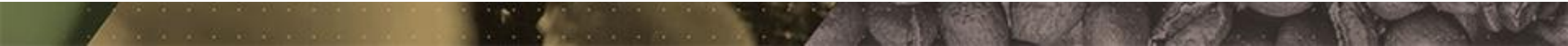
ALMA MATER STUDIORUM
UNIVERSITÀ DI BOLOGNA

Biorefinery cascading approaches applied to plant by-products: the PROLIFIC and AGRIMAX projects

Prof.ssa Annalisa Tassoni

Piacenza – Università Cattolica – 19-11-2019



EU BBI JU project PROLIFIC

Extraction and valorisation of proteins and bioactive molecules from legumes, fungi and coffee agro-industrial side streams

Philippe Corvini (FHNW) and
Annalisa Tassoni (UNIBO)

Fachhochschule Nordwestschweiz
Hochschule für Life Sciences

Project key figures

Call

- BBI 2017.R4 – Proteins and other bioactive ingredients from side streams and residues
- Research & Innovation Action project

Project duration:

- 4 years
- 1st September 2018 –31st August 2022

Funding

- 4.67 M€ EU contribution
- 5.3 M€ total cost

Partners

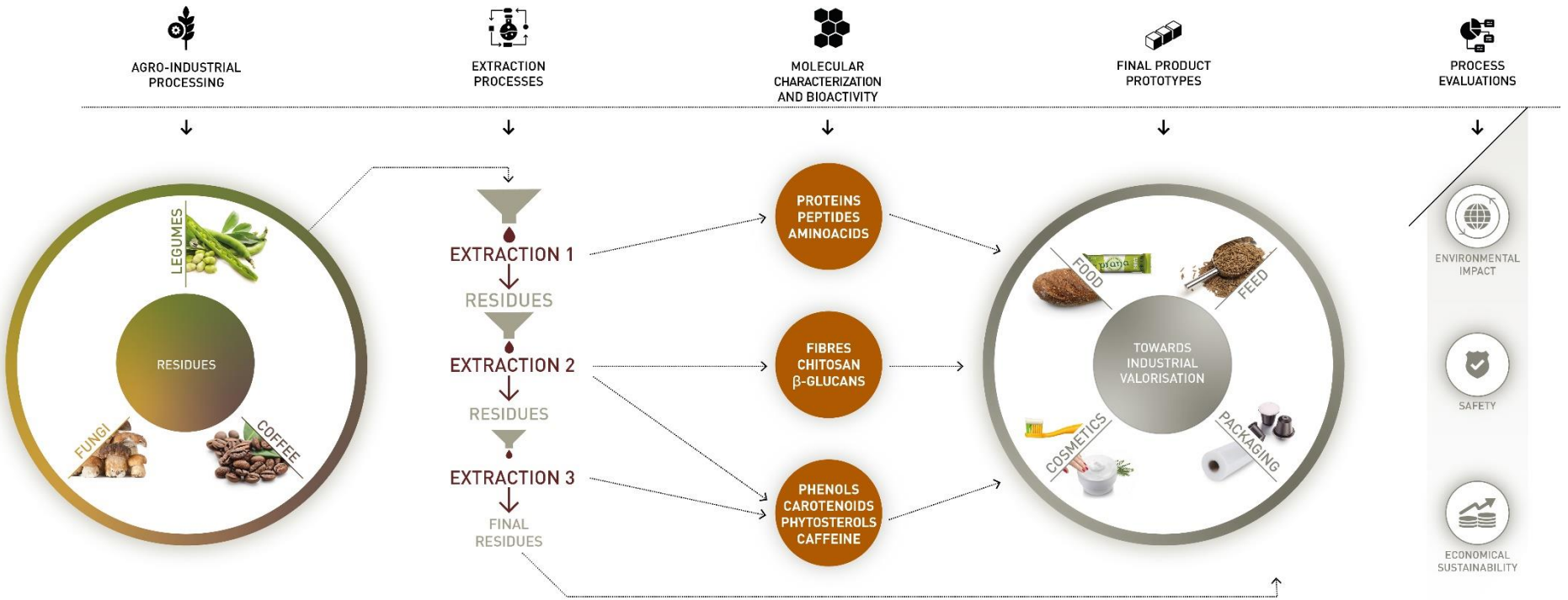
Consortium

- Coordination: UNIBO and FHNW
- 17 partners
- 11 SMEs
- 2 large companies
- 4 RTD institutions

Project idea

WP4 Evaluation and selection of the best performing isolated fractions according to foreseen applications

