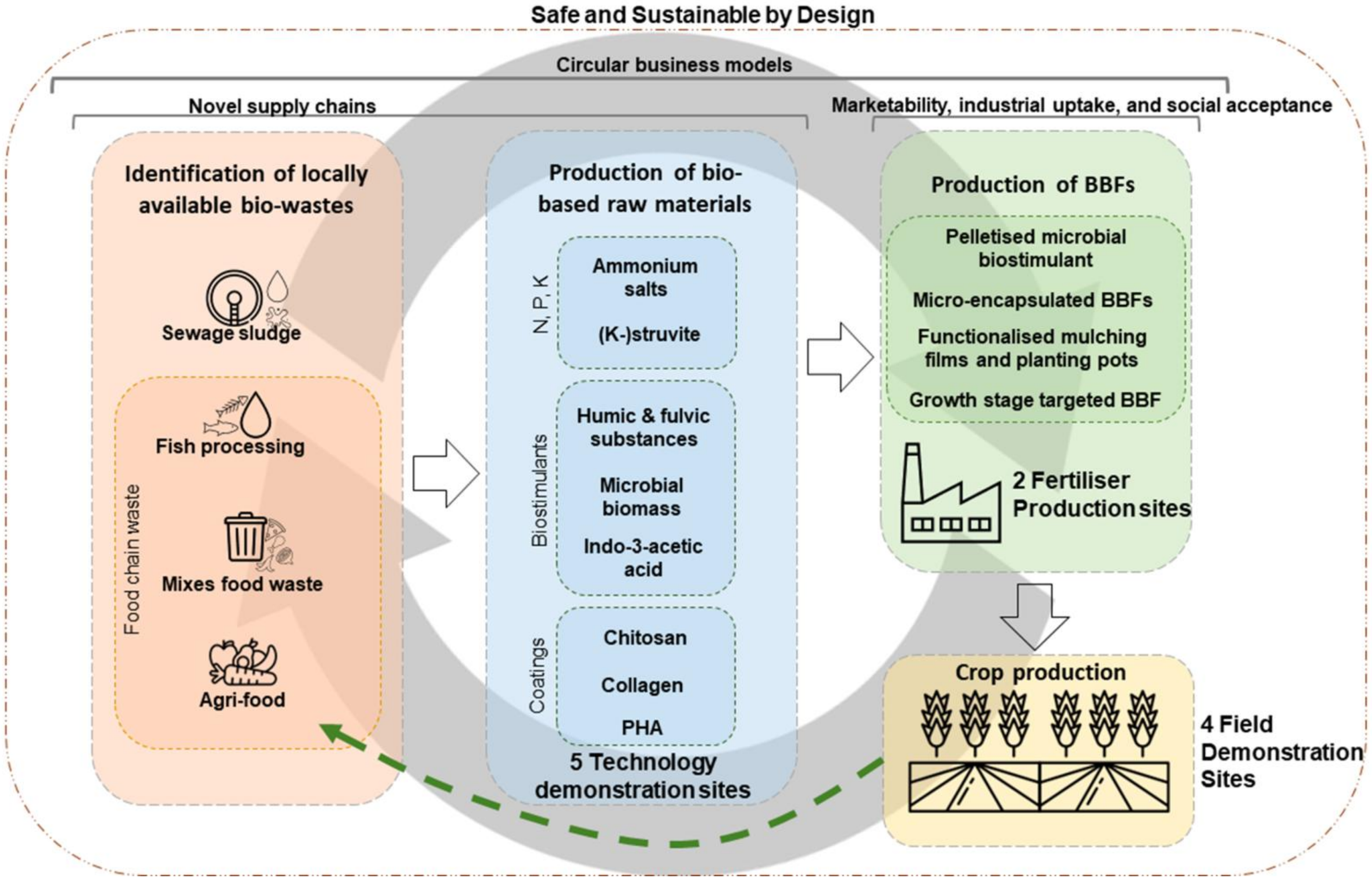
- **Project acronym:** ReLEAF
- **Project number:** 101156998
- **Programme:** Horizon Europe – CBE JU
- **Type:** Innovation Action - Demonstration
- **Duration:** 48 months
- **Project period:** 1st June 2024 – 31st May 2028
- **Total budget:** ~€7.7 M
- **CB JU contribution:** ~€6.5 M
- **Call identifier:** HORIZON-JU-CBE-2023

Coordinator & Consortium

- **Coordinator:** LEITAT (Spain)
- **Consortium:** 17 partners (EU + associated)
  - RTOs & Universities (~46%)
  - Industry (fertilisers, waste, agri-food)
  - SMEs & NGOs
- **Countries represented:**
  - Spain
  - Italy
  - France
  - Portugal
  - Poland
  - Netherlands
  - Austria
  - UK
  - Switzerland
- **Strong value chain coverage:** waste suppliers → technology developers → fertiliser producers → end-users

Project concept

- **Core idea:** Valorisation of bio-waste streams into **bio-based fertilisers (BBFs)**
- **Target waste streams:**
  - Sewage sludge
  - Fish processing waste
  - Food waste
  - Agri-food residues
- **Approach:**
  - Extraction of fertiliser ingredients
  - Formulation of BBFs
  - Demonstration + field validation
- **Goal:** circular, local, and sustainable fertiliser production



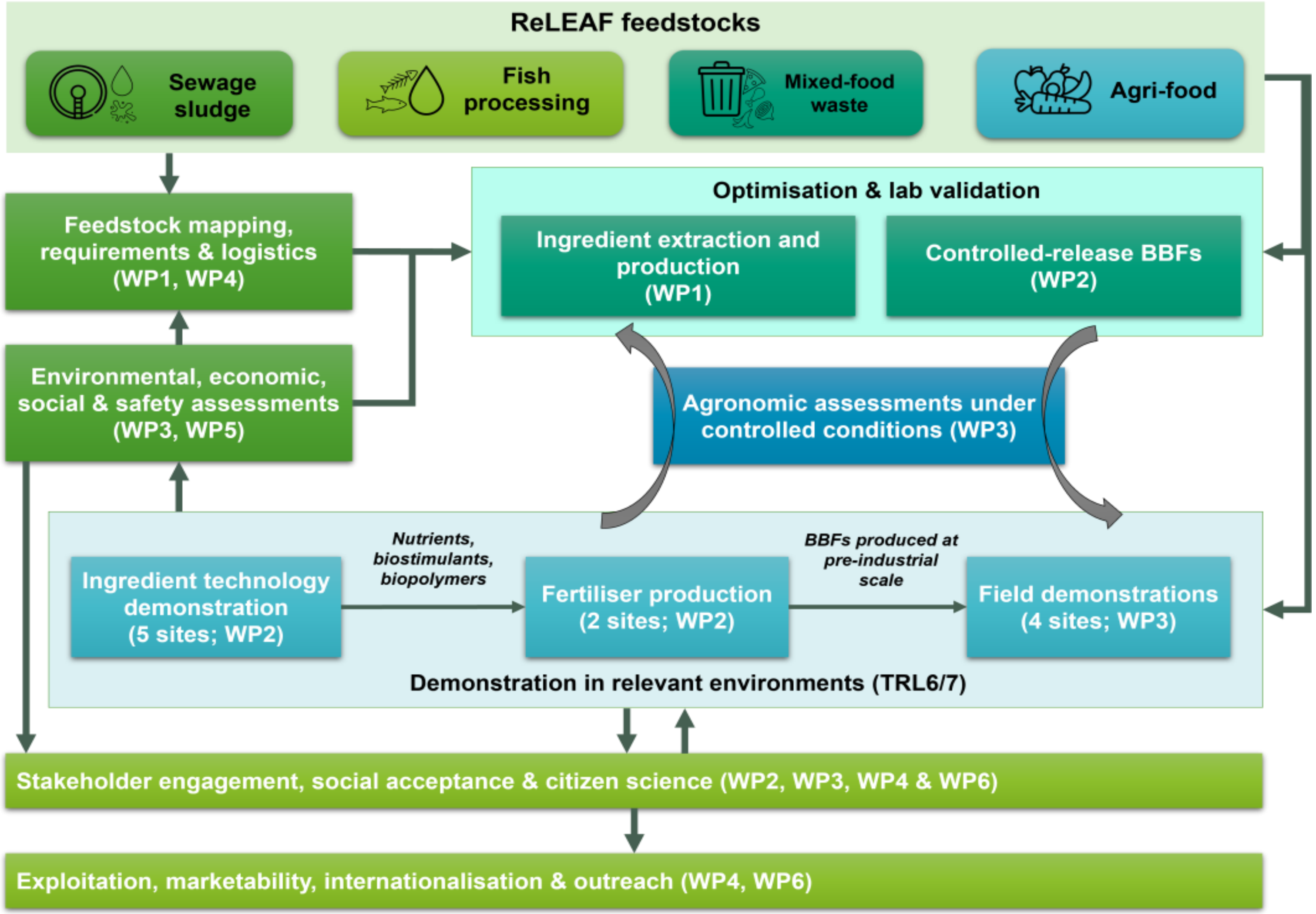
Objectives

- **Increase nutrient recovery** from selected bio-waste streams by up to 70% through optimized, innovative technologies for fertilizer ingredient production.
- **Prevent microplastic contamination** in soil through advanced bio-based, biodegradable, and biocompatible coatings for Controlled-Release Fertilizers (CRFs), ensuring safety for soil microbiome.
- **Reduce nutrient losses** by up to 60% and lower soil nutrient inputs by up to 30% via pre-industrial production of controlled-release, growth-stage targeted, and biostimulant-enhanced BBFs.
- **Develop local, cost-effective supply chains** for BBF production, increasing resource efficiency and reducing reliance on imports by up to 20%.
- Engage stakeholders through a transdisciplinary, multi-actor approach, promoting industrial adoption and social acceptance.
- **Accelerate the transition** towards sustainable, bio-based fertilizers.

Overall methodology

- **ReLEAF is structured into 7 WPs:**
  - WP1–3: Technical development & validation
  - WP4–5: Value chain & sustainability
  - WP6–7: Dissemination & management

- **2 Fertilizer production sites**
- **4 Field demo sites**
- **5 Technology demonstration sites**



Expected outcomes

- **Affordable and sustainable fertilizers** available across the EU.
- **Safe and efficient bio-based fertilizers** supporting the shift to a circular economy and sustainable agriculture.
- **Replace conventional fertilizers** with bio-based alternatives, closing nutrient cycles and creating regional value chains.
- **Innovative delivery systems** for sustainable, controlled-release bio-based fertilizers.
- **Significant progress** towards the goals of the R&I Mission, “A Soil Deal for Europe.”
- **Promote social acceptance** of circular, bio-based solutions and products.

ReLEAF

Valorising waste streams to produce safe, sustainable, and efficient bio-based fertilisers.

www.releafproject.eu

@ReLEAF Project EU

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Bio-based Industries Consortium

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LANDFEED

Unlocking efficient bio-based fertilsers for soil sustainability from underutilized side streams

Tailored Technologies for Resource Recovery from Complex Streams

RELEAF-LANDFEED Joint Session

ESNI-NERM 2026

Miriam Pinto(NEIKER)

Brussels, 27th of April, 2026

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Bio-based Industries Consortium
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LANDFEED: Unlocking efficient bio-based fertillsers for soil sustainability from underutilized side streams

LANDFEED

- Funded under HORIZON-JU-CBE-2023-IA-02 with a total cost of 8 million € and a CBE JU contribution: 6.5 million €
- Duration: September 2024 – October 2028
- Consortium: 21 partners (10 RTOs, 5 SMEs, 4 large companies and 2 Non-profit organizations)
- Feedstock: Olive mill, whey, HORECA, animal wastes as representatives of underexploited feedstocks
- Main products: Biobased fertilisers, biostimulants, and new delivery systems for fertilisers
- Objective: Integrate industrial waste valorisation into the fertiliser value chain by developing innovative bio-based fertilisers tailored to crop needs and farming practices.
- Key aspects:
  - First-of-its-kind technological approach to valorise underexploited bio-wastes into competitive bio-based fertilisers (WP1&2)
  - Nutrient efficiency enhancement by preventing loses and reduced resource dependency (WP3 &4)
  - Foster innovation ecosystems and multi-actor platforms to strengthen collaboration across the fertiliser value chain and policy innovation (WP5, 6 & 7)

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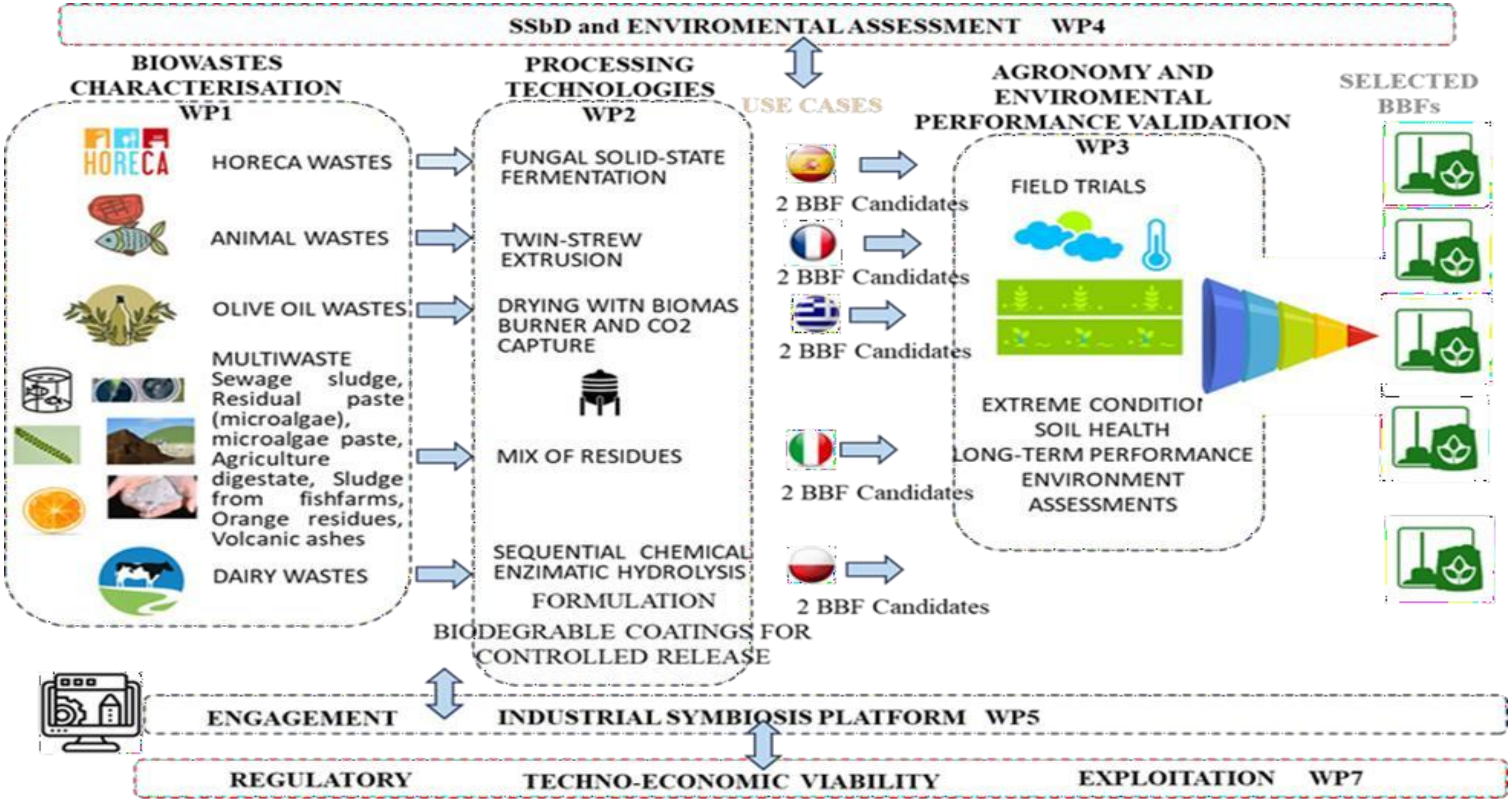
What is key in LANDFEED?

- 5 Use Cases (incl. logistic strategies and processing)
- 10 BBFs + 2 delivery systems for controlled release
- Agronomic efficiency and safety demonstration
- Sustainable by design approach through 1 Industrial symbiosis platform + 1 Digital product passport tool
- Regulatory compliant products
- Construction of profitable business models
- 5 Living labs/ communities of practice
- Strengthen innovation environment through strategic collaborations

How do we approach the work?



