BIO RESCUE

BIOrescue:
A novel biorefinery concept for mushroom compost

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A CIRCULAR BIOREFINERY CONCEPT FOR AGRO-FOOD RESIDUES: THE BIORESCUE PROJECT

Inés del Campo, CENER

TOWARDS A CIRCULAR AGRO-FOOD INDUSTRY. 4 APRIL 2019. BRUSSELS.

This project has received funding from the Bio Based Industries Joint Undertaking under the European Union's Horizon 2020 research and innovation programme under grant agreement No 720708.

BBI JU

Bio-based Industries Consortium

Horizon 2020 European Union Funding for Research & Innovation

CHALLENGES

Each year, over **3 million tonnes of mushroom compost** is generated by mushroom production, thus creating **significant economic and logistical problems** for Europe's farmers.

- Mushroom compost, prepared solely for growing mushrooms, is only suitable for one to three harvests;
- The compost is currently disposed of, even though it contains valuable components;
- The mushroom industry lacks adapted technological solutions to upgrade this compost into valuable products

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BASE CASE STUDY: MUSHROOM PRODUCTION FARM

POULTRY & HORSE MANURE/ WATER/ WHEAT STRAW/GYPSUM

MUSHROOM SPAWN

MUSHROOM PRODUCTION FARM

MUSHROOM COMPOST

MUSHROOMS

- *Compost only suitable for one to three harvests;*
- *Currently disposed of at high cost;*
- *The mushroom industry lacks adapted technological solutions to upgrade this compost into valuable products*

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BIORESCUE OBJECTIVES

- To demonstrate an innovative and resource-efficient **biorefinery concept** for mushroom compost conversion;
- **To create valuable bio-based products** from mushroom compost and other lignocellulosic feedstocks;
- To achieve a **20% overall cost-reduction** in the enzymatic hydrolysis process;
- **To reduce disposal costs** for mushroom compost and generate a new income stream for mushroom producers.

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THE NOVEL BIOREFINERY PROCESS

- **Characterisation of biomass feedstocks**
- **Fractionation**
  - Thermochemical pretreatment
  - Organosolv treatment
- **Enzyme development & enzymatic hydrolysis**
- **Chemical and biochemical conversion**
- **Environmental, resource, techno-economic and social assessment**

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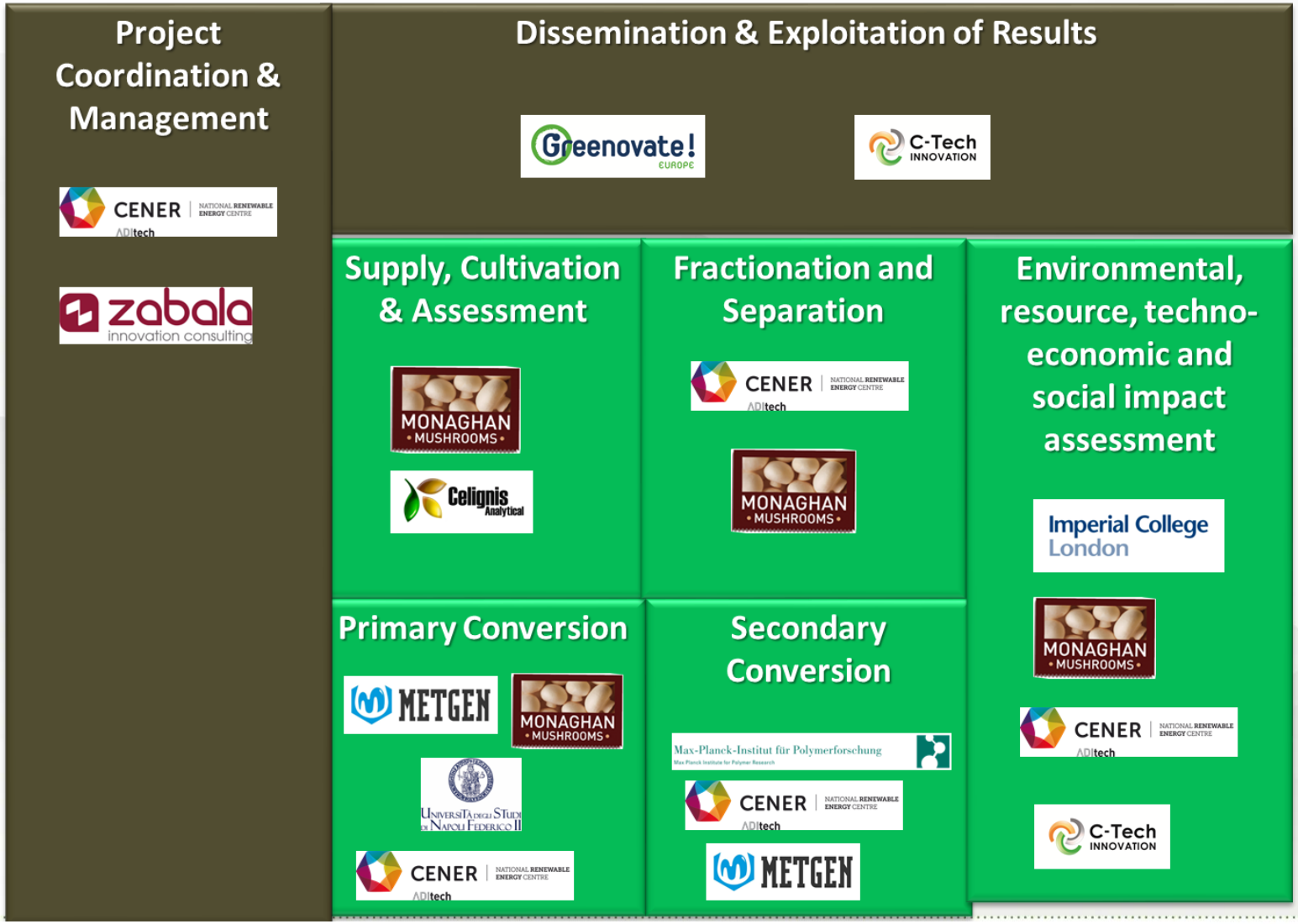