WP5 Industrial scale up of the processes and final product prototyping



WP1 Inventory and characterization of the initial feedstocks

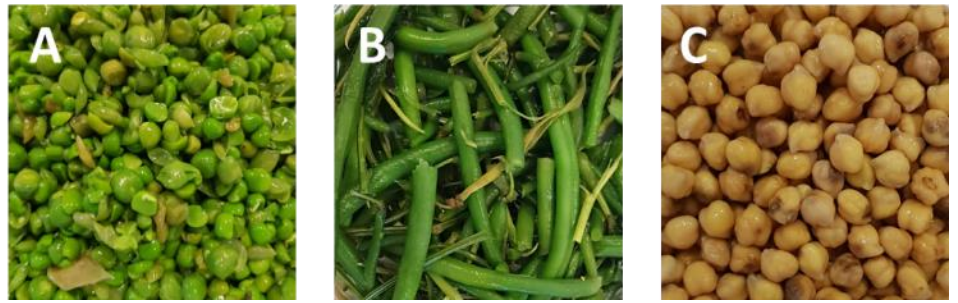
WP2 Flexible and scalable protocols for feedstock pre-treatment and extraction of the fractions of interest

WP3 Conversion of fractions and first steps of extracts valorisation

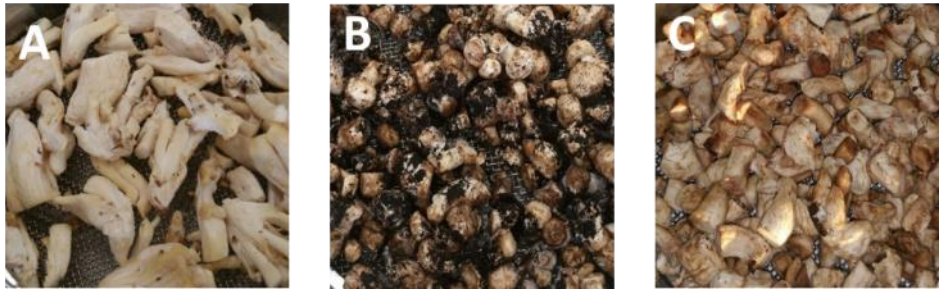
WP6 Life-Cycle Assessment (LCA) and Cost-Effectiveness Analysis (CEA)

The feedstocks

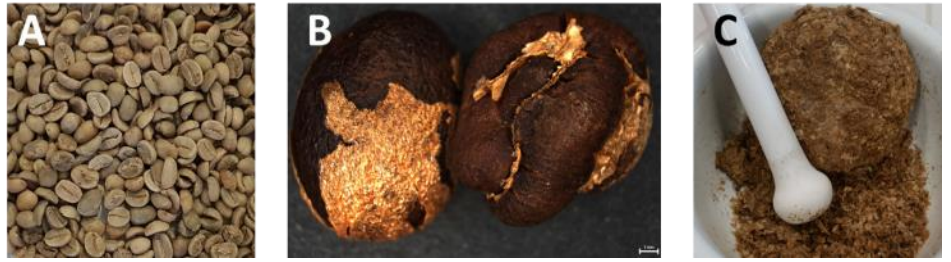
Legumes (CONSERVES FRANCE / ITALY)
Non compliant: fresh seeds of peas, fresh greenbeans, rehydrated chickpeas



Fungi (PLEURETTE)
Processing cuttings, left overs and mycelium of *Agaricus bisporus, Pleurotus ostreatus, Lentinus edodes*



Coffee (ILLY)
Silver skin and non-compliant coffee beans



Relevance of feedstocks in Europe
Annual production 2017 – FAO data

1.3 M tons mushrooms

3.6 M tons dry and green peas
1.5 M tons dry and green beans
0.14 M tons chickpeas

3.0 M tons green coffee beans (imported)

Example of pretreatment: fungi feedstocks

Cleaning loss (%)

3%

5%

35 %

Crushing and homogenizing for uniform drying conditions

Yield after drying

Flew-033	Flohk-032	FABw-036
Shiitake	Oyster mushroom	Portobello Champignon
Lentinus edodes	*Pleurotus ostreautus*	*Agricus bisporus* white strain
8.4 %	10.1 %	10 %

Aqueous extraction of legumes by-products

Peas

Chickpeas

Purity (Protein %): 70%
Yield in protein: 20%
High protein integrity
Protein form: mostly intact

PROTEIN EXTRACT

SPRAY-DRYING

RESUSPENSION IN WATER

STARTING BY-PRODUCTS

GRINDING AND HOMOGENIZATION

EXTRACTION WITH BUFFER SOLUTION

SEPARATION

Solid phase:
FIBER RICH FRACTION

Extraction FIBERS and of polyphenols, phytosterols, carotenoids

Liquid phase:
PROTEIN RICH FRACTION

PROTEIN ISOELECTRIC PRECIPITATION (ACIDIFICATION)