Technological innovation: 5 Use Cases in LANDFEED

LANDFEED

Industrial symbiosis approach

Including: sewage sludge (urban and industrial), aquaculture sludge, agricultural digestate, Orange waste, volcanic ash

Processes optimized at laboratory and scaling-up starting now…

The LANDFEED products

- Organic fertilisers rich in amino acids and peptides with biostimulant activity
- Liquid biostimulants
- Inorganic fertilisers
- Controlled release fertilisers through encapsulation and coating approaches
- Tailored formulations

Assessments ongoing for processes and products:

- SSbD at manufacture and application stages (safety, environmental and economic sustainability)
- Agronomic performance and effect on soil health
- Regulatory assessment (European and National)

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LANDFEED approach for Stakeholder engagement and strategic collaborations

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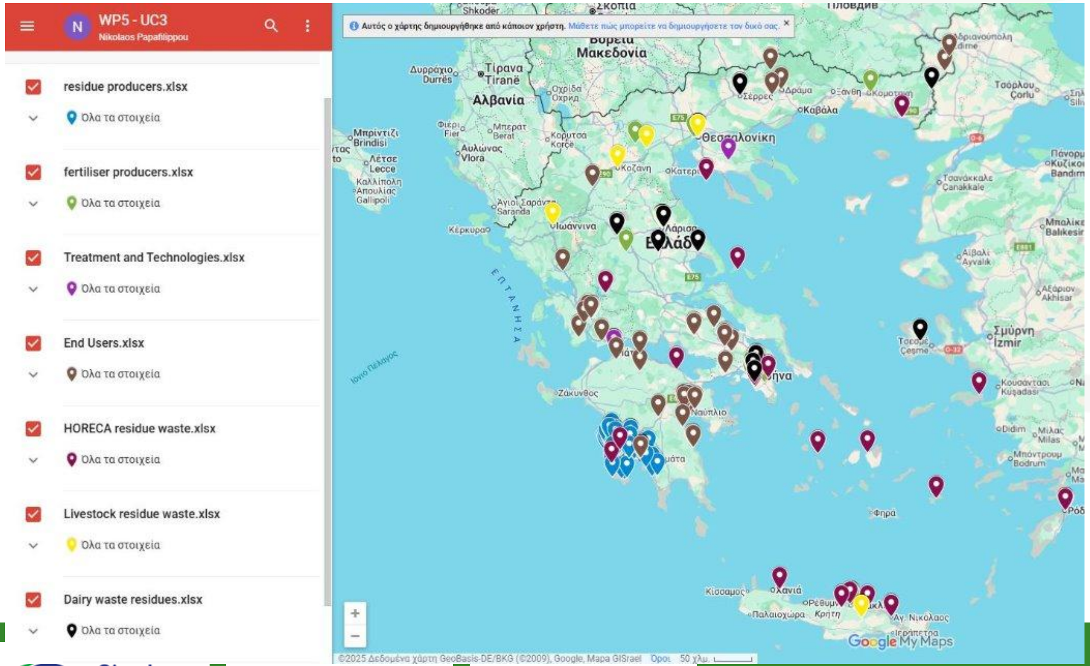
Stakeholder engagement

- Stakeholders mapped in the 5 UC regions
- **Industrial symbiosis** working tables
- Construction of **communities of practice** and **Living Labs**



Strategic collaborations with other projects:

- Active participation in Biorefine Cluster Europe and ESNI community
- Joint sessions with sister and other fellow projects aiming for dissemination and collaboration

Upcoming events…

Joint session with fellow projects (contact us!)

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Thank you!

Miriam Pinto

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https://www.landfeed.eu/

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National Technical University of Athens
School of Chemical Engineering
Unit of Environmental Science & Technology

Turning Olive Mill Waste into Resources: A Demonstration of Circular Fertiliser Production

E.M. Barampouti*, S. Mai, K. Moustakas

ESNI-NERM
28-29 April 2026 Brussels & hybrid

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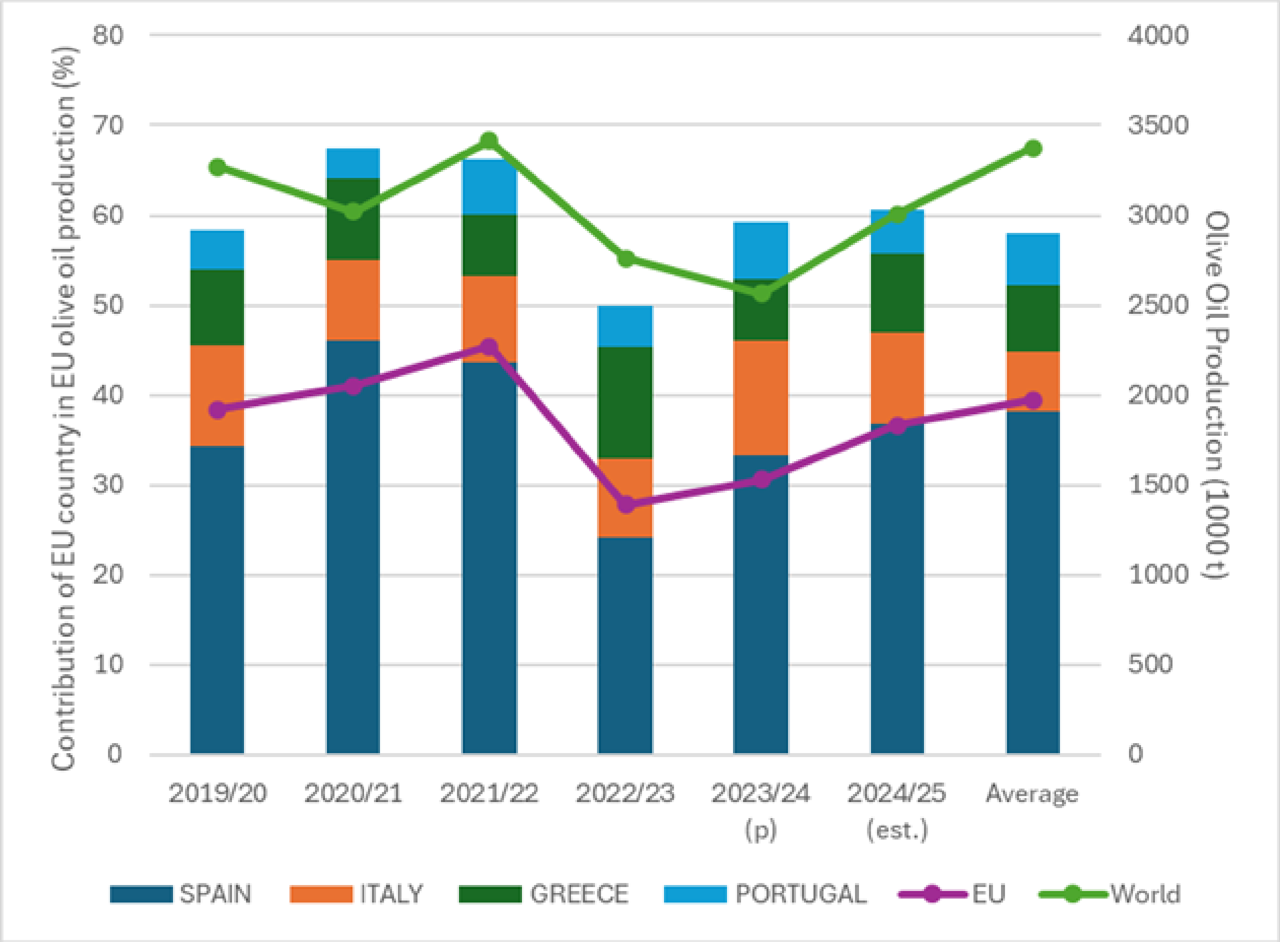
Olive Oil Production in the EU

Main EU olive oil producers



Olive oil production in the EU and globally and contribution of main EU oil producer countries in the EU

Production of Olive Oil

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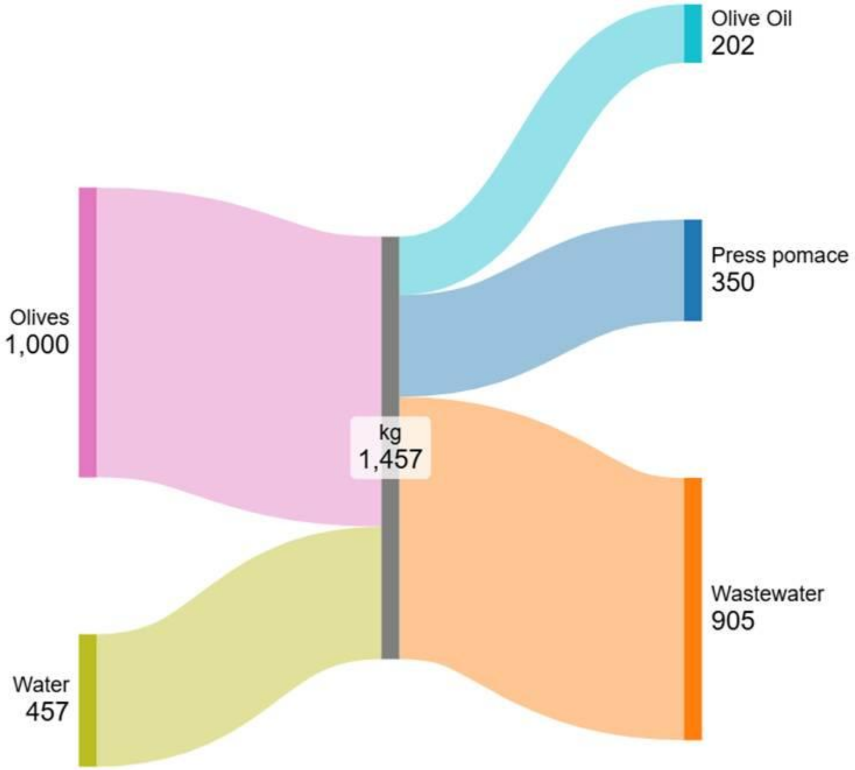
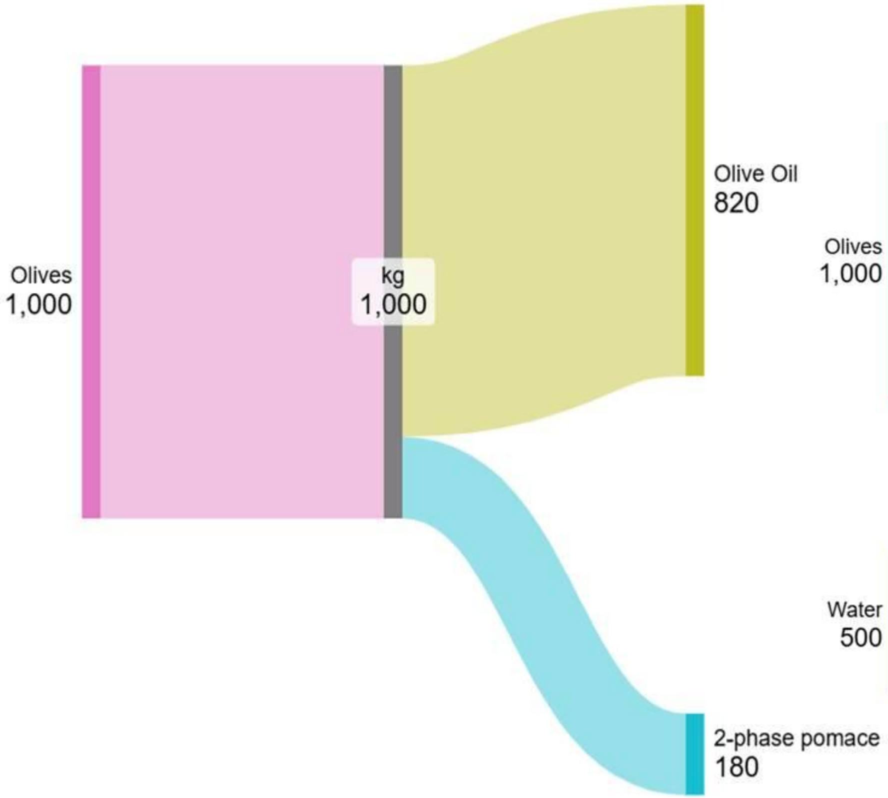
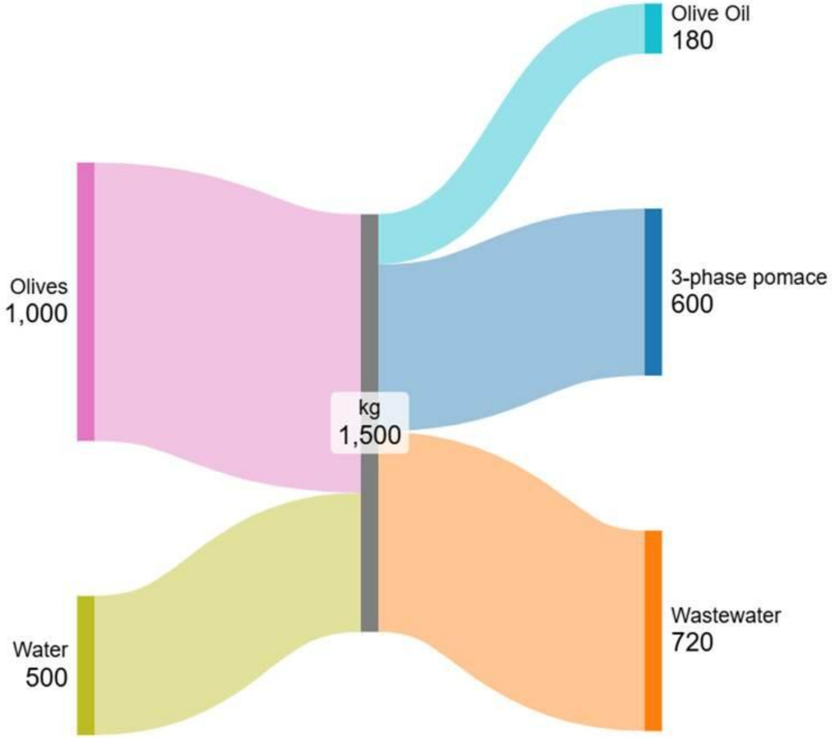


Olive pressing process



2-phase Olive mill



3-phase Olive mill

Olive pomace

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Extraction process affects moisture, nutrients & phenolics

Two-phase pomace = wetter, richer in organics & phenolics

Three-phase pomace = drier, less nutrient-rich

Climate conditions (rainfall, temperature, sunlight) influence oil yield & phenolic profile

High moisture → harder to transport & valorize

Physicochemical and Mineral Composition

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Physicochemical properties:

- pH: 4.8–5.6
- Dry matter: 23–44%
- Volatile solids: ~95%
- Total organic carbon: 65%
- Total nitrogen: 1.1%
- Oil content: 15% (avg) → supports bioenergy potential

Mineral content:

- K: 8,620 mg/kg | Ca: 1,516 mg/kg | Mg: 347 mg/kg
- Cu: 4.1 mg/kg | Zn: 10.6 mg/kg | Mn: 6.4 mg/kg

