



AgriMax Biorefinery

Valorization of crop and food processing by-products through an integrated cascade process



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Horizon 2020
European Union Funding
for Research & Innovation





SSICA, Experimental Station for the Food Preserving Industry, is a **Research Institute**, established in Parma in 1922.

SSICA activities focus on applied research regarding the production chain in the agro-food sector and food processing industry.

SSICA has about 100 employees in 2 locations, Parma and Angri (SA).



The **Packaging department** focuses its activity on the hygienic-sanitary control, as well as on the correct functioning of the containers and of the materials involved, in relation with their construction characteristics and operating conditions for use.

The Packaging department is actively involved in research projects related to the development of new sustainable packaging and biobased materials for the food sector.



One third of all food produced globally is wasted every year  1.3 billion tons of food¹

Within the European Union approximately 90 million tons of food are wasted² and about 700 million tons of agricultural wastes³ are generated annually.

These wastes can be reused in other production processes and are potential sources of bioactive compounds.

¹<https://www.fao.org/state-of-food-agriculture/2019/en/>

²A. Stenmarck, C. Jensen, T. Quested, G. Moates. 2016. Estimates of European Food Waste Levels. FUSION.

³A. Pawelczyk. 2015. EU policy and legislation on recycling of organic wastes to agriculture. ISAH. 1. 64-71.

AgriMax General Information

Type of action: Innovation Action - Demonstration

Start date: 01 October 2016

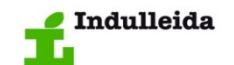
End date: 30 September 2021

BBI JU contribution: € 12,484,461.46

The Consortium

- ✓ 11 RTDs
- ✓ 18 SME and Large industry
- ✓ 3 partners are BIC members and 8 associated BIC members to maximise the output alignment to the BBI programme

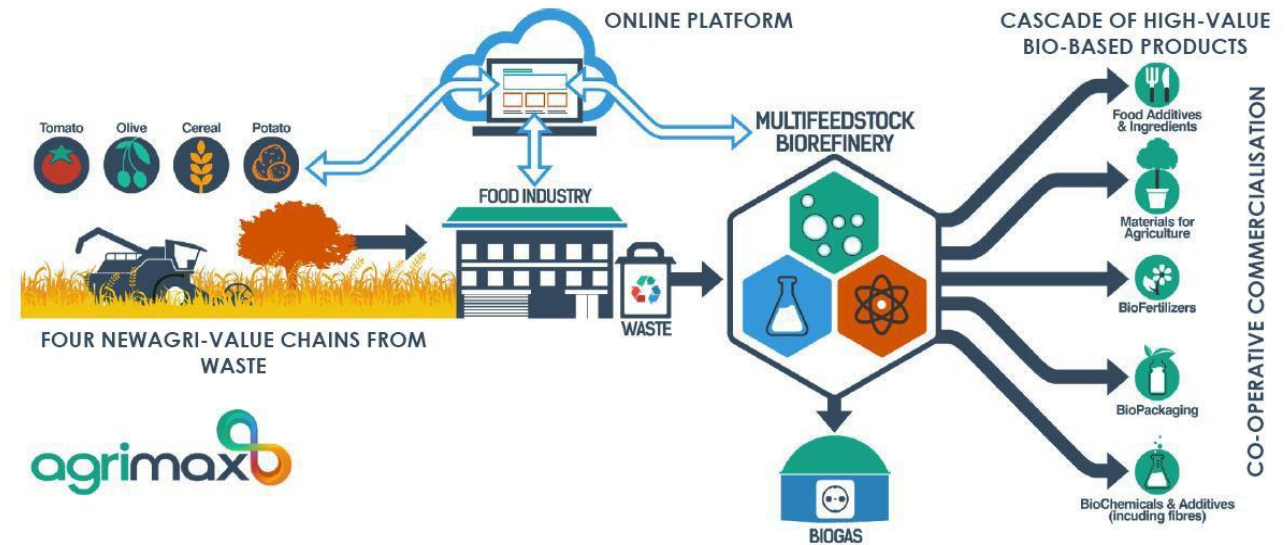
covering the whole supply and value chain



Project goals

→ To demonstrate the **technical and economic feasibility of combined flexible biorefinery processes** for valorising crops & food processing derived wastes

→ To maximise the economic and environmental **sustainability** of the EU **agricultural and food sectors** in while providing new **bio compounds** to the chemical, bioplastic, **food, packaging and agriculture sectors**.