CENTRIFUGATION

Supernatant:
WASTE

Precipitate:
PROTEIN RICH FRACTION

Enzyme-assisted extraction

- Alcalase
- Papain
- Pepsin
- Trypsin
- Mix (alcalase + papain)

Chickpeas

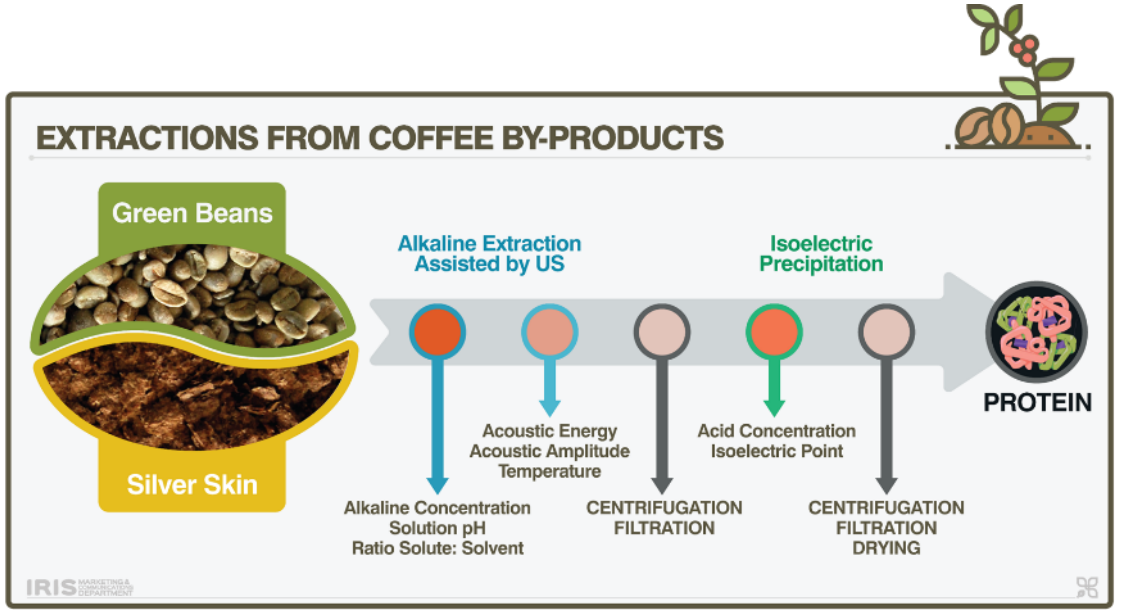
Purity (Protein %): 45%

Yield in protein: 30%

High protein integrity

Protein form: mixtures of peptides

Ultrasound-assisted extraction



Coffee green beans extracts

Purity (Protein %): 40%
Yield in protein: 40%
Protein form: mostly intact proteins