Heavy metals: below detection limits

Phenolic compounds: 2,800 mg/kg → balances antioxidant potential & phytotoxicity

Concept – Circular biofertiliser model

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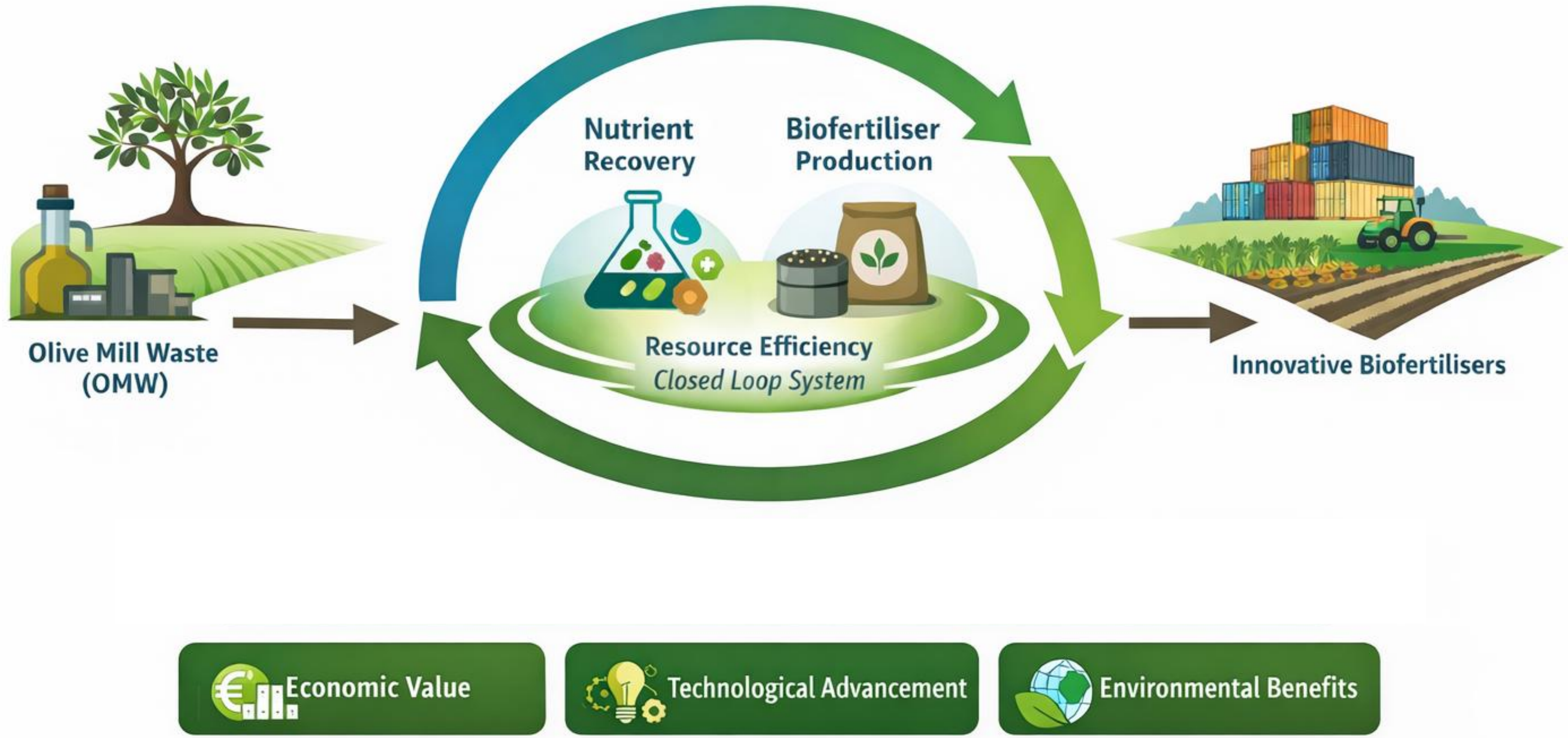
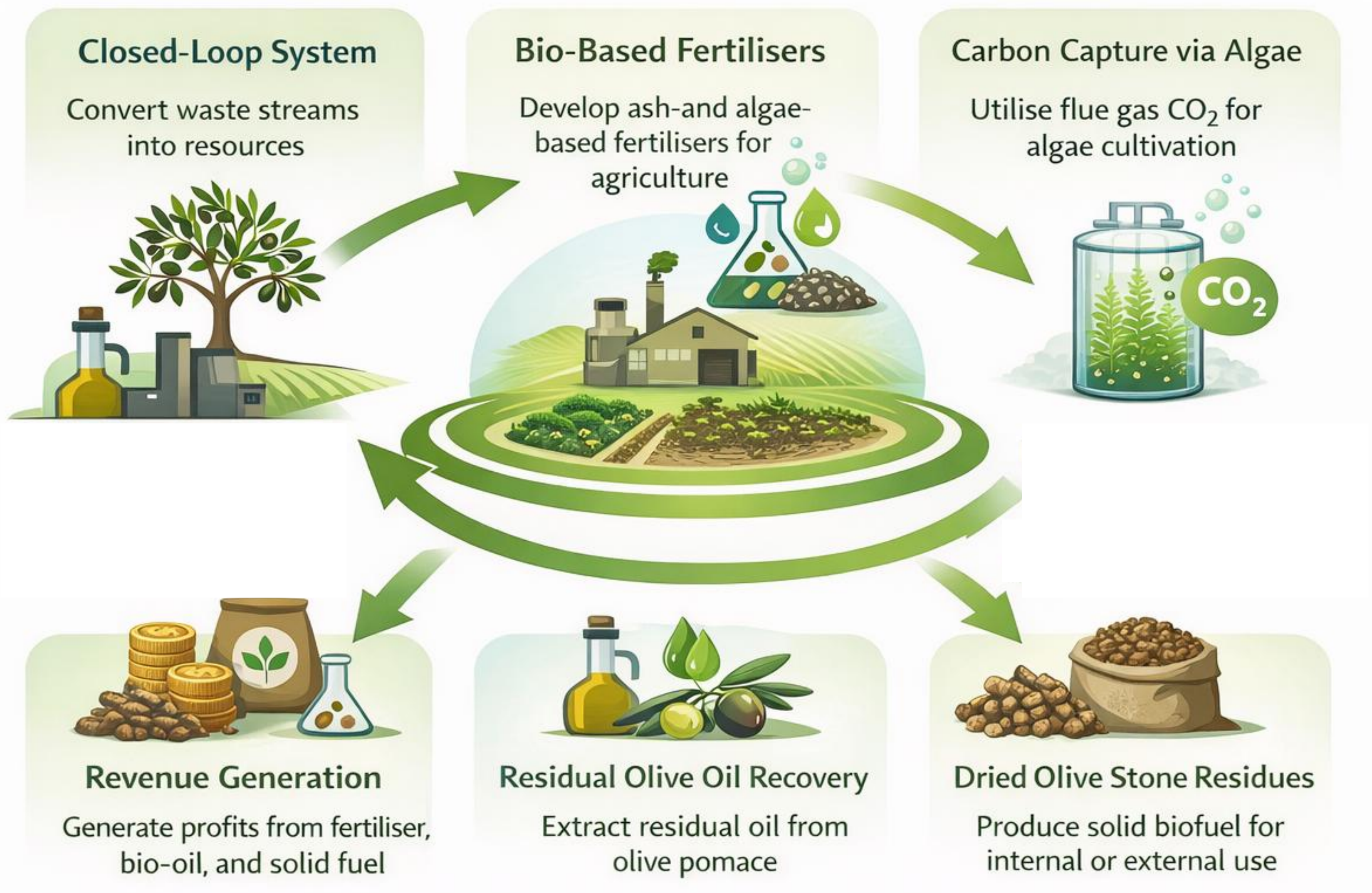


Key points of concept



Process Overview

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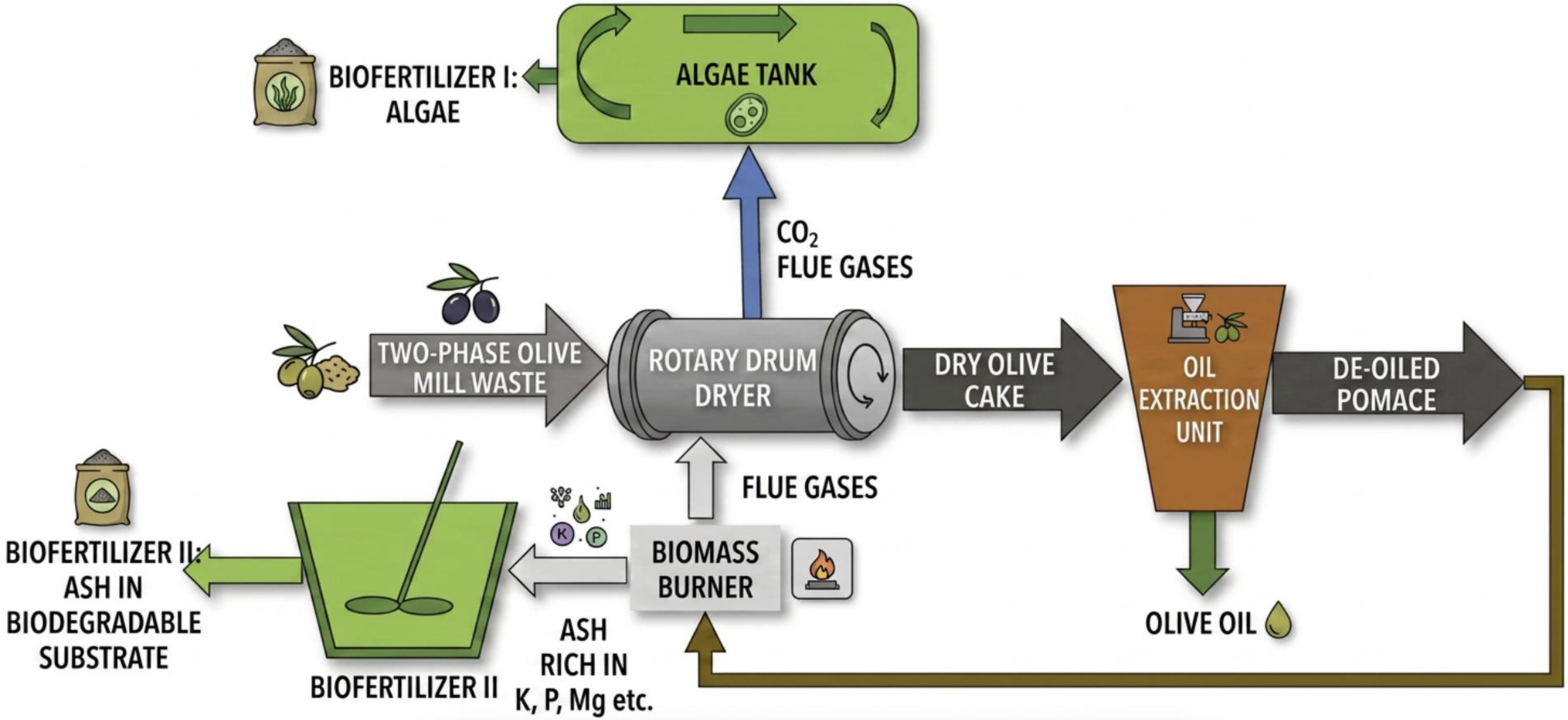

Upscaling

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Existing Biorefinery Life CircforBio

Upscaling

Existing Algae Open Ponds CRONUS

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CRONUS

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Process Optimisation

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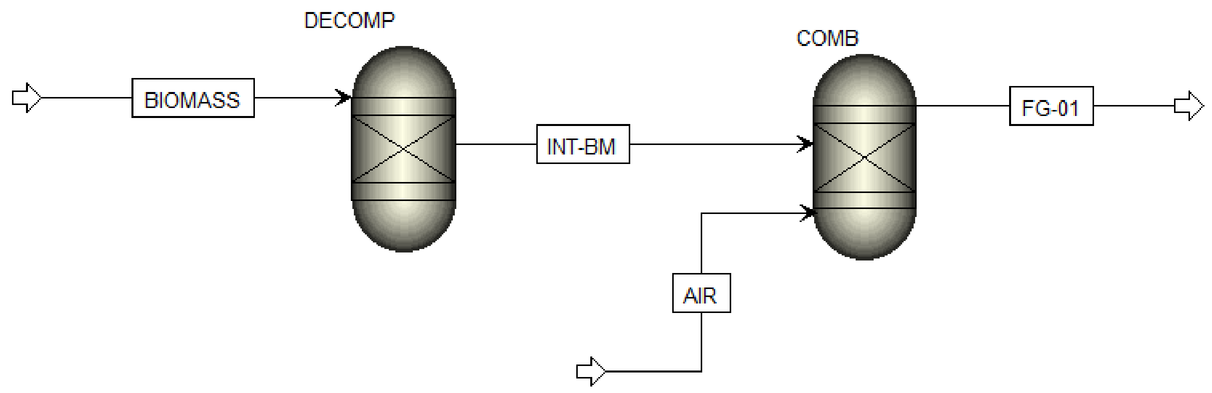
1. Biomass combustion and Drying
2. Oil extraction
3. CO_2 capture and algae cultivation trials

Olive stone wooden residue detailed characterisation

Olive stone wooden residue combustion

- Cone calorimeter experiments
- TGA /DSC analysis



Oil extraction

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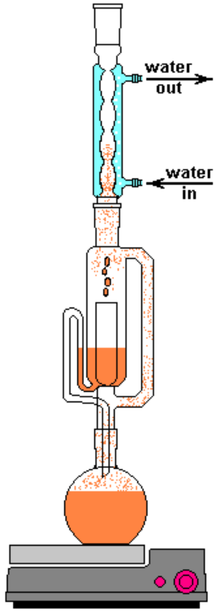
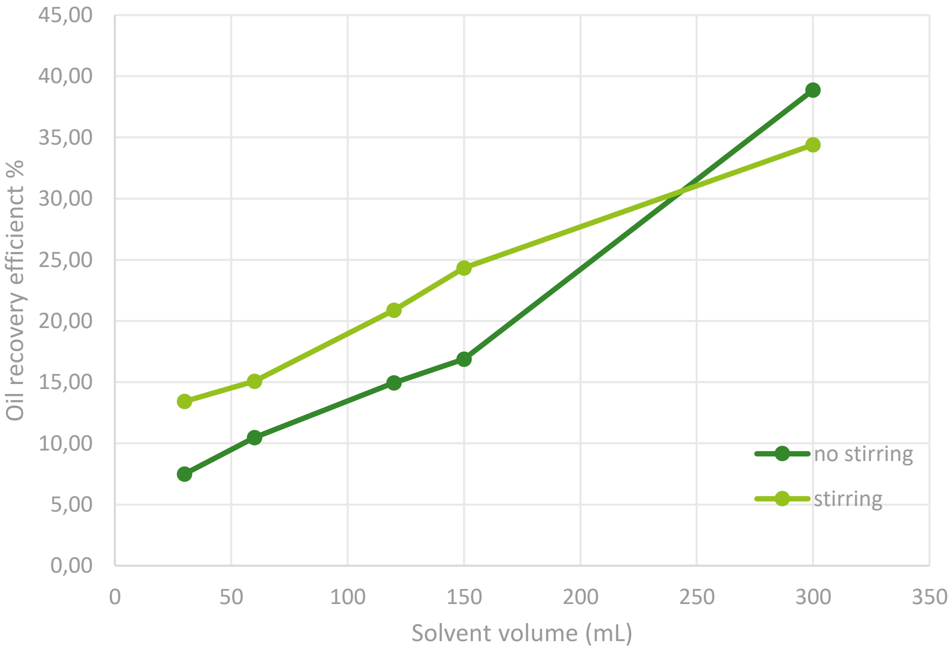
Green solvents as alternatives of hexane

Solvents tested:

