The PRIMA programme is supported under Horizon 2020, the European Union's Framework Programme for Research and Innovation

Innovations in Food Loss and Waste Management

Final meeting of PRIMA project StopMedWaste and Meeting of COST CA22134 Action FoodWaStop
January 23-25, 2024 – D3A, University of Ancona

"BiOrangePack" is a supply chain project aimed at enhancing the sustainability of post-harvest practices for citrus fruit

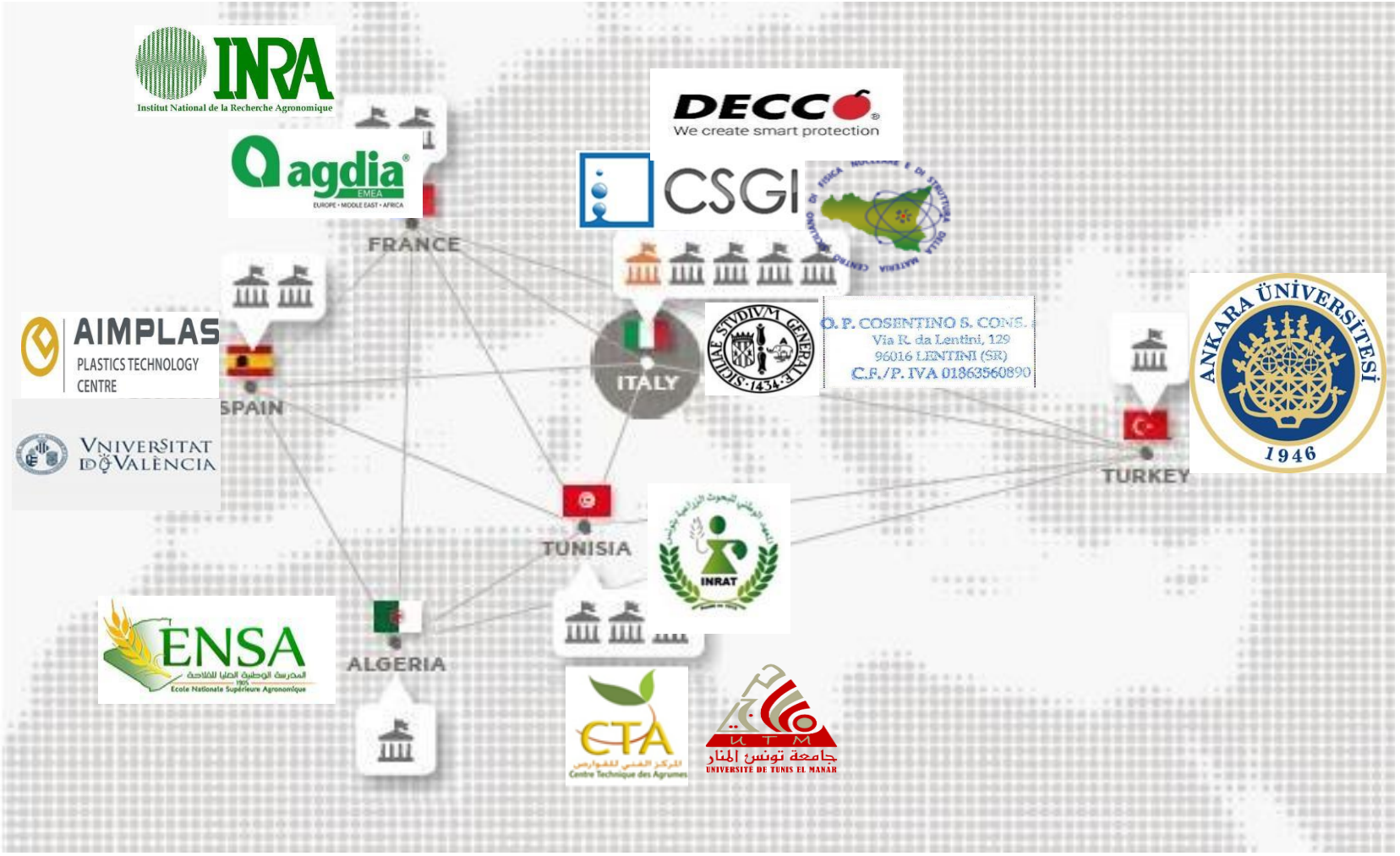
Dott. Federico LA SPADA, Prof. Santa Olga Cacciola