Extraction of fungi by-products

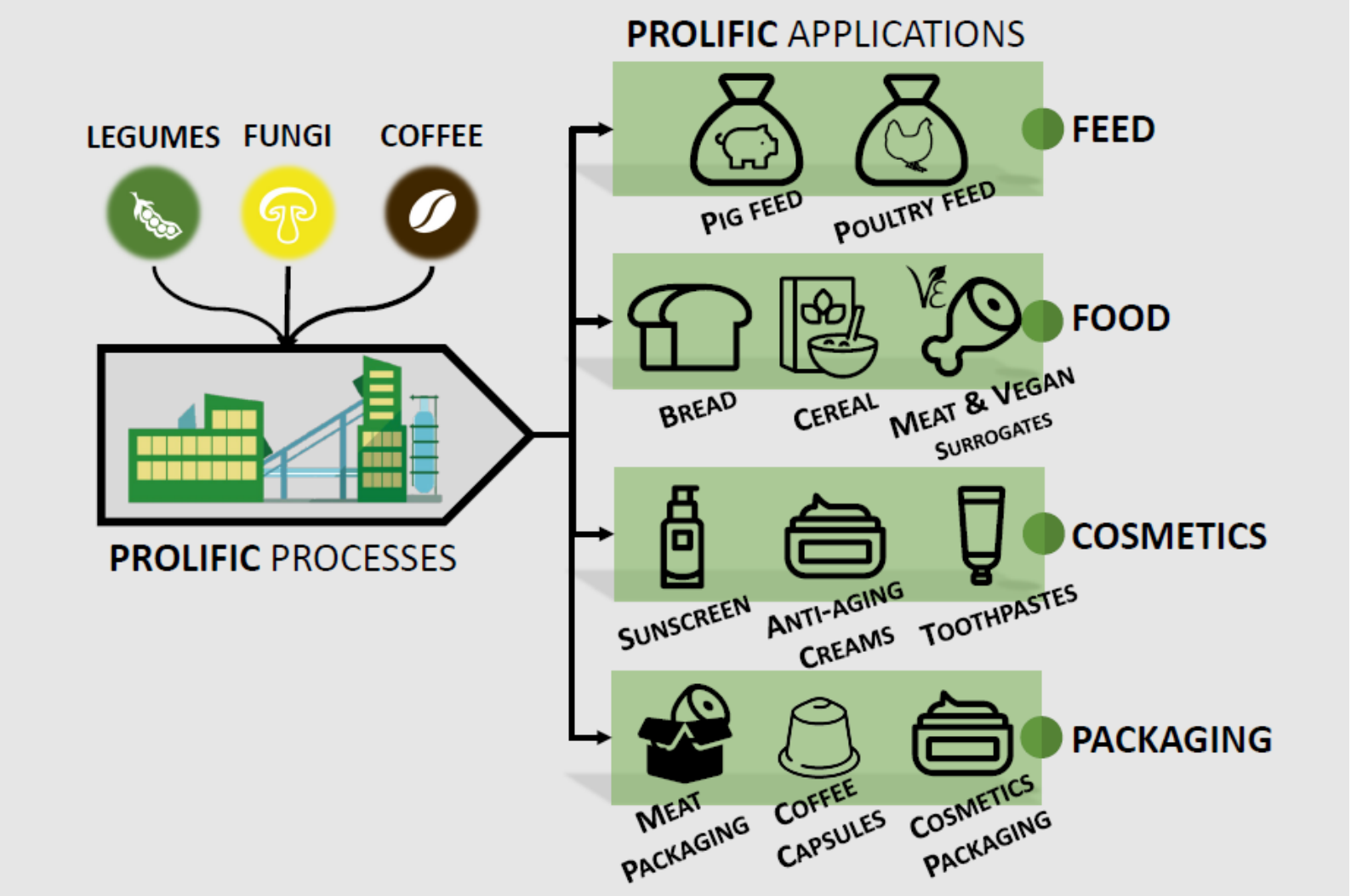
Pleurotus lentinus

Milling

Ethanolic extract :
30% yield
(containing **polyphenols**)

Fiber extract :
20% yield, (containing **chitosan/*β*-glucans**)

During PROLIFIC **16 new product prototypes** will be produced in 4 different industrial fields: **food, cosmetic, feed, packaging**



First high-protein cereal-based FOOD prototypes

Emmer - spelt bread + pea proteins

High proteins spelt bread + chickpea proteins

First FOOD prototypes: extrudates with total dried fungi

Extrudates without or with 10% dried Pleurotus ostreatus

Extrudates with 10% dried Agaricus bisporus

PROLIFIC's foreseen PACKAGING applications

At least 4 bioactive and/or biodegradable **packaging prototypes for food and cosmetics** will be produced among which:

- **meat coating (SSICA)**
- **biodegradable and bioactive coffee capsules (FEMTO, ILLY)**
- **bioactive cosmetic packaging (FEMTO, COSMETICS)**
- **biocomposites (FEMTO, UNIPISA)**

Thank you for your attention!