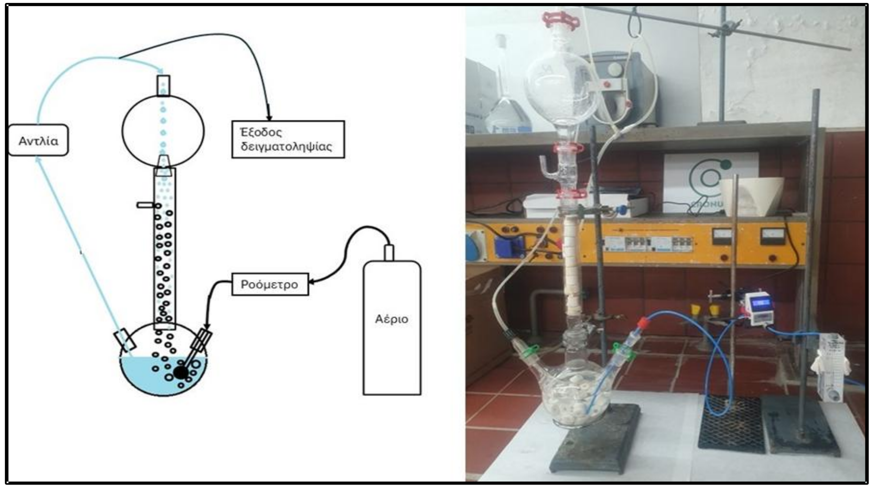
- Ethanol
- Ethyl Acetate
- DMC

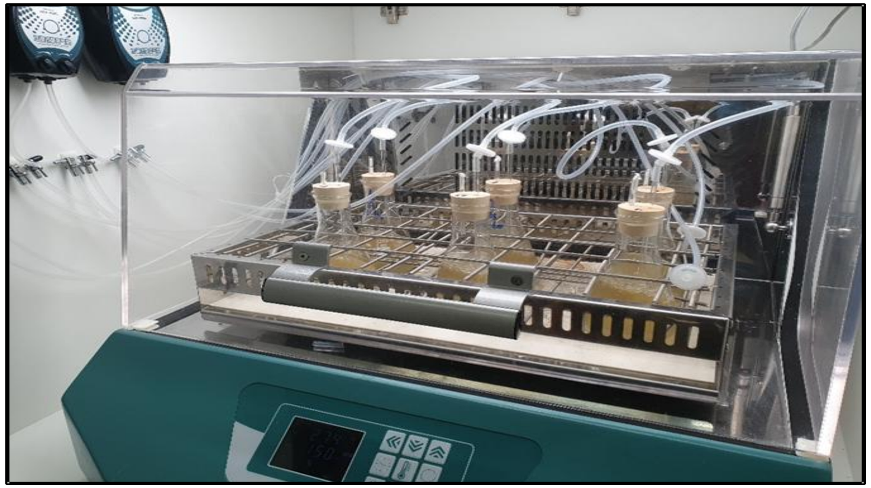
Effect of stirring

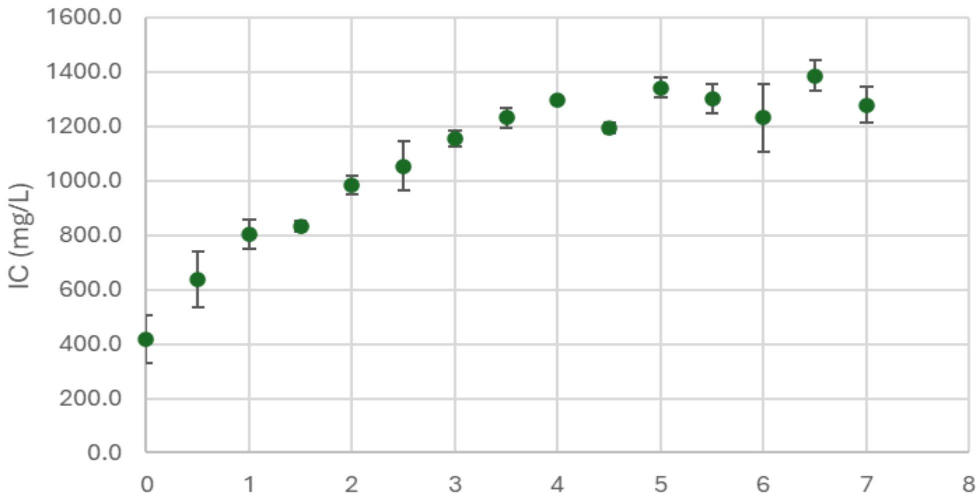


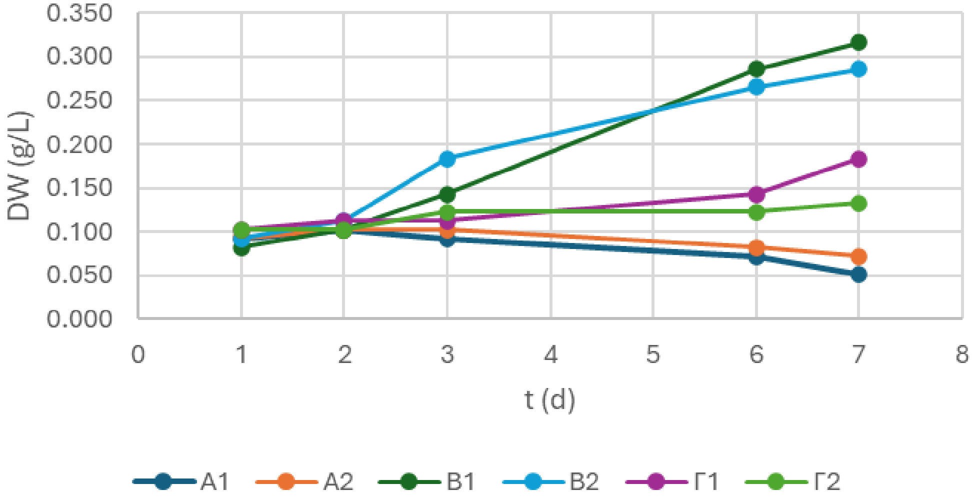


3 CO_2 capture and algae cultivation trials









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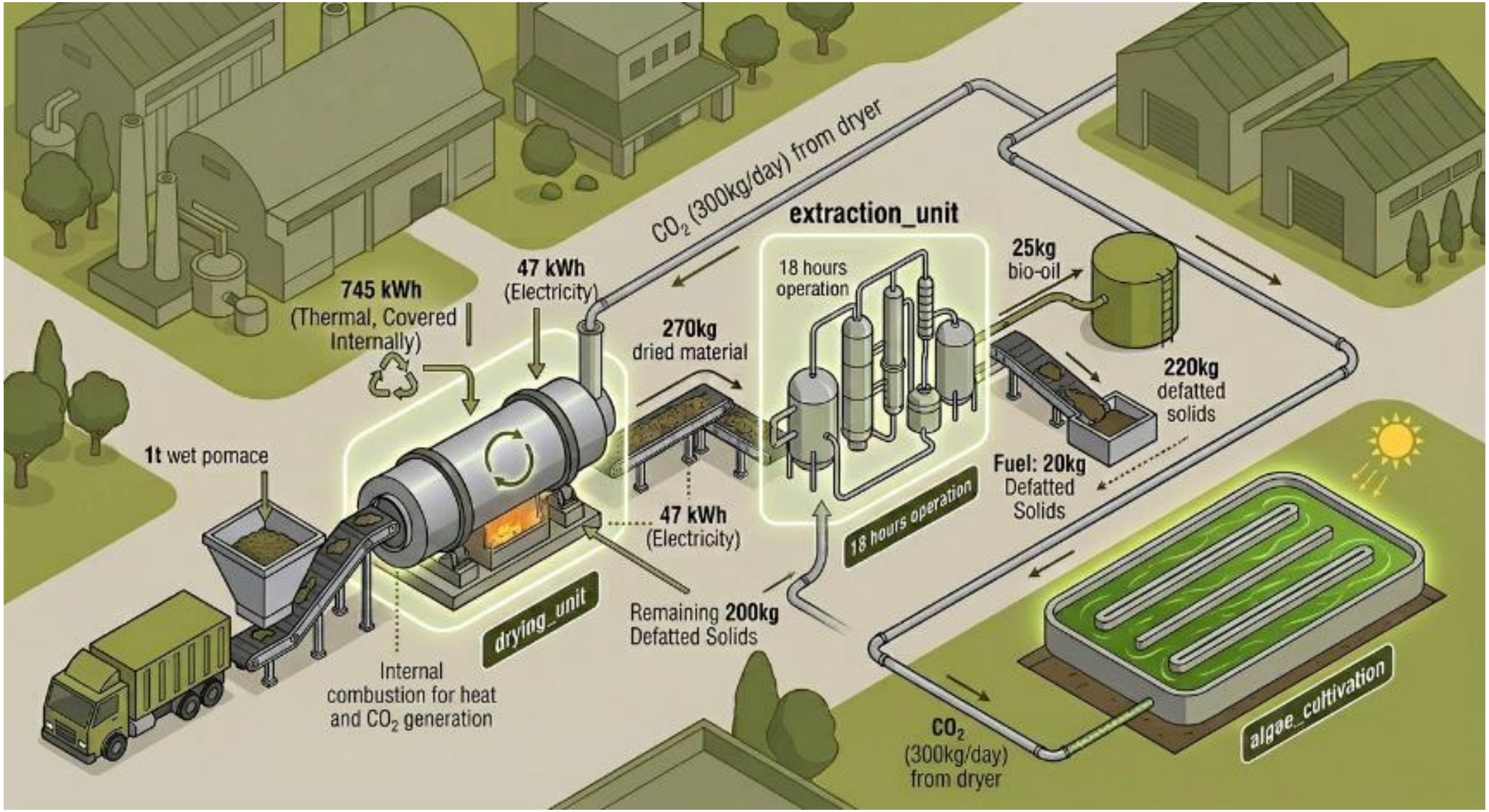

CO2 (300kg/day) from dryer
extraction_unit
18 hours operation
25kg bio-oil
745 kWh (Thermal, Covered Internally)
47 kWh (Electricity)
270kg dried material
220kg defatted solids
1t wet pomace
Fuel: 20kg Defatted Solids
47 kWh (Electricity)
18 hours operation
drying_unit
Remaining 200kg Defatted Solids
Internal combustion for heat and CO2 generation
CO2 (300kg/day) from dryer
algae_cultivation

Fertiliser characterisation

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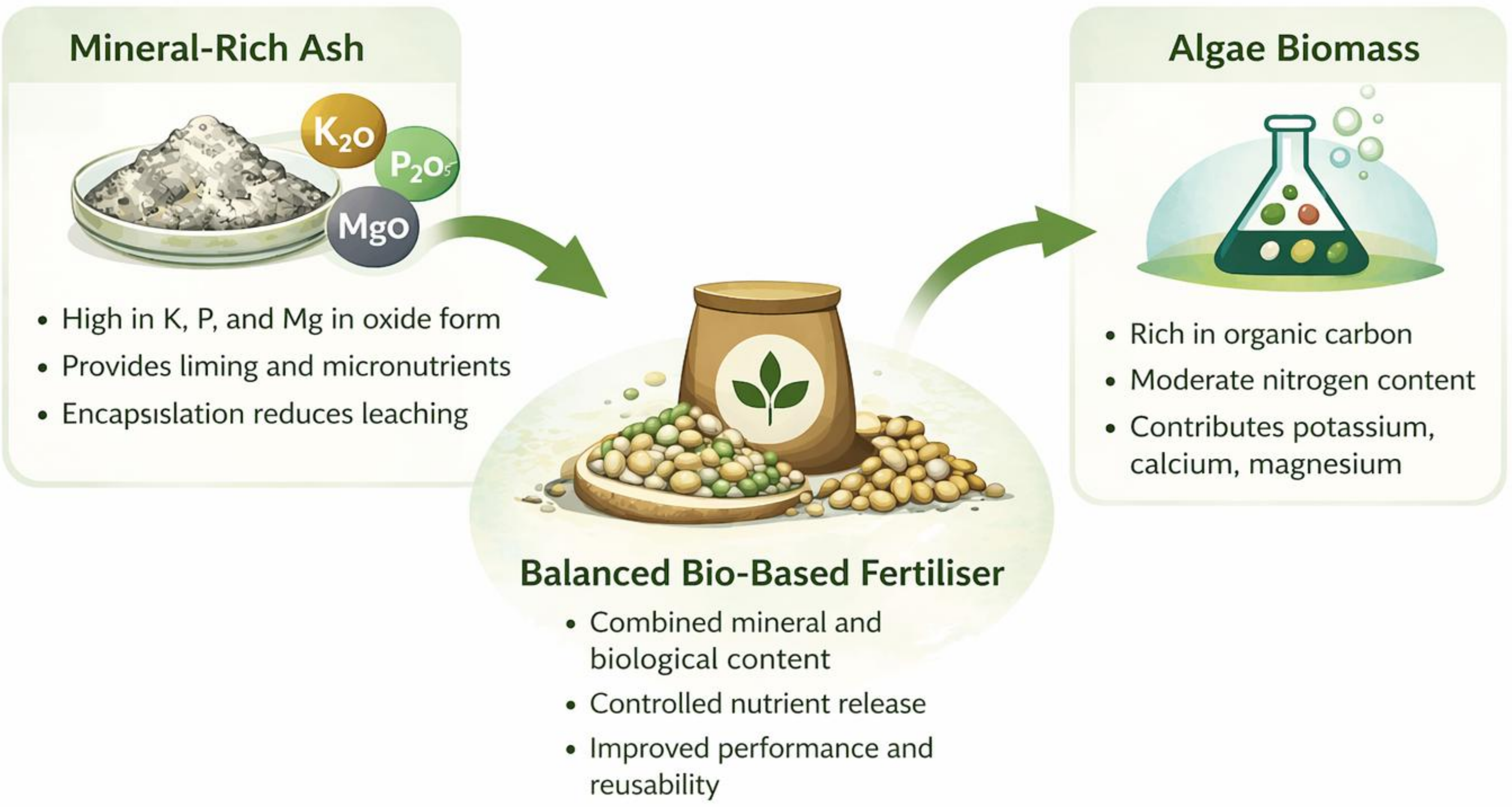

Key innovations

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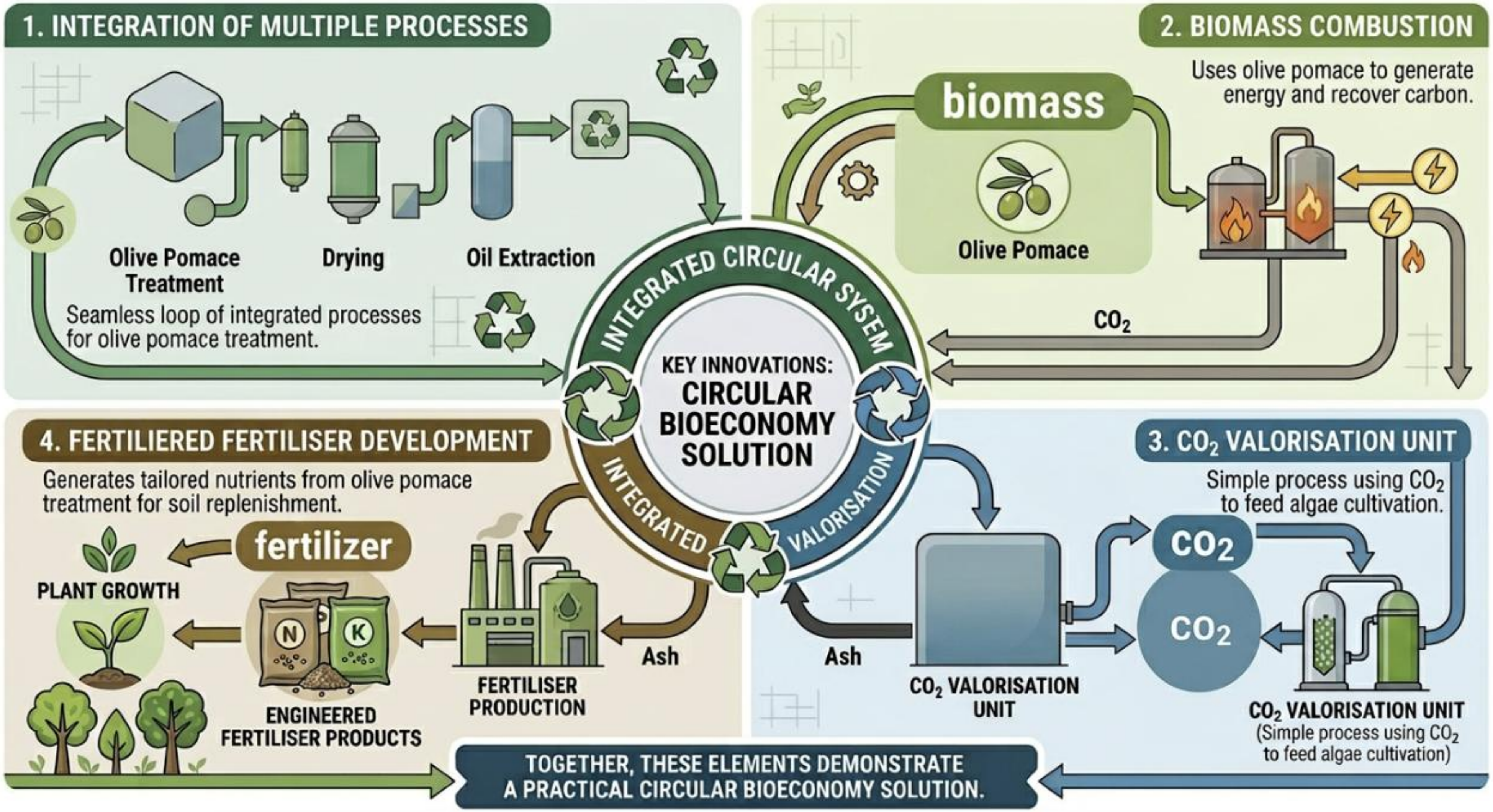
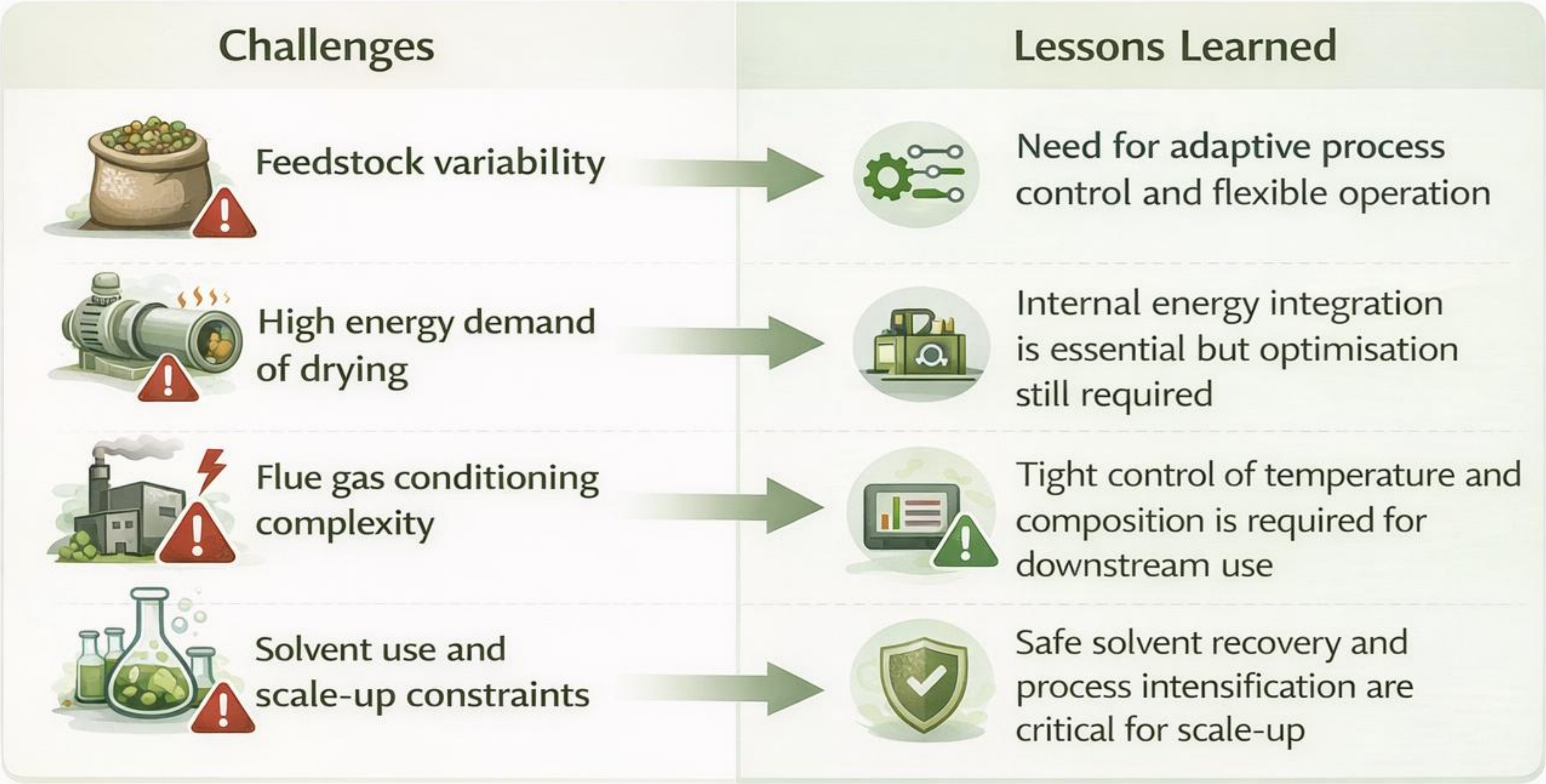