Di3A, University of Catania

BiOrangePack Project – The Consortium

14 PARTNERS from 6 Countries

- ITALY
- ALGERIA
- FRANCE
- SPAIN
- TUNISIA
- TURKEY



PUBLIC Institutions and PRIVATE companies involved in the citrus market

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BiOrangePack Project – The Consortium

- **ITALY: University of Catania coordinator (UNICT); Interuniversity Consortium for the Development of Large Interface Systems (CSGI); the Sicilian Center for Nuclear Physics and Structure of Matter (CSFNSM); a private company developing eco-formulates (DECCO), Organization of citrus producers (OP-Cosentino)**

- **ALGERIA: National School of Agronomy (ENSA)**

- **FRANCE: National Research Institute for Agriculture, Food and the Environment (INRAE); a private company that provides diagnostic solutions for plant pathogens (AGDIA)**

- **SPAIN: University of Valencia (UNIValencia); AIMPLAS, a Plastics Technology Research Center**

- **TUNISIA: University of Tunis El Manar, CTA, the Technological Center For Citrus; INRAT, the National Institute for the Research in Agriculture**

- **TURKEY: University of Ankara**

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BiOrangePack

Project data

http://mel.cgiar.org/projects/biorangepack

PRIMA-MED

Thematic area
Agro-food Value Chain
Section II-2019

Budget
1.282.397,00 €

Topic
Extending shelf-life of perishable Mediterranean food products

Durata
36 mesi

Period of implementation:
03/nov/2020 - 02/nov/2024

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Main goal of BiOrangePack

To increase the efficiency, sustainability and competitiveness of the post-farming supply chain of organic citrus fruit in the EU-MED area

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Background and context

Weakness Points in the Mediterranean citrus supply chain

- Presence of quarantine pathogens
- Competitiveness of other markets
- The need for expansion of fresh citrus fruit trade to distant markets LOGISTICS
- POST-HARVEST LOSSES
- Rapid perishability of citrus fruits
- Restrictive laws which reduced or banned the use of pesticides
- MYCOTOXINS produced by post-harvest fungal pathogens

TO BE COMPETITIVE CITRUS FRUIT produced by Med. Countries should be of high quality, ensure health of the consumers and have a long shelf-life

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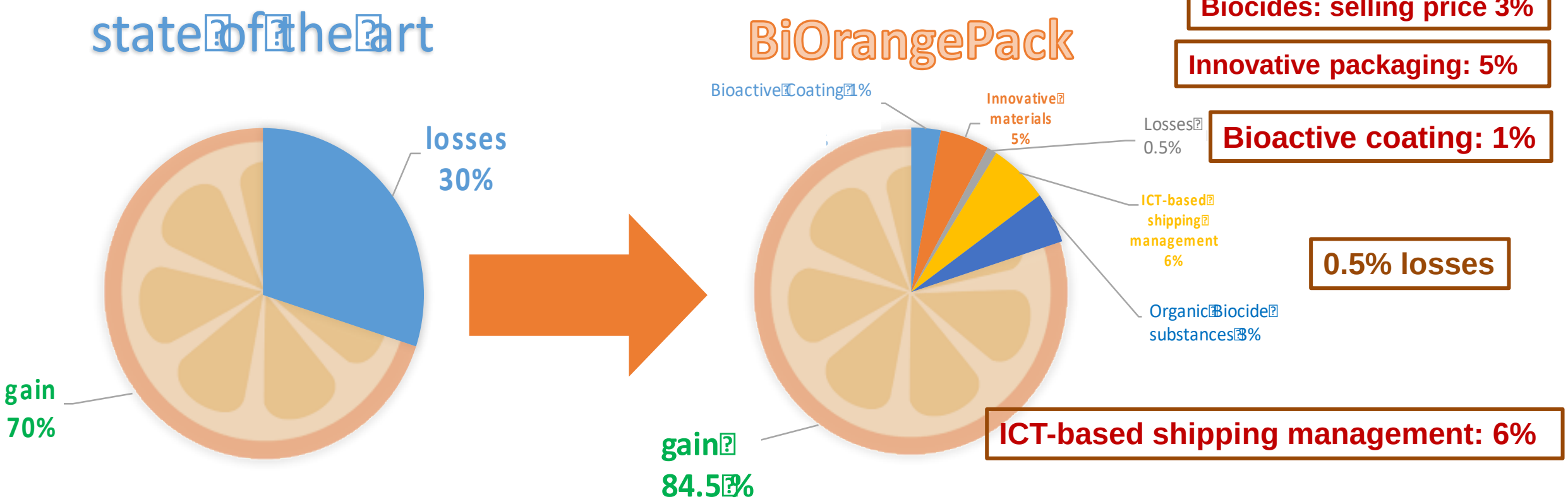
Estimated Economic impact of BiOrangePack