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www.prolific-project.eu

prolificproject

prolificH2020

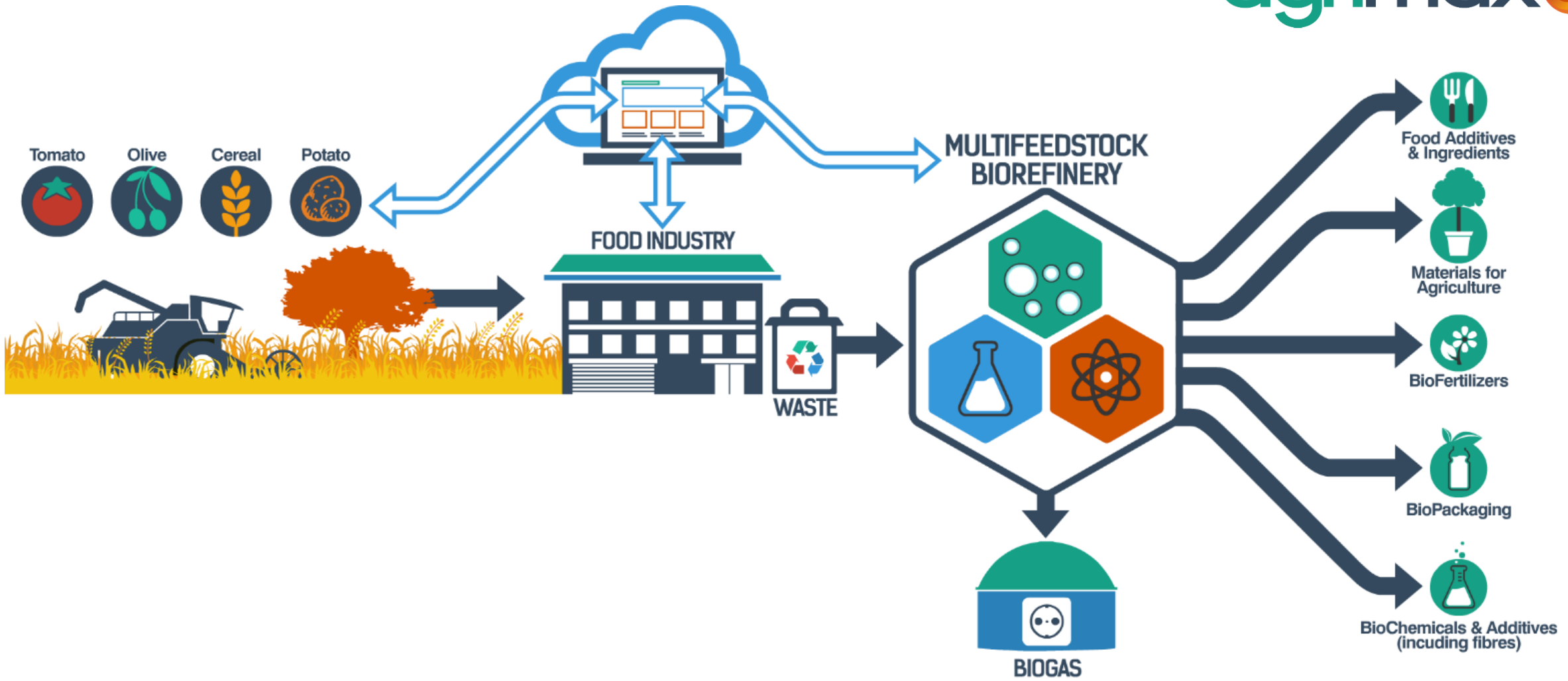
www.researchgate.net/project/PROLIFIC-3

Horizon 2020
European Union Funding
for Research & Innovation

PROLIFIC has received funding from the Bio Based Industries Joint Undertaking (JU) under the European Union's Horizon 2020 research and innovation programme under grant agreement No 790157.

PROJECT: **AGRIMAX (2016-2020)**
financed by H2020-BBI-JU (GA n. 720719)

Agri & food waste valorisation co-ops based on flexible multi-feedstocks biorefinery processing technologies for new high added value applications



Horizon 2020
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BIO-BASED INDUSTRIES
Public-Private Partnership

Bio-based Industries
Consortium

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. 720719.

Agrimax in numbers

48 Months (1st October 2016 – 30th September 2020)

29 Partners

11 Countries (Austria, Belgium, Germany, Hungary, Ireland, Italy, the Netherlands, Norway, Slovenia, Spain, United Kingdom)

15 Million € (ca. 12 M€ EC contribution)

TRL >7 Demonstration Action

BBI VC3.D5 - 2015 Valorisation of agricultural residues and side streams from the agro-food industry