Challenges & Lessons Learned



Challenges	Lessons Learned
Feedstock variability	Need for adaptive process control and flexible operation
High energy demand of drying	Internal energy integration is essential but optimisation still required
Flue gas conditioning complexity	Tight control of temperature and composition is required for downstream use
Solvent use and scale-up constraints	Safe solvent recovery and process intensification are critical for scale-up

Outlook & Next Steps

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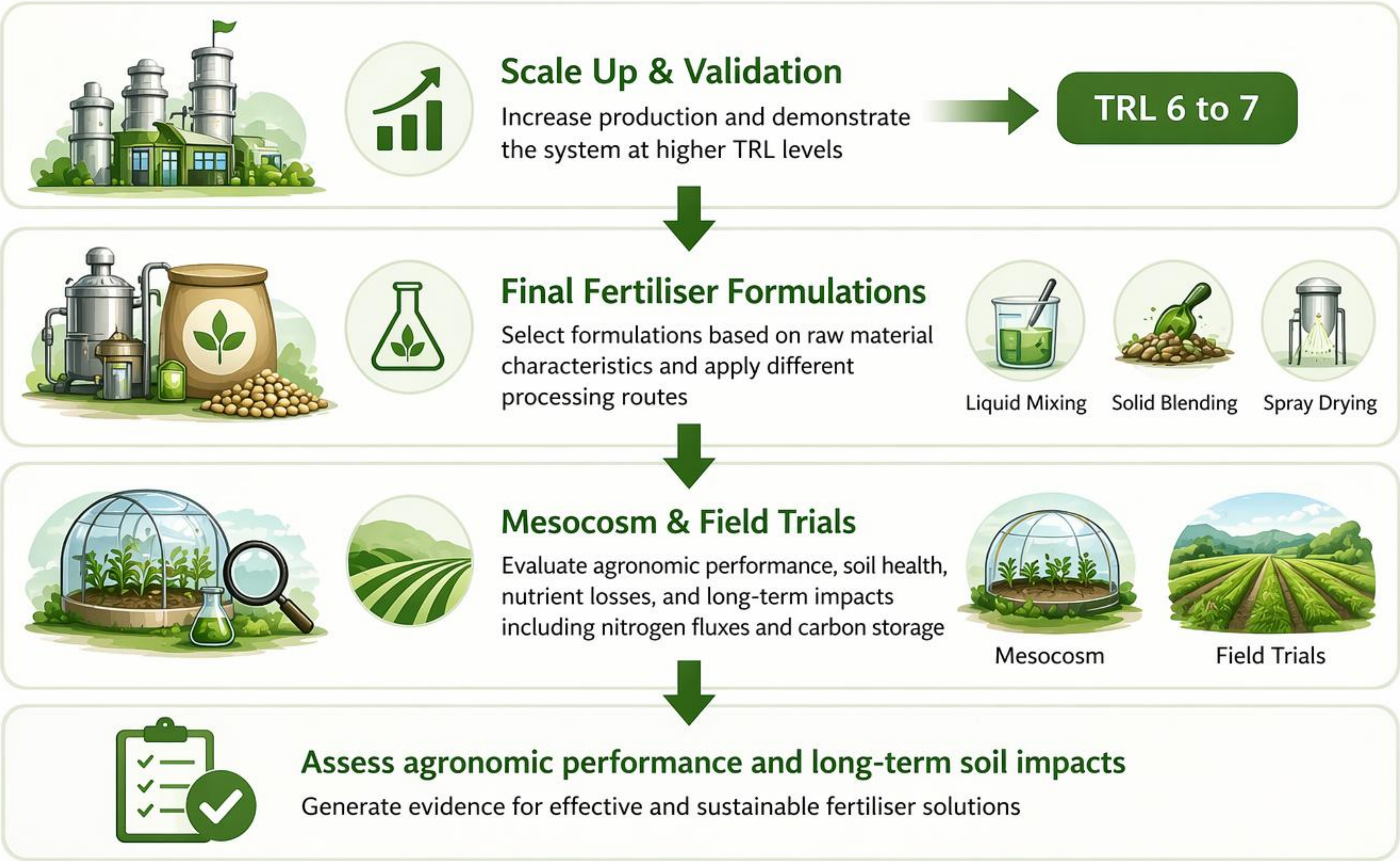

Thank you for your attention

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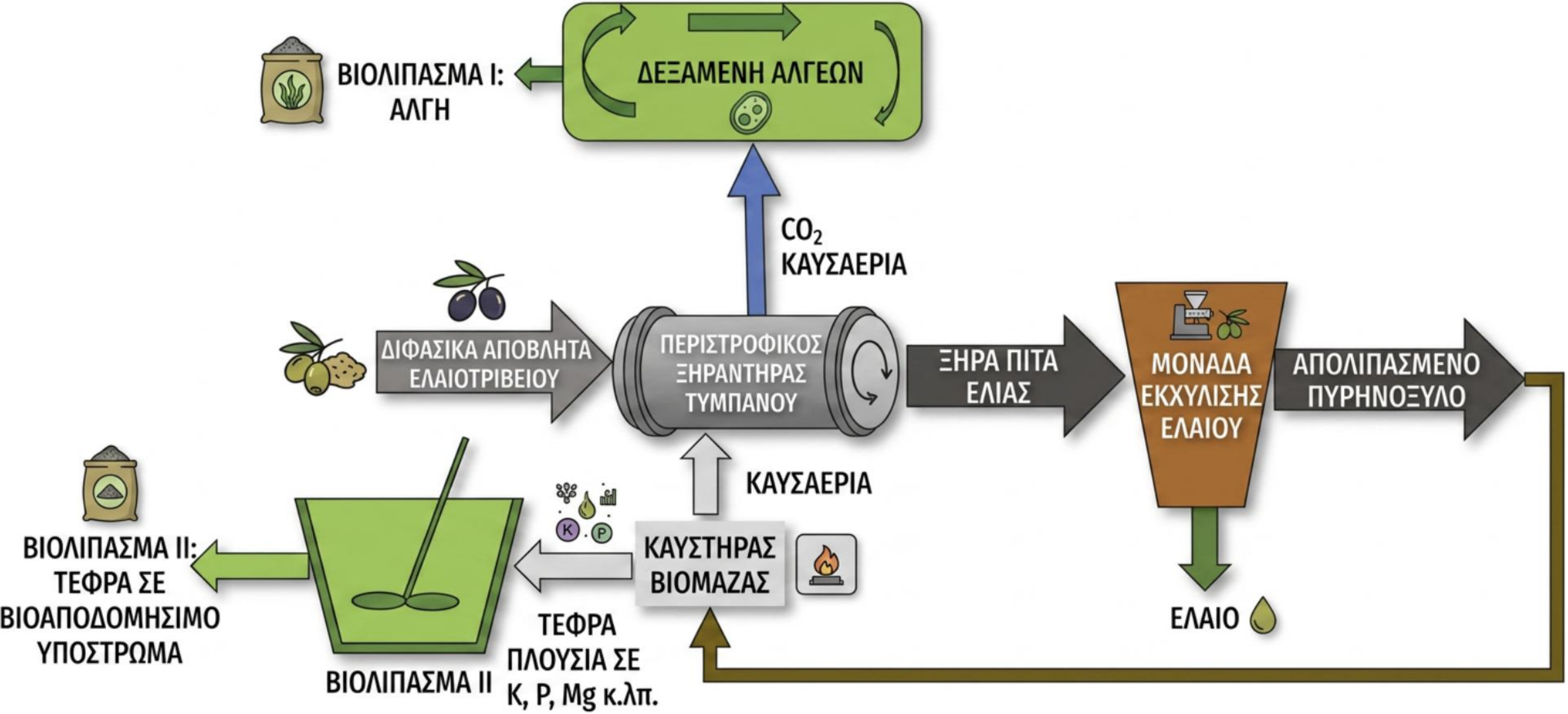

ΔΕΞΑΜΕΝΗ ΑΛΓΕΩΝ
ΒΙΟΛΙΠΑΣΜΑ Ι:
ΑΛΓΗ
CO_2
ΚΑΥΣΑΕΡΙΑ
ΔΙΦΑΣΙΚΑ ΑΠΟΒΛΗΤΑ
ΕΛΑΙΟΤΡΙΒΕΙΟΥ
ΠΕΡΙΣΤΡΟΦΙΚΟΣ
ΞΗΡΑΝΤΗΡΑΣ
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ΞΗΡΑ ΠΙΤΑ
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ΤΕΦΡΑ
ΠΛΟΥΣΙΑ ΣΕ
K, P, Mg κ.λπ.

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GICOM
Grup d'investigació en Compostatge
Universitat Autònoma de Barcelona

Valorising waste streams to produce safe, sustainable, and efficient bio-based fertilisers.

Biostimulant production through solid-state fermentation: Organic waste valorisation

PhD student Jana Font

Aeris and Composting Research Group (GICOM), Barcelona

ESNI-NERM conference 28, 29 April 2026 Brussels

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UK Research and Innovation

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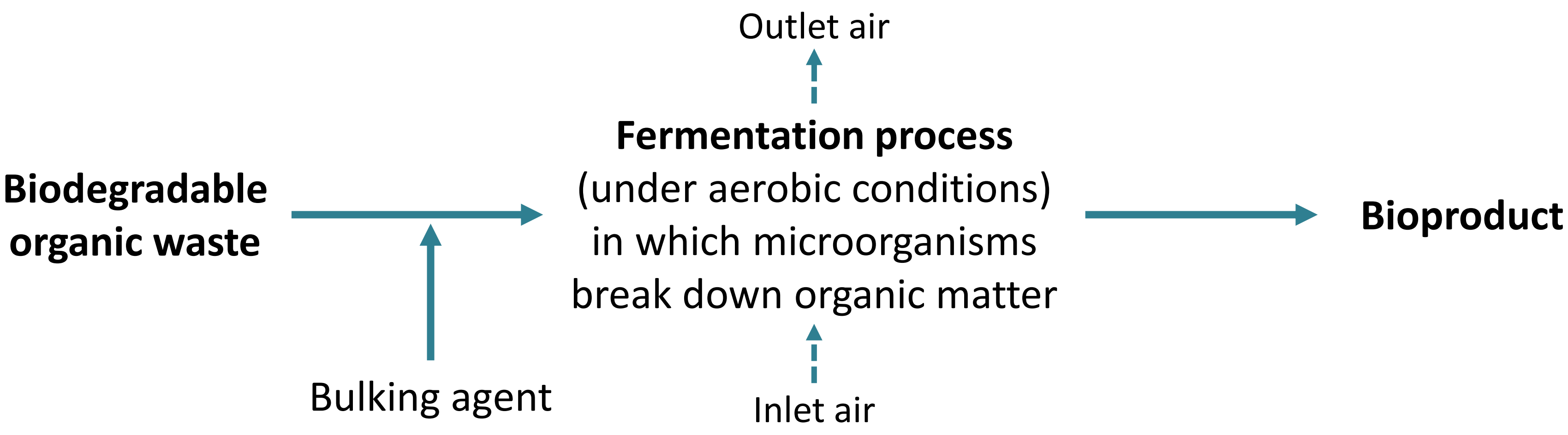
Solid-state fermentation

WHAT IS **SOLID-STATE FERMENTATION (SSF)?**

SSF is defined as the growth of microorganisms on solid substrates in the absence (or near absence) of free water, under aerobic conditions, where the substrate provides physical support and nutrients while retaining sufficient moisture to sustain microbial growth and metabolism [1].

It enables the transformation of biodegradable organic waste into value-added bioproducts [2].



[1] Pandey, A. (2003). Solid-state fermentation. *Biochemical engineering journal*, *13*(2-3), 81-84.
[2] Sánchez, A. (2024). A perspective of solid-state fermentation as emergent technology for organic waste management in the framework of circular bioeconomy. *ACS sustainable resource management*, *1*(8), 1630-1638.

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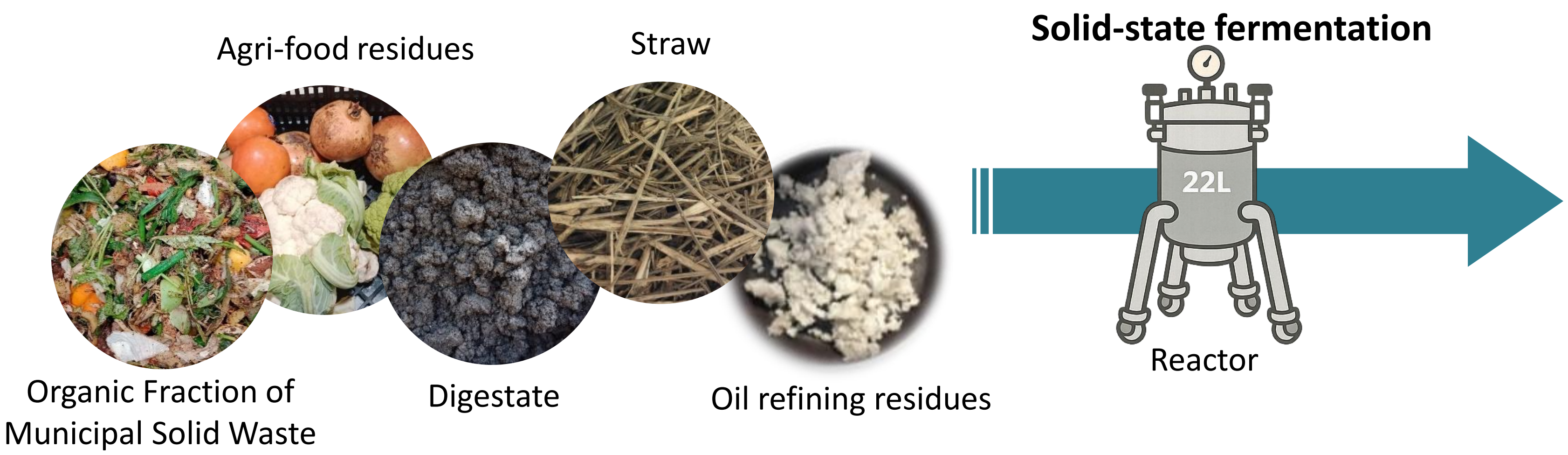

Bioproducts:

- Biosurfactants
- Biopesticides
- Biostimulants
- Enzimes…

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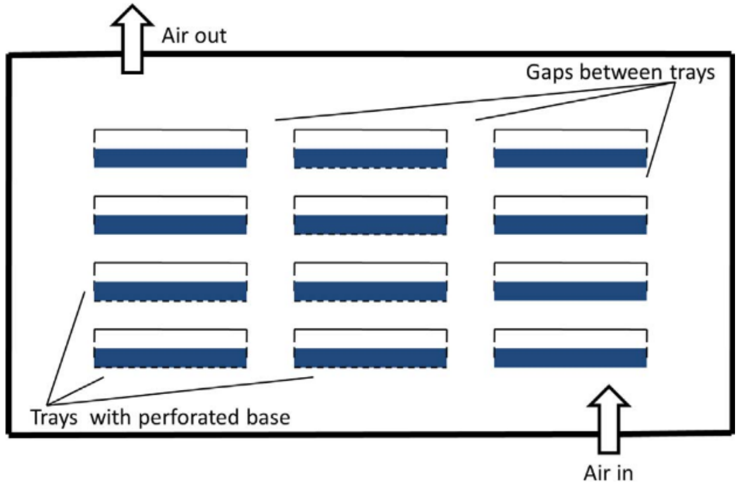
Solid-state fermentation – Reactor designs