Thank to the introduction of BiorangePack approach, total income (gain) will increase from 70% to 84.5%

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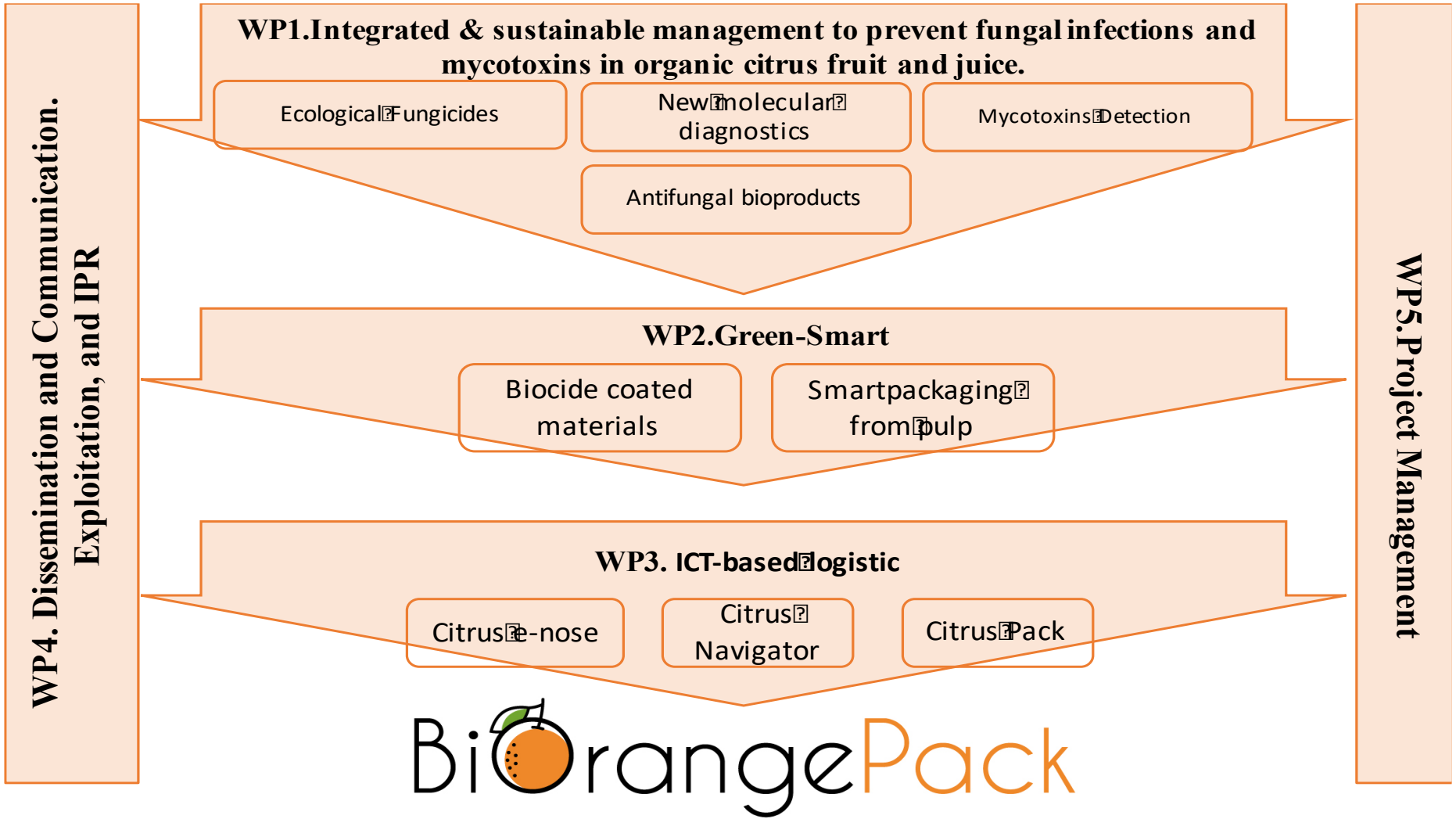
How the Project is organized