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FEEDSTOCK ANALYSIS

Rapid biomass Analysis

- Novel methodology based on Near Infrared (NIR) Spectroscopy
- Analysis of the composition of mushroom compost;
- Development of rapid analysis methods for real-time evaluation of biomass feedstocks (**2 weeks→ 1 day**)

Assessment of the availability of other underutilised agricultural feedstocks in mushroom producing regions;

- Southern EU → pruning from vineyards
- Western EU → barley and oat straw
- Northern EU →sugar beet pulp
- Eastern EU → apple pomace

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FRACTIONATION PROCESSES

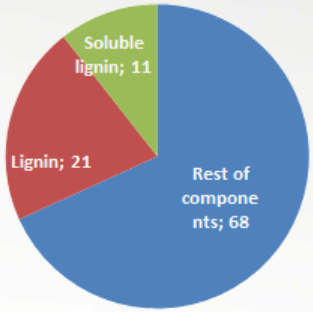
Thermochemical pretreatment for sugars

- **Mushroom compost blended with cereal straw** → enriched cellulose fraction prone to enzymatic hydrolysis for sugar production (>96% yield cellulose to glucose conversion)

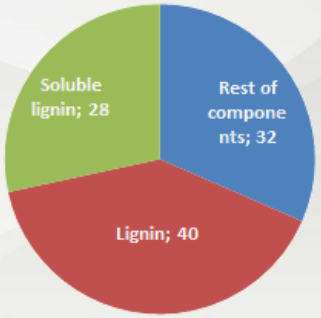
Organosolv treatment for lignin

- Successful process for dissolving lignin contained in either pristine mushroom compost (from 28% up to 38%) or recalcitrant (residue left after enzymatic hydrolysis) (from 30% up to 40%)

Mushroom compost



Recalcitrant fraction (mushroom compost + wheat straw)



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PRIMARY CONVERSION. ENZYMATIC HYDROLYSIS

- MetGen's tailored MetZyme® SUNO™ solutions enable **affordable sugar production** from mushroom compost
  - High operational and long-term stability of enzyme components used in MetZyme® SUNO™ solutions verified
  - Additional **cost reduction strategies** offered by efficient enzyme crosslinking and immobilization strategies
  - Additional novel cellulases and other booster enzymes available from UNINA through protein engineering, ready for production upscaling after the project.