1. Tray reactor
2. Rotating drum
3. Packed bed reactor

1



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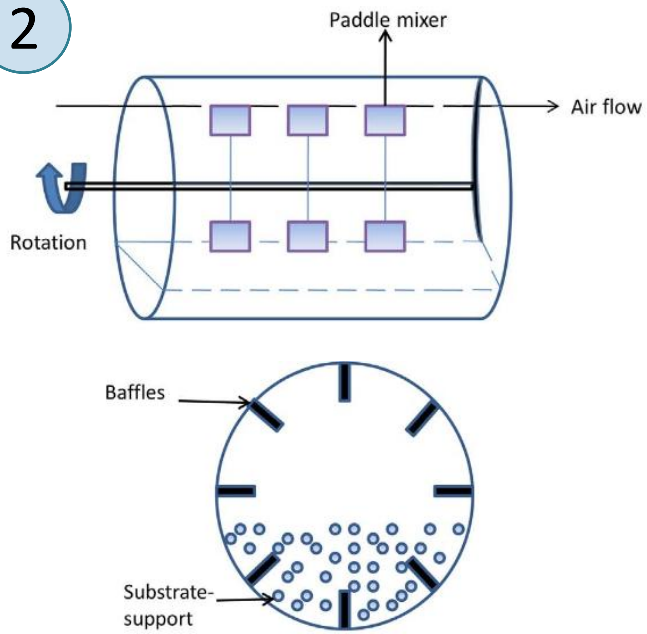

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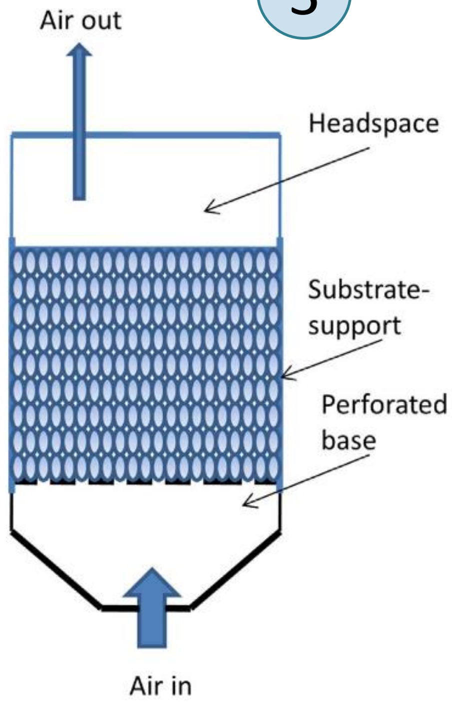


Arora, S., Rani, R., & Ghosh, S. (2018). Bioreactors in solid state fermentation technology: Design, applications and engineering aspects. *Journal of Biotechnology*, *269*, 16-34

Solid-state fermentation – Packed bed reactors

Packed bed reactors from **Aeris** and **GICOM** (Composting Research Group)

aeris

GICOM
Grup d'Investigació en Compostatge
Universitat Autònoma de Barcelona

0.5 L Erlenmeyer

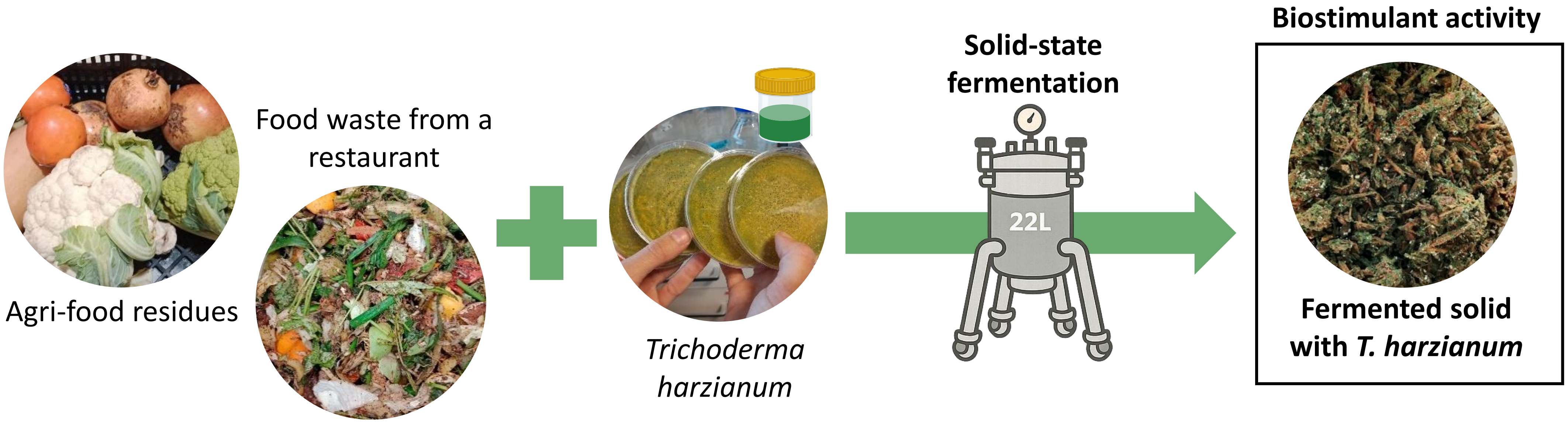
0.5 L

22 L

50-300 L

Objective

- The aim is to study **solid-state fermentation** as a technology for the **valorisation of organic waste** to produce **biostimulants**, followed by its subsequent implementation at **pilot scale**.

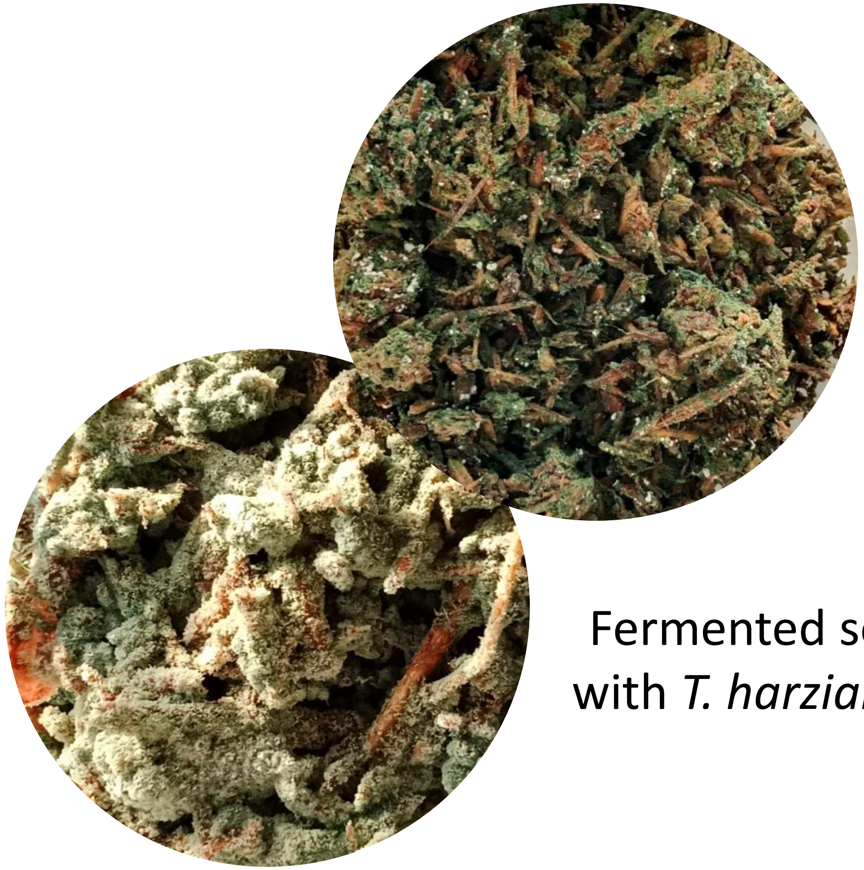


Trichoderma harzianum as biostimulant

1. **Direct biological control agent** (Mycoparasitism, antibiosis, and competition against phytopathogens)

2. **Priming, indirect biological control** (Systemic defence against diseases, pests, and biological stress)

3. **Biostimulant** (promotion of root growth and development)



Fermented solid with *T. harzianum*

Solid-state fermentation – Methodology

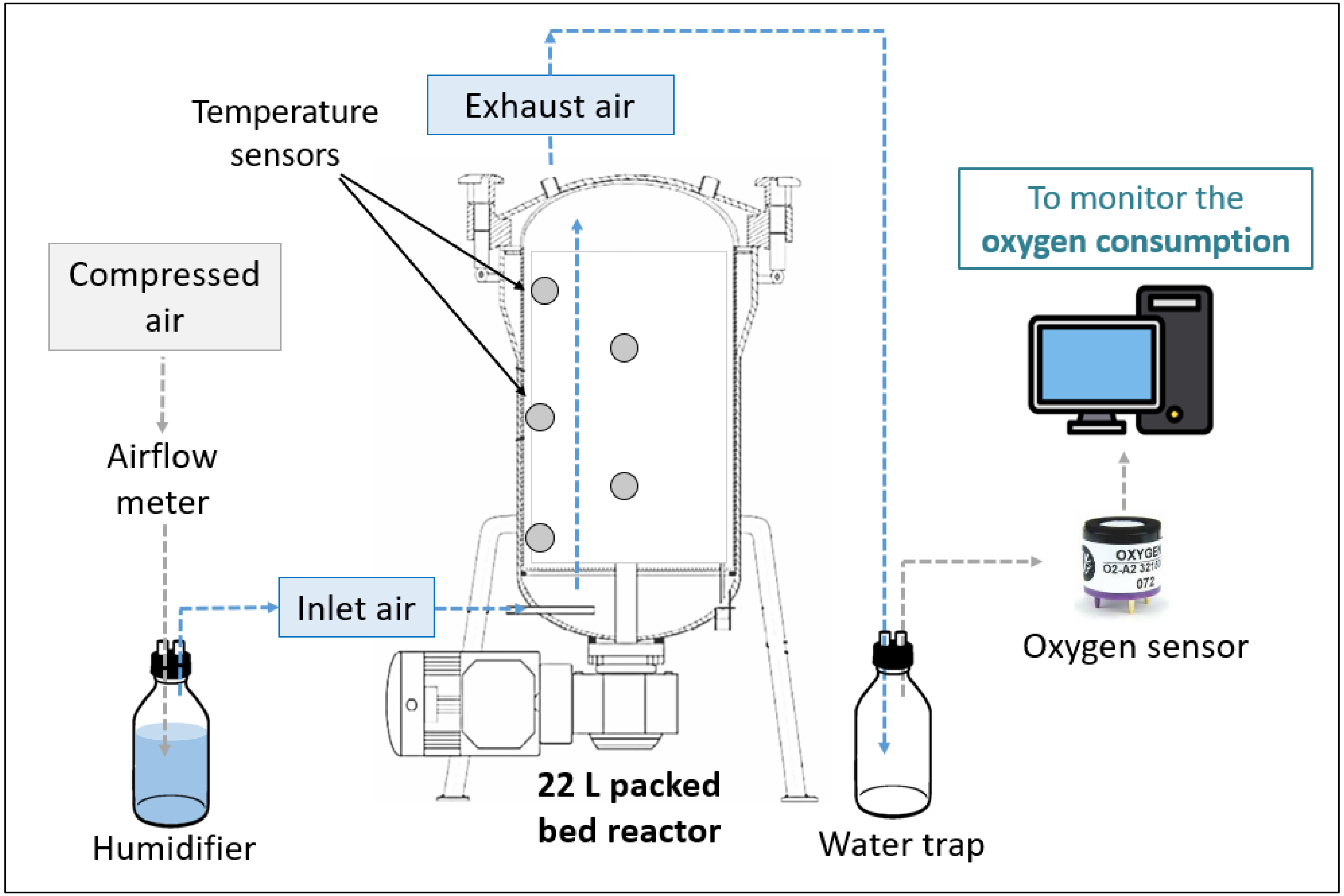
Food waste + Wood chips → Autoclave → Inoculation with *Trichoderma* → SSF → Fermented solid with *Trichoderma*







Solid-state fermentation – Set-up



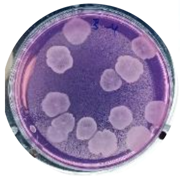
Solid-state fermentation – Methodology

Monitoring parameters:

- **Physicochemical parameters**: Dry matter, organic matter, pH
- **Oxygen consumption** as an indicator of the **biological activity** calculated as **specific Oxygen Uptake Rate (sOUR).**

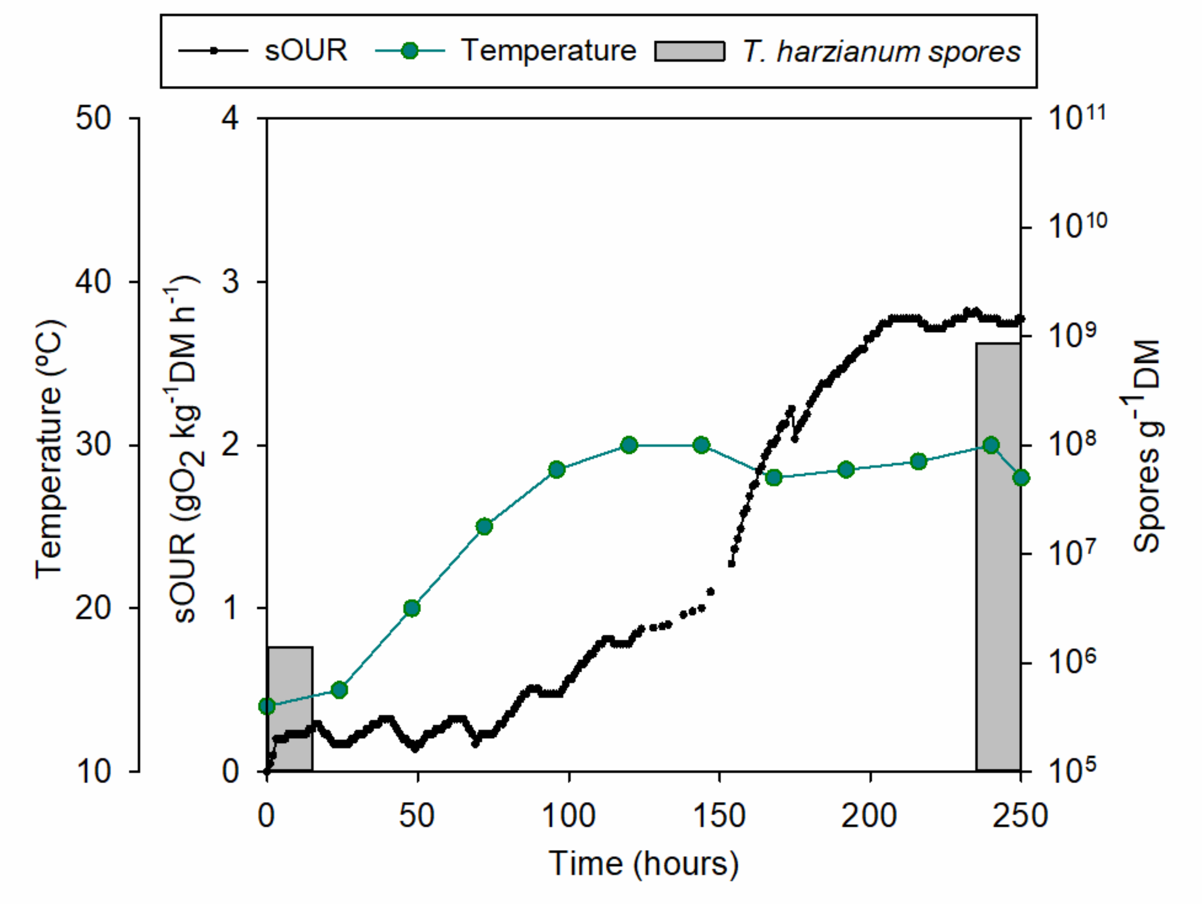
→ sOUR (g O_2 kg^{-1} DM h^{-1})

- ***T. harzianum*** **spore concentration** counted by:
  - Neubauer chamber
  - Potato Dextrose plus Rose Bengal agar plates



Solid-state fermentation – Results

- Solid-state fermentation of food waste with *T. harzianum* at pilot scale (22 L)



Conclusions

- **Laboratory trials** demonstrated that *Trichoderma* can grow via SSF using food waste as a substrate.

- SSF was operated at **pilot scale** under real environmental conditions, using **restaurant-derived food waste** and beyond controlled laboratory systems.

- **Future work** will investigate the adoption of a **sequential batch strategy** to minimise inoculum requirements and improve overall process efficiency.

- Overall, SSF shows strong potential as a sustainable technology for waste valorisation within a **circular economy framework**.

QUESTIONS?

ReLEAF

Valorising waste streams to produce safe, sustainable, and efficient bio-based fertilisers.

www.releafproject.eu

@ReLEAF Project EU

@ReLEAFprojectEU

This project is supported by the CBE JE and its members. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the funding body. Neither the European Union nor the granting authority can be held responsible for them. Project number 101156998.