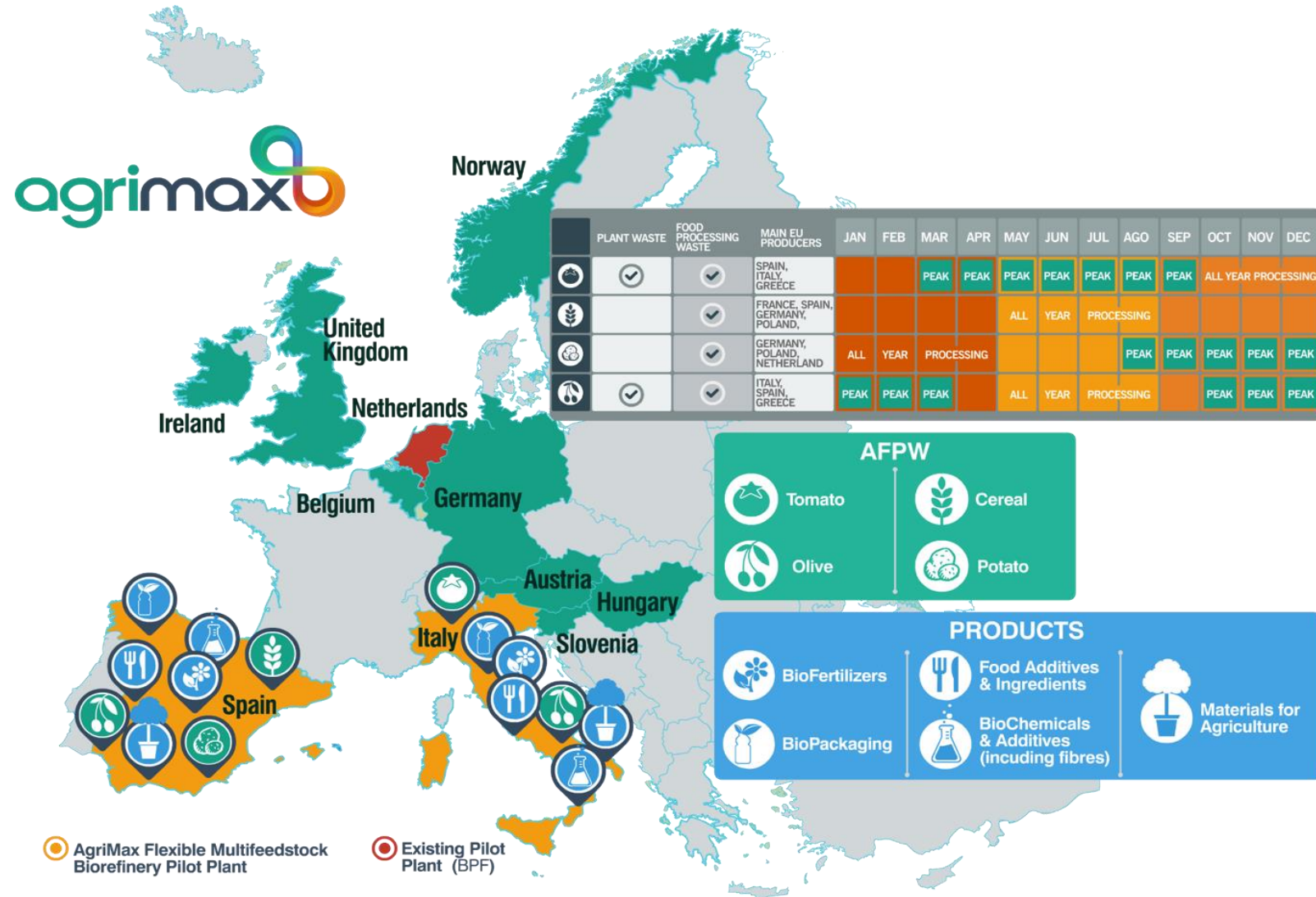
agrimax



2 pilot biorefineries

The two pilot plants were built (one in Italy and one in Spain) on a cooperative basis to prove the viability of the proposed approach

- *Flexible and integrated*
- *Designed to maximise shared equipment*



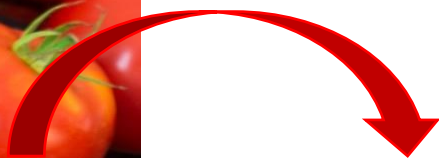


Italian Biorefinery Canneto sull'Oglio (MN) - ITALY





Tomato by-products



Cereals by-products



- Cutin



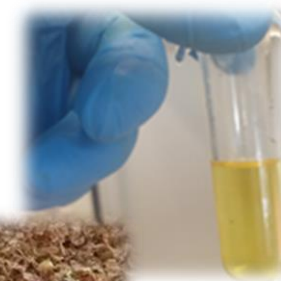
- Lycopene



- Compost and hydrocompost



- Ferulic acid



- Fibers





Tomato (peels & seeds) waste

- **Cutin extraction:** a new coating, from natural source, for metal food packaging industry
- **Lycopene extraction:** antioxidant, food ingredient for the food industry
- **Biogas production:** exploitation of the residual biomasses from the cutin and the lycopene extraction, for a sustainable production of energy