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Collaborative working

ARCHA Analisi, ricerca e formazione

ArdaghGroup

AIMPLAS INSTITUTO TECNOLÓGICO DEL PLÁSTICO

Barilla

BioVale

Chiesa

exergy Engineering that inspires

FEMTO Engineering srl

FEDERACIÓ DE COOPERATIVES AGRÀRIES DE CATALUNYA

Fraunhofer

BPF BIOPROCESS PILOT FACILITY

FERTINAGRO BIOTECH

Gaviplás

iris

PACKAGING, TRANSPORT & LOGISTICS RESEARCH CENTER ITENE

INSTM

Indulleida

IRTA RECERCA I TECNOLOGIA AGROALIMENTÀRIES

LC Innoconsult INTERNATIONAL

LVA LEBENSMITTEL. VERTRAUEN. ANALYSEN. LEBENSMITTELVERSUCHSANSTALT

mogu RADICAL BY NATURE

Nofima

OWS Organic Waste Systems

GROZD PLASTTEHNIKA GP SLOVENIJA

SSICA STAZIONE SPERIMENTALE PER L'INDUSTRIA DELLE CONSERVE ALIMENTARI

IN LUMINE SAPIENTIA UNIVERSITAS ALMERIENSIS

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

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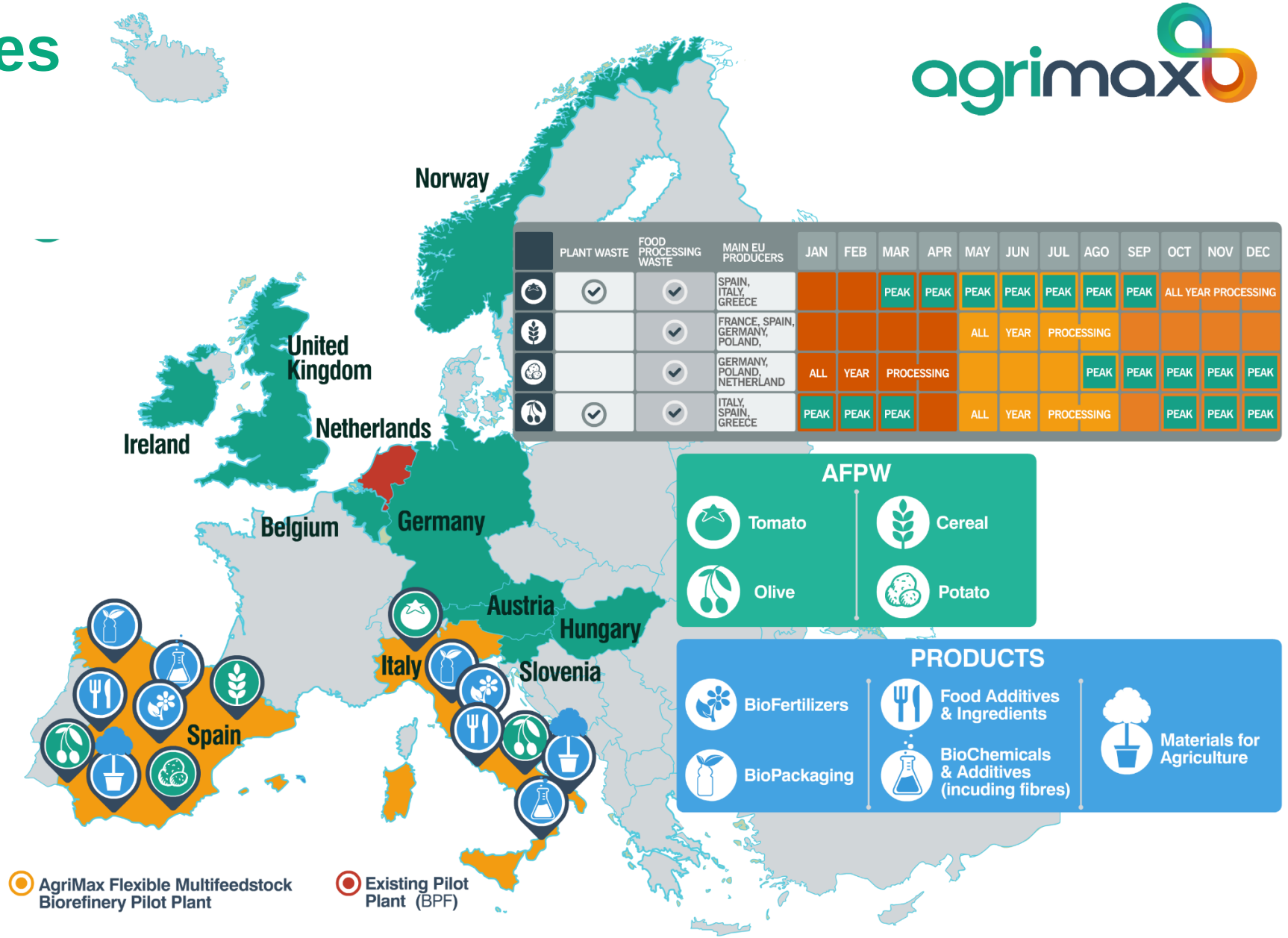
2 pilot biorefineries in Italy and Spain

Two pilot plants were built and are running on a cooperative basis to prove the viability of the proposed **multi-feedstock biorefinery approach**