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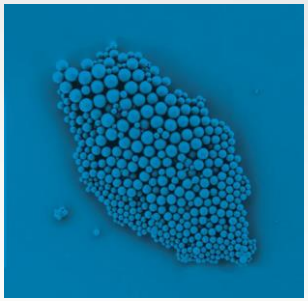
SECONDARY CONVERSION. CHEMICAL CONVERSION

Biodegradable nanocapsules for enhanced drug delivery

- Microscopic capsules made out of **polymer** membranes
- Use of soluble lignin-enriched fraction for the formation of nanocapsules and loading with hydrophilic or hydrophobic drugs
- Testing of drug loading and release from the lignin nanocapsules by enzymatic degradation
- **Encapsulation and release** of the produced **biopesticide**



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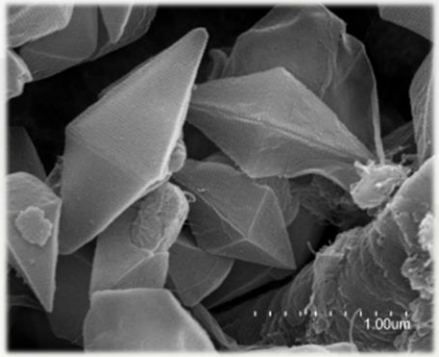
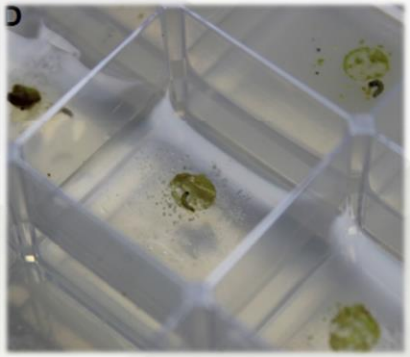
SECONDARY CONVERSION. BIOCHEMICAL CONVERSION

Low cost and sustainable biopesticides

- Validation of biopesticides production at pilot scale from BIOrescue sugars
- **High efficiency** against two Lepidoptera (insects) species (*Spodoptera littoralis, Spodoptera exigua)*





CENER facilities

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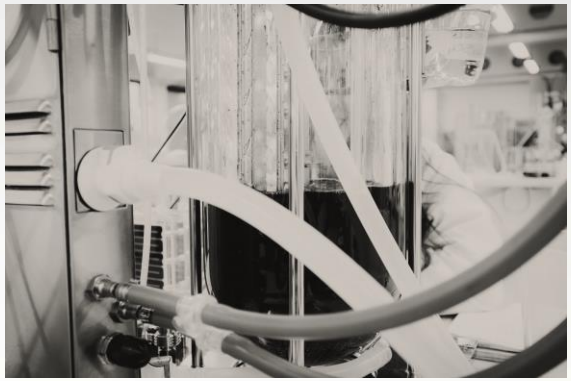
SECONDARY CONVERSION. BIOCHEMICAL CONVERSION

Laccases for lignin fractionation

- Production of laccase using BIOrescue sugars to be used in **lignin valorization** tests
- Lab-scale enzyme impact trials using organosolv lignin from compost



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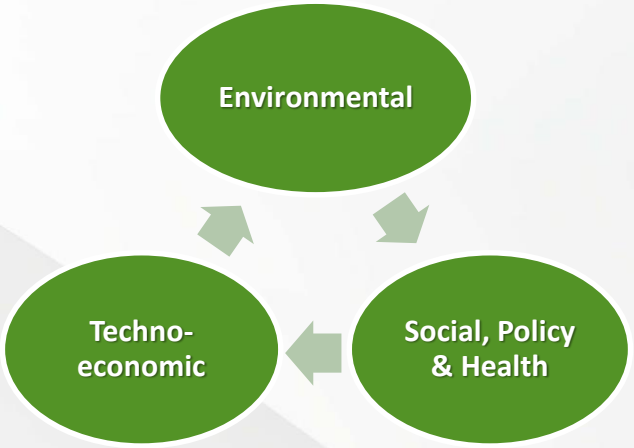
ENVIRONMENTAL, TECHNO-ECONOMIC AND SOCIAL ASSESSMENT

- **Technology performance** and efficiency evaluation of the biorefinery process
- **Environmental evaluation** based on LCA methodology
- **Techno economic assessment** to determine costs and benefits of individual process chains
- **Social, policy and health assessment**
- **Sustainability integration of all issues** to describe the most sustainable pathways among the value chains compared to all reference systems.



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PROJECT PARTNERS

- 10 partners from 7 different countries
- Duration: 3 years (September 2016-August 2019)
- Coordinated by CENER with the support of Monaghan Mushrooms as Technical Coordinator
- Co-funded by the Bio-Based Industries Joint Undertaking

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