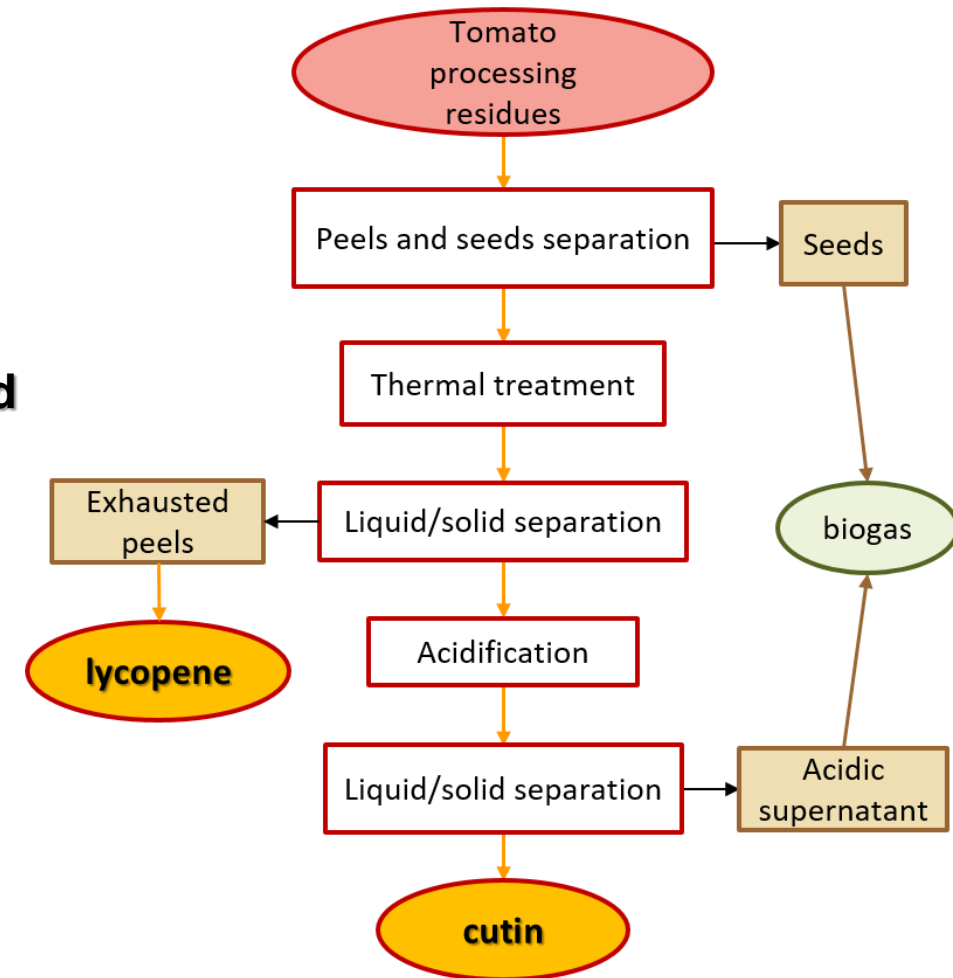
Cutin is:

- ✓ a component of the cuticle of the tomato peels
- ✓ **natural polymer of polyester type⁴**
- ✓ Mainly composed (70-80%) of **10,16 dihydroxyhexadecanoic acid** starting substance for the polymerization



Cutin is **extracted** from tomato **by-products**:

- ✓ Avoiding organic solvent
- ✓ Exploiting few simple steps
- ✓ Using commercial available equipment



⁴Heredia-Guerrero, J., Heredia, A., Dominguez, E., Cingolani, R., Bayer, I., Athanassiou, A., & Benitez, J. (2017). Cutin from agro-waste as a raw material for the production of bioplastics. *Journal of Experimental Botany*, 68(19), 5401-5410



Project Development

- ✓ Formulation of the **new bio-lacquer** at **pilot scale**
- ✓ **Industrial application** on aluminium, tin free steel and tinplate
- ✓ Evaluation of the **chemical** and **mechanical properties** and **food contact compliance** with the Italian and European legislation
- ✓ **Industrial production** of 3 pieces cans and open top ends
- ✓ **Filling** of the cans with tomato, tuna and legumes for **shelf life** evaluation