	PLANT WASTE	FOOD PROCESSING WASTE	MAIN EU PRODUCERS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AGO	SEP	OCT	NOV	DEC
	✓	✓	SPAIN, ITALY, GREECE			PEAK	PEAK	PEAK	PEAK	PEAK	PEAK	PEAK	ALL YEAR PROCESSING		
		✓	FRANCE, SPAIN, GERMANY, POLAND,					ALL	YEAR	PROCESSING					
		✓	GERMANY, POLAND, NETHERLAND	ALL	YEAR	PROCESSING					PEAK	PEAK	PEAK	PEAK	PEAK
	✓	✓	ITALY, SPAIN, GREECE	PEAK	PEAK	PEAK		ALL	YEAR	PROCESSING			PEAK	PEAK	PEAK

AFPW

- Tomato
- Cereal
- Olive
- Potato

PRODUCTS

- BioFertilizers
- Food Additives & Ingredients
- BioPackaging
- BioChemicals & Additives (incuding fibres)
- Materials for Agriculture

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Italian Pilot Plant

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Tomato (peel & plant) waste

- **Cutin extraction: a new coating for metal food packaging industry, safer to the consumer, more sustainable**
- Lycopene extraction: antioxidant, food additive for the food industry
- Biogas production: after the cutin and lycopene extraction better performances of the exhausted skins in comparison with non-treated ones

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Tomato (cull fruit & plant) waste

- Compost: solid fertiliser for the farming industry
- Hydrocompost: liquid fertiliser for the farming industry

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Cereals wheat bran processing

- **Extraction of ferulic acid via an alkaline-based process; extraction of fibres for biocomposites; polyphenols for food/packaging applications**
- **Polymerization of ferulic acid to produce biopolymers for farming / packaging industry**

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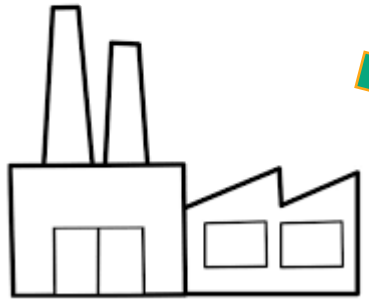
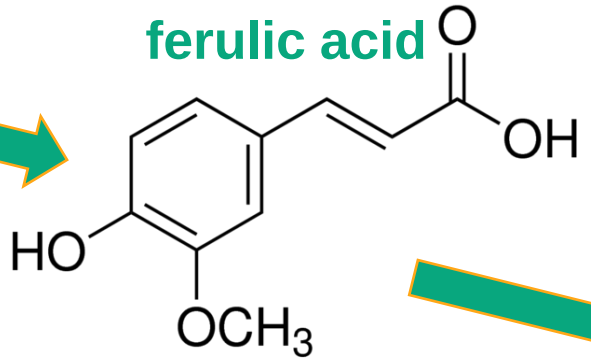
Wheat bran valorisation



Barilla spa
(Italy)

wheat bran

ferulic acid



aqueous residue
(sugars, peptides
and aminoacids)

fungi growth medium,
biogas

solid residue
(insoluble fibers)

nanofibers,
biocomposites

bioplastics

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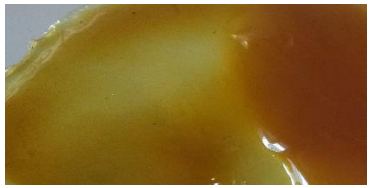
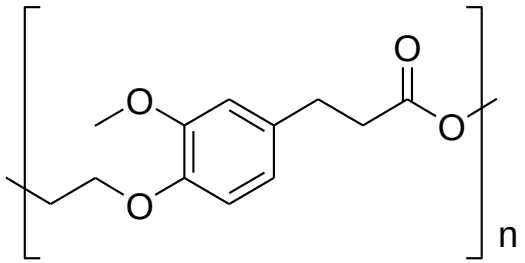
2-step Chemical Modification and Polymerization => Bio-based PHEF polymer





Poly-dihihidro (ethylene ferulate) PHEF

- *Rigid and flexible packaging*
- *Materials for agricultural applications*

TGA		DSC	GPC		
Onset (° C)	Max Degradation (° C)	(° C)	Mw	Mn	PDI
398	435	30.4	33000	11000	3.0

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Spanish Pilot Plant

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Olives (pomace and leaf) by-products and bio-wastes

- **Extraction of phenolic compounds: antioxidant ingredients and edible coatings for food & packaging industry**
- Extraction of natural aromas from olive by-products and bio-wastes for the food industry
- Fibres: food ingredient for the food industry