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Bio-based Industries Consortium

Funded by the European Union

Project funded by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

UK Research and Innovation

This project has received funding from UK Research and Innovation (UKRI)

LANDFEED

Use Case 2 : Animal waste - France

Transformation of animal waste into bio-based fertilizers by twin-screw extrusion combined to enzymatic hydrolysis

Julien Lequitte (INPT – CATAR)

2026-04-28

Brussels ESNI-NERM

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

Co-funded by the European Union

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UC2 – Partners' presentation

LANDFEED

Université de Toulouse

RTO

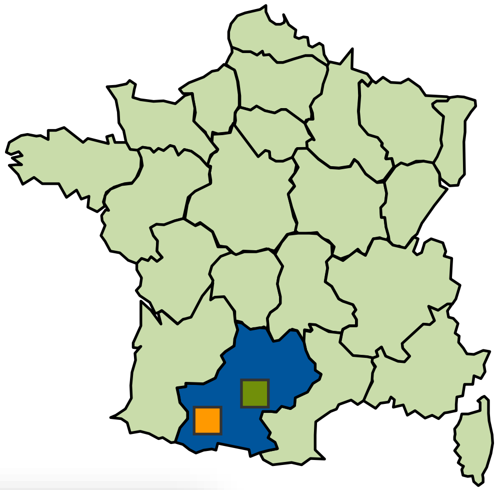
Research ↔ Technology transfer

Research: LCA Laboratoire de Chimie Agro-Industrielle; Toulouse INP Ensiacet; INRAE UMR 1010; Carnot 3BCAR

Technology transfer: CATAR Agro Ressources; CRT; Carnot 3BCAR

LCA Laboratoire de Chimie Agro-Industrielle

CATAR Agro Ressources



Toulouse

Tarbes

AGROMAT R&D à l'échelle industrielle

UC2 – Partners' presentation

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CATAR (Centre d'Application et Traitement des Agro-Ressources)

- Toulouse (FRANCE)
- RTO since 1991
- Labeled « Technological Resource Center (CRT)» by the French Ministry of Research
- Missions: Innovation's support to industry through R&D&I and technology transfer
- Expert in the application and treatment of bioresources in partnership with academic and industrial sectors
- Expertise:
  - ✓ Biorefinery, specifically extraction and fractionation of plant and animal raw materials
  - ✓ Production and characterization of industrial-size samples (scale-up)
  - ✓ Synthesis of biomolecules
  - ✓ Physico-chemical and sensory characterization of fine molecules and biomolecules

Toulouse INP

Laboratoire de Chimie Agro-industrielle (LCA)

- Toulouse (FRANCE)
- Public laboratory created in 1975: UMR1010 INP/INRAE
- Expertise: 4 thematics

T1
Biomass fractionation

T2
BioPolymers processing
-
Biobased materials

T3
Chemical reactivity and design of biobased molecules

T4
Environmental evaluation and ecodesign

UC2 - Raw materials supply, characterisation

IZPEGI Arraina · Truite | Mytilimer Groupe | Abattoirs de Saint Gaudens | fertilaine

	Fish	Shellfish	Meat	Sheep farming
RM provider	Pisciculture Ispeguy	Mytilimer group	Abattoirs de Saint Gaudens	Fertilaine
Type of industry	Fish farm	Food industry	Slaughterhouse	Sheep breeder
Type of RM	Trout's by-products	Mussels by-products	Meat by-products	Sheep by-product
RM's description	• Heads • Frames		• Cattle bones (from meat cutting plant) • Lamb skins	• Sheep wool





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LCA LABORATOIRE DE CHIMIE AGRO-INDUSTRIELLE
CATAR AGRO RESSOURCES

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UC2 - Raw materials supply, characterisation

IZPEGI Arraina · Truite · Baigorri — Mytilimer Groupe — Abattoirs de Saint Gaudens — fertilaine

	Fish by-products (trout)		Shellfish by-products	Meat by-products		Sheep farming
	Heads	Frames		Cattle Bones	Animal skins	Sheep Wool
						
Total solids (%)	35 ± 1	35 ± 1	99.8- 99	82	56 ± 2	94.7 ± 0.8
Proteins (%/DM)	37.9 ± 2	38.4 ± 2.4	0 - 63.3 ± 3.2	16.2	72.5 ± 6.9	43.6 ± 1.2
Fat (%/DM)	42.5 ± 3.8	46.5 ± 5.6	0 - 0.8 ± 0.1	30.6	4.9 ± 3.0	10.5 ± 0.1
Ash (%/DM)	11.8 ± 1.6	10.7 ± 1.5	21.3 - 96.9 ± 2.0	41.3	23.7 ± 1.1	21.7 ± 0.2
N (%/DM)	6.8 ± 0.4	6.9 ± 0.4	0.42 - 13.7 ± ± 0.06	2.9	11.6 ± 1.1	10.8 ± 1.2
C (%/DM)	53.8 ± 1.7	54.9 ± 0.3	12.6 ± 0.1 42.2 ± 0.1	14.6 ± 0.2	-	38.8 ± 0.1
P (g/kg DM)	14 ± 4	19 ± 1	0.19 - 0.3 ± 0.01	58.9 ± 0.1	-	3.6 ± 1.4
K (g/kg DM)	5.4 ± 0.6	6.2 ± 0.1	0.06 - 0.2	0.43 ± 0.01	-	74.9 ± 22.7
Ca (g/kg DM)	23.7 ± 0.3	18.5 ± 0.1	49 - 393	130 ± 1	-	3.9 ± 0.0
S (g/kg DM)	4.0 ± 0.1	3.6 ± 0.1	1.8 - 5.3 ± 0.1	0.48 ± 0.01		8.9 ± 0.1

UC2 - Contribution of animal wastes for the process development and BBF compositions

Abattoirs de Saint Gaudens

		Fish by-products (trout)		Shellfish by-products		Meat by-products		Sheep farming
		Heads	Frames			Cattle Bones	Animal skins	Sheep Wool
								
Fertilization	Supply N	X	X		X			
	Supply P	X	X			X		
	Supply K						X	X
Process	Adjuvants			X	X			

UC2 - Main technologies

LANDFEED

Twin screw extruder

Main parameters

Machine set-up

Screw profile

Operating parameters:

- Temperature
- Screw speed
- Raw material's feed rate
- Liquid/solid ratio
- Reagents and reactants: catalysts, enzymes, acids, bases,...

Bioreactor Solaris

Main parameters

Machine set-up

Agitator

Operating parameters:

- Temperature
- Agitator's speed
- Liquid/solid ratio
- Reagents and reactants: enzymes, acids, bases,...

UC2 – Step 1 - Optimal separation in the TSE

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TRL 3-4

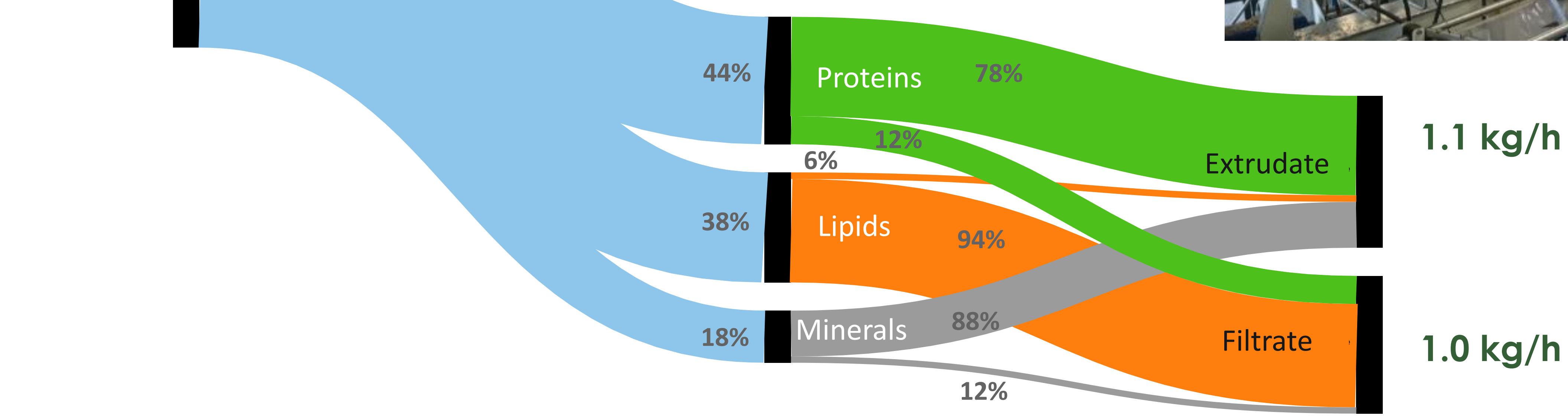
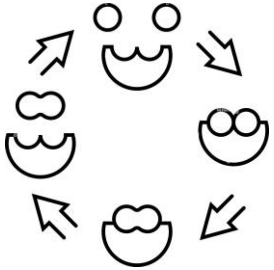


Figure : Sankey diagram of the separation inside the TSE for the optimal parameters

UC2- Processing technologies - Step 2

Extrudate

6 enzymes (endo and exoproteases)
2 temperatures



128 trials

DoE: D-optimal

Enzymatic hydrolysis

40 trials

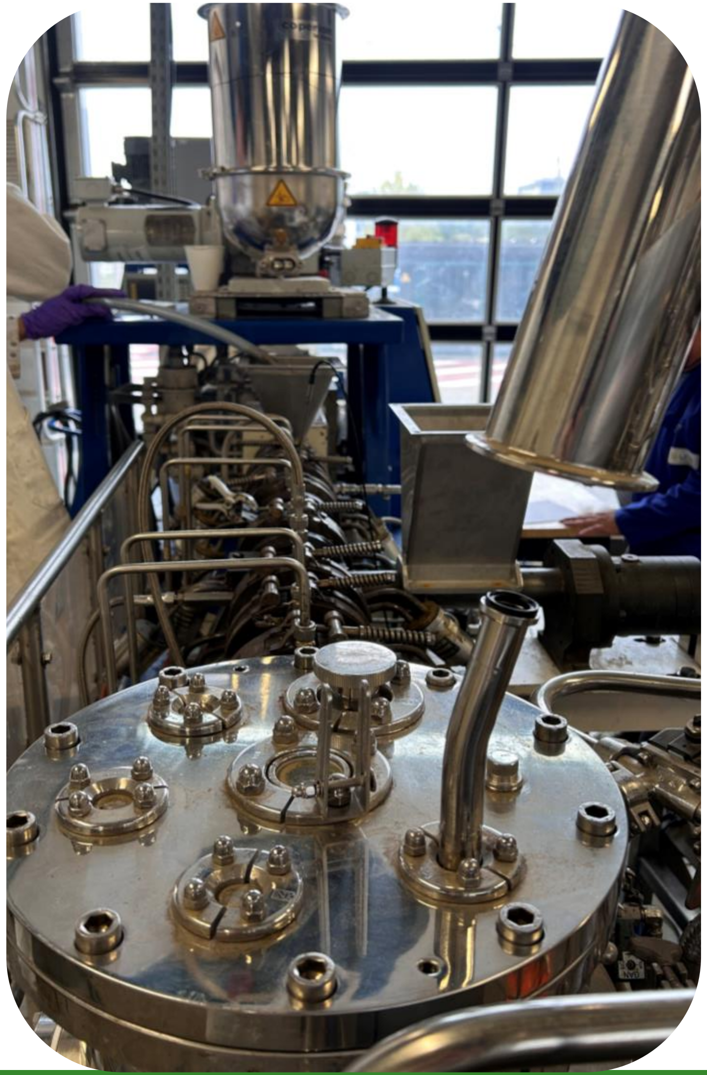
Degree of hydrolysis – OPA
N%/DM of the solid fraction

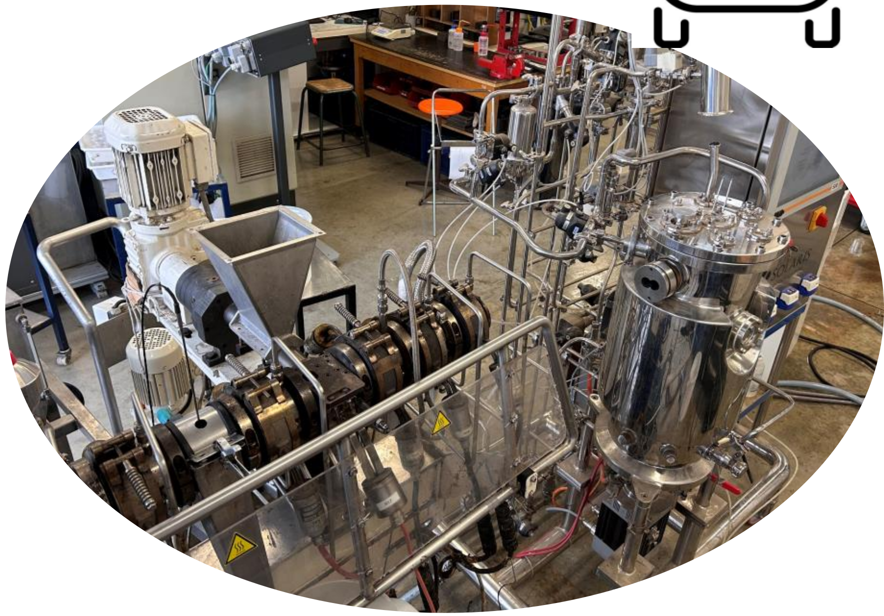
Optimal temperature
2 optimal mixture of enzymes

UC2- Step 3 – Combined TSE & Enzymatic hydrolysis

Objectives

- Design and test of Liquid/Solid separation
- Extended study on the impact of the high consistency enzymatic hydrolysis
- Stabilization of the process (extruder + bioreactor)
- Assessment of the stability of the continuous extrusion process
- Analysis of the production of BFF at lab scale (22L)





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UC2 – Composition of the bio-based fertilisers

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	Bioreactor: Solid residue		Bioreactor: Hydrolysate	
Compound	Avg. (%)	STD (%)	Avg. (%)	STD (%)
Minerals	38.25	0.29	4.58	0.09
C	30.22	0.02	13.69	0.01
H	4.34	0.01	2.04	0.00
N	7.23	0.00	3.25	0.00
C/N	4.2		4.2	
P2O5	6.57	0.02	0.62	0.01
K2O	1.39	0.01	0.93	0.00
Free Amino Acids	8,8	0.1	4,6	0.3

EU Regulation 1009/2019 ☑

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UC2 – Scale-up

- Scalability of the process

TRL 3-4

Evolum 25 (Clextral)

2-10 kg/h

LCA LABORATOIRE DE CHIMIE AGRO-INDUSTRIELLE

TRL 6-7

Evolum HT53 (Clextral)

50-150 kg/h

CATAR AGRO RESSOURCES

LANDFEED

Thank you

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catar.critt.net

CATAR CRITT Agroressources (CRT)

Circular Bio-based Europe Joint Undertaking

Bio-based Industries Consortium

Co-funded by the European Union

Valorising waste streams to produce safe, sustainable, and efficient bio-based fertilisers.

Valorization of fish wastewaters and fish waste to produce microbial biostimulants

Francesca Patrignani

Alma Mater Studiorum-University of Bologna

francesca.patrignani@unibo.it

ESNI-NERM conference 28, 29 April 2026 Brussels

This project is supported by the CBE JU and its members. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the funding body. Neither the European Union nor the granting authority can be held responsible for them. Project number 101156998.

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Project funded by

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

UK Research and Innovation

This project has received funding from UK Research and Innovation (UKRI)

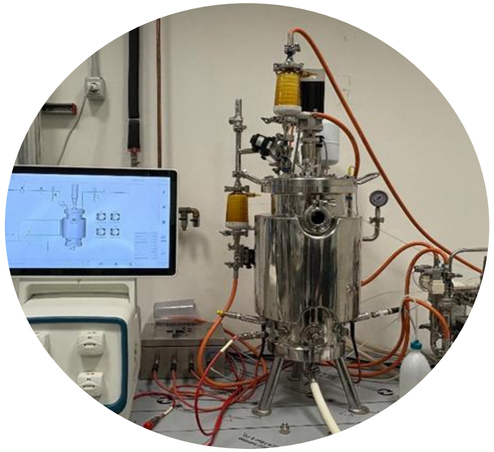
THE UNIBO APPROACH -FISH MEDIUM

- **Sardina Fish wastewaters** (Average composition): pH 6.79±0,08, No sugar present, Total N: 144±10 mg/l, no protein, Mg 21,8±4,9 mg/l, K 88±22 mg/l, BOD 5 780±76 mg/L (as O2), 1 200±65 mg/l (as O2)

- **Fish Hydrolysate (8%)** (1 part fish waste-head, bones, skin, viscera, and 2 parts of water)

- **Molasses (2%)** for the strains SP43, SP9, V2, DSM
- **Residuces of juice fruit (2%)** for the strain DAN 39
- **Spent yeast 0.5%**

- **Inoculum level** at 6 log cfu/ml and growth temperature at 25x 48h °C for SP43, SP9, V2, DSM and 37°C for 48h for DAN 39



From vitro…….

…. lab scale reactor…….