Evaluation of the bio-lacquer applied on metal sheets

✓ Food contact compliance

Overall and specific migration tests referring to the National (Ministerial Decree 21st March 1973 and further amendments, Ministerial Decree 18/2/84 and Ministerial Decree 26th April 1993) and European (Regulation (EU) n.10/2011 and further amendments and Regulation (UE) n. 2018/213 - 12nd February 2018) Legislation

✓ Chemical and mechanical properties

Test	Method	Results
WACO porosity	NaCl 1% solution (electrochemical analysis)	< 10 mA/dm ²
Dry adhesion	UNI 8574/6	Good
Thermal resistance	Water and vapour 121°C 1h (UNI 8574-1:1984)	Good
Corrosion resistance	Citric solution pH 4 and cysteine solution pH 6 EIS (Electrochemical Impedance Spectroscopy)	Low-medium acidic products

Some data about production

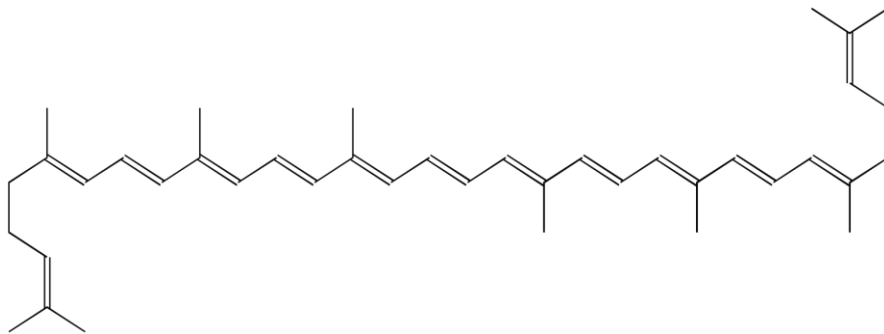
- ✓ The biorefinery can process 500 kg/h of tomato by-products
- ✓ n. 10 trials carried out on the biorefinery to optimize the cutin extraction process
- ✓ 90 kg of cutin produced for the industrial bio-lacquer production
 - ✓ 90 kg of bio-lacquer produced
- ✓ n. 6000 tinplate cans of ½ kg size produced on industrial line
- ✓ n. 500 tinplate cans of 80 g size produced on industrial line
 - ✓ n. 500 cans filled with tomato passata
 - ✓ n. 200 cans filled with legumes
 - ✓ n. 170 cans filled with tuna



By courtesy of Salchi Metalcoat

Lycopene is:

- ✓ a molecule present in red fruits and vegetables of which tomatoes are the major contributor⁵
 - ✓ a natural antioxidant
 - ✓ a carotenoid
- 
- A collage of images showing red fruits and vegetables, including tomatoes, strawberries, pomegranates, and mangoes, alongside a pile of red capsules, illustrating the natural sources of lycopene.



⁵Usman Mir Khan , Mustafa Sevindik, Ali Zarrabi , Mohammad Nami, Betul Ozdemir, Dilara Nur Kaplan, Zeliha Selamoglu, Muzaffar Hasan, Manoj Kumar, Mohammed M. Alshehri and Javad Sharifi-Rad. *Lycopene: Food Sources, Biological Activities, and Human Health Benefits*. Oxidative Medicine and Cellular Longevity, Volume 2021, Article ID 2713511, <https://doi.org/10.1155/2021/2713511>

Project development and results

- ✓ Extraction of lycopene from the tomato peels discarded by the cutin extraction process (additional valorization of tomato by-products)
- ✓ Set up of the extraction method at laboratory scale - n.12 trials on 2 L Naviglio® Extractor
- ✓ Scale up of the extraction protocol to pilot scale - n.12 trials on 40 L Naviglio® Extractor
- ✓ Application as food colorant





Tomato (cull fruit & plant) waste

- **Compost:** Solid fertiliser for the farming industry
- **Hydrocompost:** liquid fertiliser for the farming industry





Cereals (wheat bran) waste

- **Biopolymers (mycelium materials)** for farming / packaging industry
- Extraction of **ferulic acid, phenolic compounds and fibres**
- **Proteins plus ferulic acid** extract as ingredient for functional food



Conclusions

The biorefinery can successfully process all the feedstocks tested

All the products obtained were applied in their specific sector

Cutin

- ✓ Successfully extracted from tomato peels at the biorefinery
- ✓ Production of the bio-lacquer at pilot scale and its application on industrial line
- ✓ Industrial production of tins and filling with food products on industrial line
- ✓ The migration tests verified the compliance to food contact
- ✓ The bio-lacquer is suitable for packing medium and low acidic food products (e.g. tomato, legumes, tuna)

Lycopene

- ✓ Identification of the extraction protocol at laboratory scale
- ✓ Scale up of the protocol at pilot scale → further research needed



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