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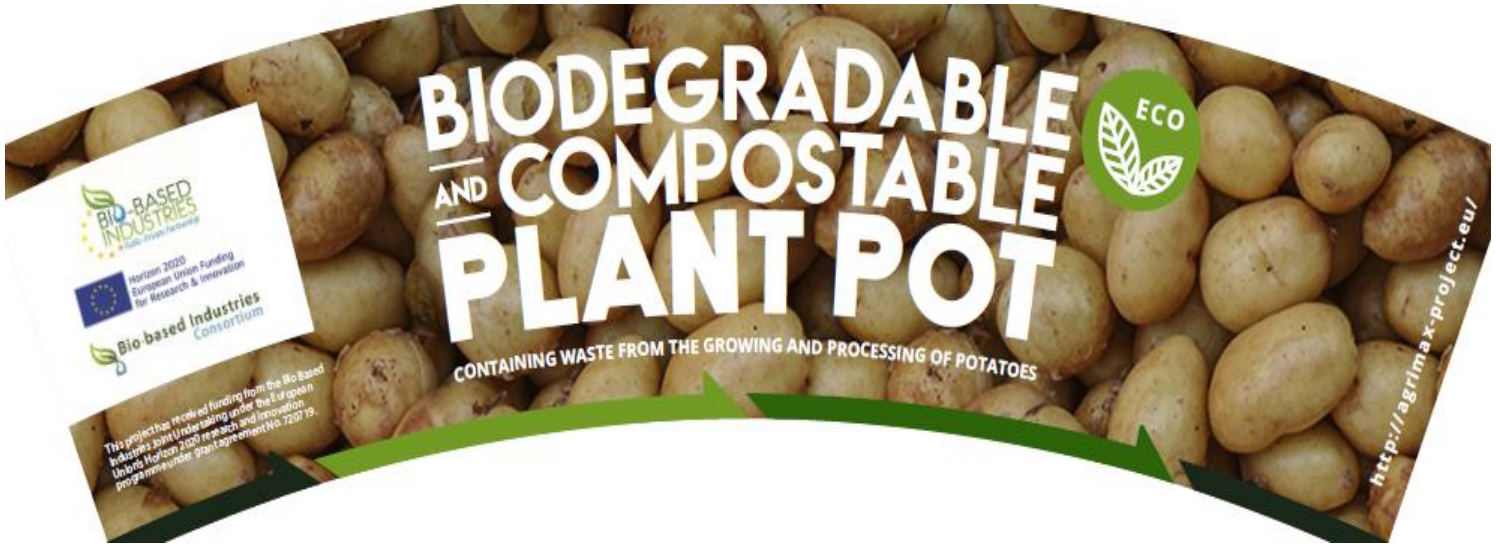

Potato (from pulp and peel) waste

- **Fibres: bio-composites, biodegradable and compostable plant pots for the agricultural industry**

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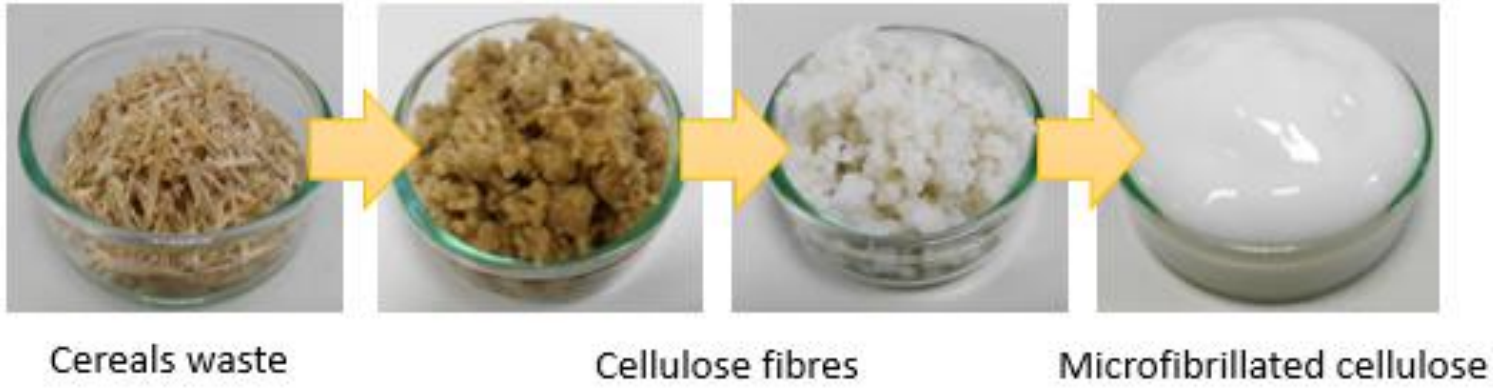

Oat husk, spelt husk, wheat bran and potato waste

- Cellulose fibres (micro fibrillated cellulose)
- **Barrier coating for food packaging / films industry**
- Thickening agent and natural additive for the food industry
- Phenols extracted from potato peel

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