1. **Cheap, Rapid, Simple Detection methods**
2. **New Eco-friendly formulations**
3. **Bio-edible coatings**
4. **Active Packaging from citrus waste**
5. **ICT for the logistics.**

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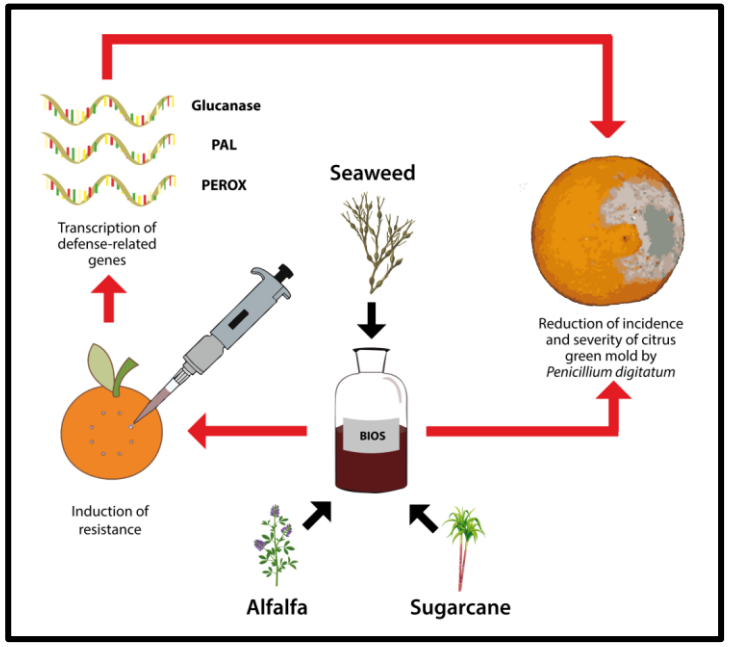
Results of BiOrangePack - WP1

Development of eco-friendly antifungal products to control major fungal infections (citrus green mold)



1. seaweed extract and plant derivative 'formula'

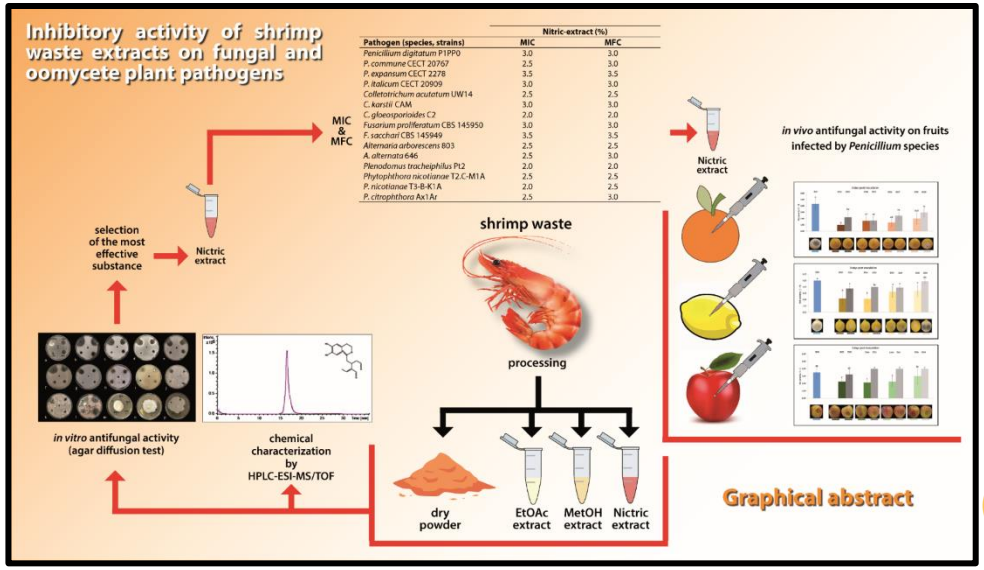
- **marked antifungal post-infection activity;**
- **elicitation of plant defence response.**

La Spada, et al. *Front. Plant Sci.* **2021**, *12*

2. shrimp waste extract

- ***In vitro* reduction of pathogen growth and viability;**
- ***In vivo* reduction of incidence of the green mold.**