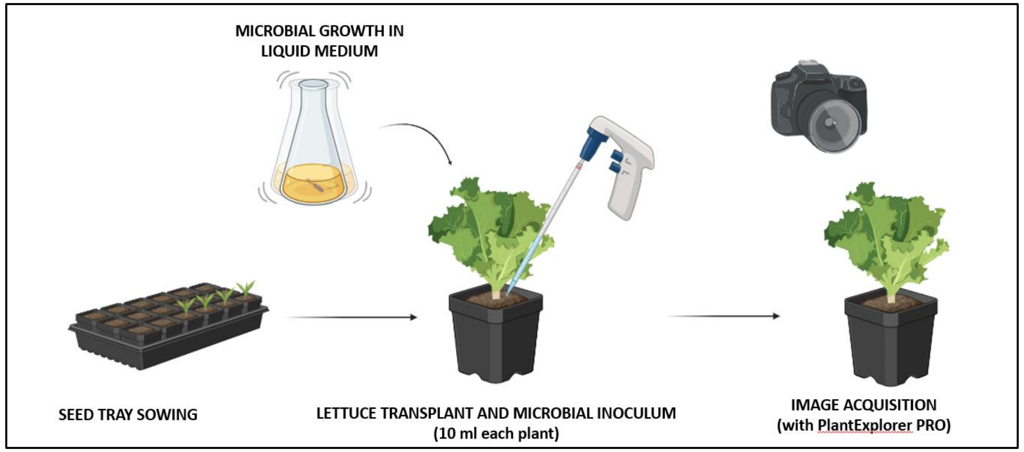
……..To pilot scale

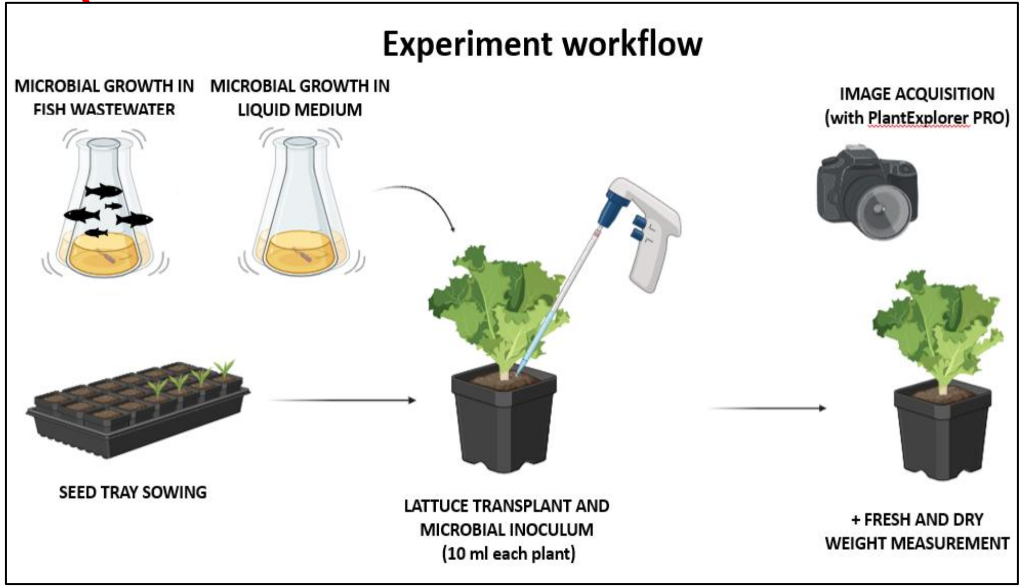
THE UNIBO APPROACH

20 strains for
In vitro characterization

20 strains for
Plant Phenotyper analysis

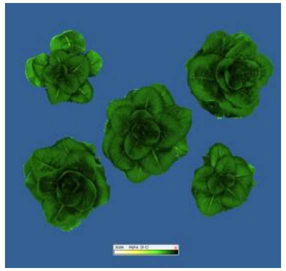
13 strains grown in optimal and fish medium for *Plant Phenotyper analysis*





Test

- Antimicrobic activity,
- MnO and PO4 solubilization capacity
- IAA production
- Siderophore
- α and β haemolytic activities.



PP Parameters

- Fresh and dry weight
- Fq'/Fm' (yield of Photosystem II)
- Chlorophyll Content Index
- Rate of electron transport

THE UNIBO APPROACH

OUTPUT: panel of strains endowed with PNPG potential

Strain in fish wastewater

Lb. plantarum DAN39
B. amyloliquefacens SP43
B. toyonensis SP27
B. licheniformis SP9
P. chlororapis V2
A. brasiliense DSM2298

Strain in TSB

Lb. plantarum DAN39
B. amyloliquefacens SP43
B. toyonensis SP27
B. licheniformis SP9
P. chlororapis V2
A. brasiliense DSM2298

- **Fq'/Fm'**
- **rETR**
- **ChlIdx**
- **NDVI**
- **AriIdx**
- **Fresh weight**
- **Dry weight**

In conclusion, the PGPB properties of the selected microorganisms are maintained, and in some cases even enhanced, when grown on fish wastewater medium.

Bacterial susceptibility to antibiotics

Antibiotics	Strain	MIC (mg/L)	Antibiotics	Strain	MIC (mg/L)
Ampicillin	SP9 SP27 C7 V2 DSMZ2298	64 128 128 128 128	**Tetraciclin**	DAN39 SP27 C7 V2 DSMZ2298	8 4 8 8 1
Gentamicin	SP27 C7 V2 DSMZ2298	8 8 8 4	**Erytromicin**	DAN39 SP27 C7 V2 DSMZ2298	1 128 128 128 0.25
Kanamicin	SP27 C7 V2 DSMZ2298	16 4 4 8	**Cloramphenicol**	DAN39 SP27 C7 V2 DSMZ2298	2 128 64 64 4
Streptomicin	SP27 C7 V2 DSMZ2298	64 128 64 32			
Vancomicin	DAN39 SP27 C7 V2 DSMZ2298	128 128 128 128 32	**SP43 = no growth.** **No cut-off value for *Azospirillum*** ***Pseudomonas* to test (always) with WGS for acquired resistance**		

References:

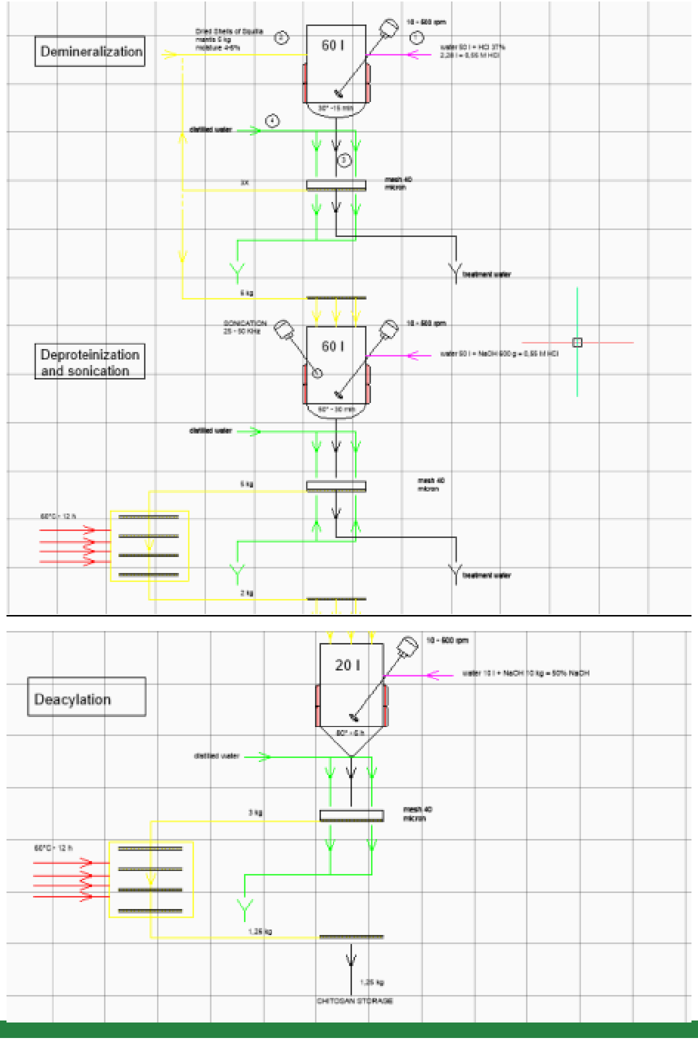
- EFSA Journal, Scientific Opinion
- SANTE/2020/12260 "ANTIMICROBIAL RESISTANCE« APPLICABLE TO MICROORGANISMS USED FOR PLANT PROTECTION IN ACCORDANCE WITH REGULATION (EC) No 1107/2009

THE UNIBO APPROACH

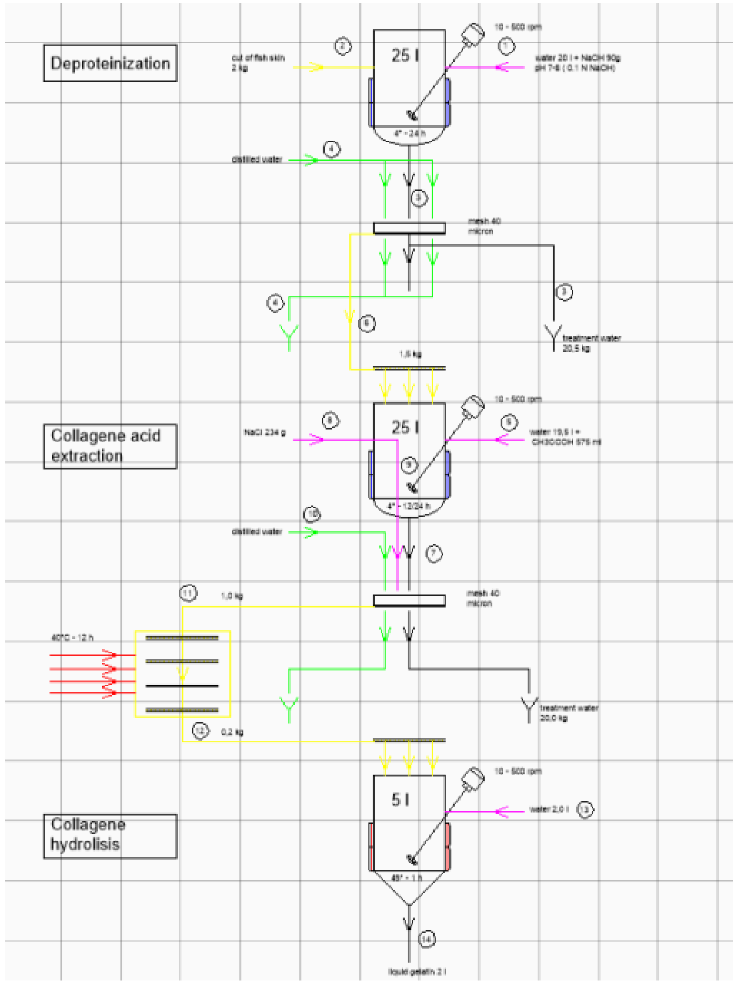
	Bacillus spp.	*Lactobacillaceae*	*Pseudomonas* spp.
Market presence	**High** – many products available	**Limited** – found in few formulations	**High** – widely used in biocontrol
Industrial interest	**Very high** – versatile and stable	**Emerging** – growing in biofertilizers	**High** – strong in biopesticide development
Formulability / stability	**Excellent** – spores ensure long shelf life	**Weak** – sensitive to pH/temp/humidity	**Good** – non-sporulating, requires stabilizers
Main commercial applications	Biostimulant, biofertilizer, biocontrol	Microbial soil amendment, compost, digestates	Biocontrol, ISR, root stimulation
Patent/innovation potential	**High** – many strains remain unexplored	**High** – many environmental species unstudied	**High** – genetically diverse and promising
EU regulatory barrier (2025)	Not yet included in PFC 6A	No near-term inclusion expected	Not yet approved but under discussion
Growth potential	**Very strong** – regulatory support expected	**Increasing** – if CE market opens	**Strong** – especially in biocontrol applications

Set-up of 20 L BIOREACTOR for the production of microbial biomass

Chitosan preliminary flow pattern

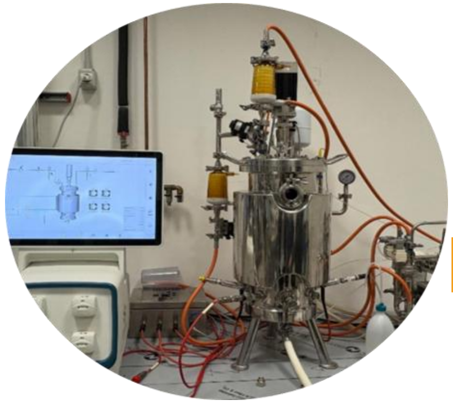


Collagen/Gelatin preliminary flow pattern



UNIBO APPROACH

- **3 strains were chosen for demonstration in 20 L bioreactor in relation to biostimulation and process resistance**



UNIBO has tested in 20L bioreactor the strain SP9, SP43, DSM, DAN 39

Parameters	SP43	DAN39	SP9	DSM 2298 (Control)
Biomass Yield in bioreactor (g/L)	0.60	1.24	3.81	2.07
Biomass Yield in flask (g/L)	0.63	0.95	0.77	0.48
Log CFU/g in biomass obtained in bioreactor	8.00	9.20	11.27	9.91
Bioreactor parameters	30°C, 200 rpm, 30h	37°C, 100 rpm, 48 h	30°C, 200 rpm, 30 h	30°C, 100rpm, 30 h
Robustness of the strain	Moderate	High	Very High	Very high

Optimal fish waste medium
- Carbon source: molasse or peach by-products (2%)
- N source: hydrolysate of blue fish waste 8%
- Spent yeast: 0,5%
- Fish wastewaters: 100mL

UNIBO-CNR APPROACH

Initial Viability Biomass (log CFU/g)	Viability in the pellets (log CFU/g)	Code	Strain	Formulation
8	5.4	SP43	*Bacillus amyloliquefaciens*	1
	6.0			2
9.2	5.3	DAN39	*Lb. plantarum*	3
	6.4			4
11	6.0	SP9	*Bacillus licheniformis*	5
	7.0			6
9.9	7.4	DSM2298	*Azospirillum brasiliense*	7
	7.7			8
--	<3	-	*Blank control (no biomass)*	9
	<3			10

Consiglio Nazionale delle Ricerche

CELL (wt%)	CH (wt%)	GEL (wt%)	ALG (wt%)	Biomass (wt%)
50	2	18	20	10

with glycerol (Gly, 10 wt%)

without glycerol (no Gly)

Tests in pot are running in RITTMO

Consortium

Thank you all the Partners

Project Coordinator

LEITAT managing technologies

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA | DIPARTIMENTO DI SCIENZE E TECNOLOGIE AGRO-ALIMENTARI

RITTMO agroenvironnement

Consiglio Nazionale delle Ricerche

NOVA ID — ASSOCIAÇÃO PARA A INOVAÇÃO E DESENVOLVIMENTO NOVA SCHOOL OF SCIENCE AND TECHNOLOGY

UNIVERSITY OF AGRICULTURE IN KRAKOW

ISQ

EFFoST

alchemia nova research

ECOPESCE

aeris TECNOLOGÍAS AMBIENTALES

tecno packaging tp

global omnium

Anecoop

Timac AGRO Italia

CMI CENTRE MONDIAL DE L'INNOVATION ROULLIER

FiBL Switzerland

iNeuvo

Tailored Technologies for Resource Recovery from Complex Streams

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Tailored Technologies for Resource Recovery from Complex Streams

Context:

Scaling **from pilot to industrial** level amplifies **operational, economic and quality-control challenges**, particularly as feedstock variability increases…

¿*When scaling up from pilot to industrial level,* ***how can*** *producers* ***balance process efficiency, product quality and low cost processing*** *when feedstocks are inherently variable?*?

Tailored Technologies for Resource Recovery from Complex Streams

Context:

Decentralised, seasonal and perishable feedstocks make **logistics a key driver** of feasibility, cost and process design…

¿*How do **logistics** (including decentralised generation, freshness, and seasonal availability) **shape technology choice and processing strategies** in real projects?*?

Tailored Technologies for Resource Recovery from Complex Streams

Context:

Regulatory uncertainty around **waste and by-product status** directly **shapes logistics, technology choices and investments**…

*How does the **uncertainty around waste versus by product classification** affect **decisions on transporting** bio based feedstocks across **regions or borders**? Or saying it in another way how risky is it for operators to **rely on by product status**, given different regional interpretations.*

*How does this uncertainty **affect investor confidence and the attractiveness of investing** in bio-waste valorisation projects*

Tailored Technologies for Resource Recovery from Complex Streams

Context:

Products derived from **waste streams** require higher levels of **transparency** (on agronomic performance, quality, safety, traceability, consistency…) and trust **to gain end-user acceptance**…

¿*What type of evidence (field trials, demonstrations, certifications) is* ***most convincing*** *for end users?*?

Tailored Technologies for Resource Recovery from Complex Streams

Context:

When **technology, logistics, regulation and markets are not aligned**, the **impact** of secondary stream valorisation **is limited**…

If you had to choose ***one key lever to unlock*** *wider* ***deployment of complex bio-waste valorisation*** *(process robustness, feedstock logistics, or regulatory adaptation)* ***WHICH*** *would it be, and* ***WHY****?*

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Thank you for joining us!

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