El boumlasy et al., *Plants* **2021**, *10*, 2452

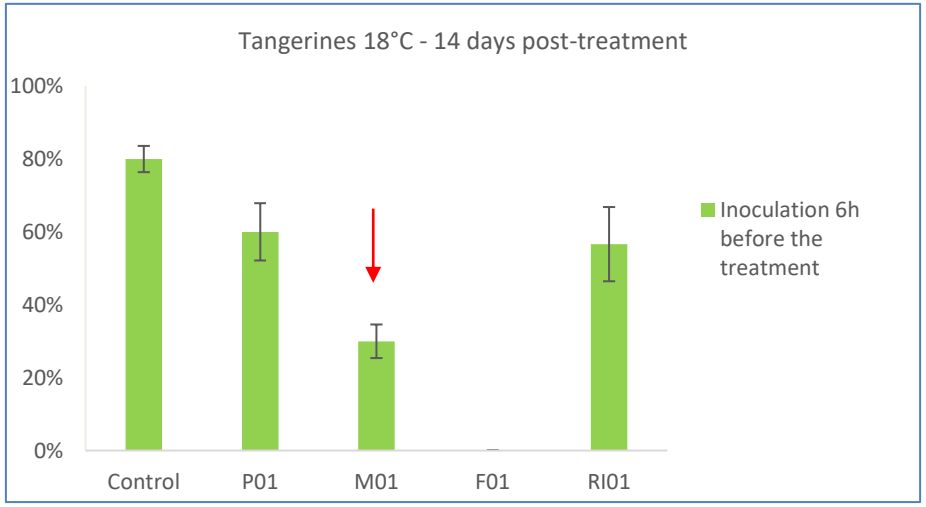


Results of BiOrangePack - WP1

New selected bioproducts (living microrganisms) strongly effective in the reduction of incidence of citrus green mold in tangerines and oranges.

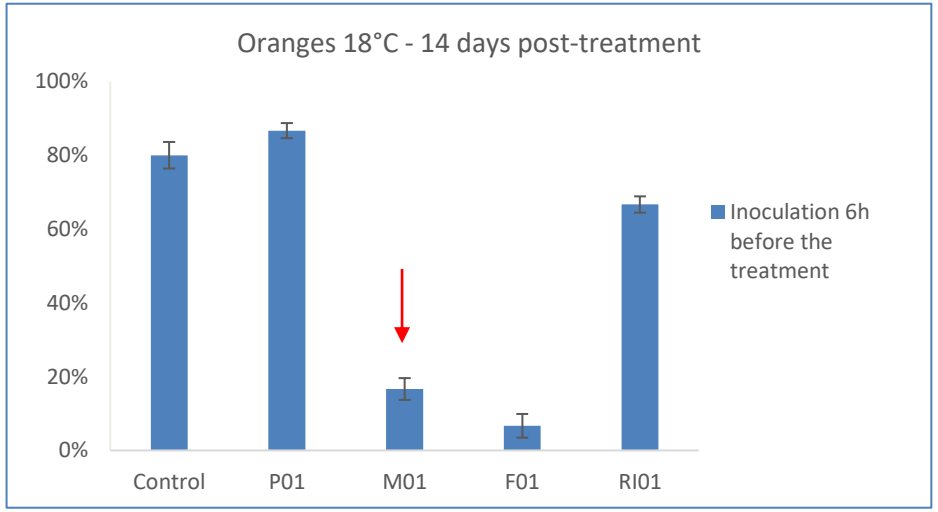
ID Substance - application	Type of treatment
Control - spray	Water
P01 - immersion	Sanitizing pre-treatment
M01 – spray	Sanitizing pre-treatment followed by treatment with bioproduct (living microrganism)
F01 - spray	Sanitizing pre-treatment followed by treatment with fungicide
R01 - spray	Sanitizing pre-treatment followed by treatment with chemical resistance inducer

Incidence of green molds in *Penicillium digitatum* pre-inoculated-tangerine fruits 14 days (*i.e.*: 7 days of incubation at 8°C followed by additional 7 days of incubation at 18°C) after treatment with water (control), sanitation agent (P01), living microorganism (M01), fungicide (F01), chemical resistance inducer (R01). Bars represent standard deviation.



NEW Biological Control Agents

Elicitation of Defence Mechanisms



Incidence of green molds in *Penicillium digitatum* pre-inoculated-orange fruits 14 days (*i.e.*: 7 days of incubation at 8°C + 7 days of incubation at 18°C) after treatment with water (control), sanitation agent (P01), living microorganism (M01), fungicide (F01), chemical resistance inducer (R01). Bars represent standard deviation.

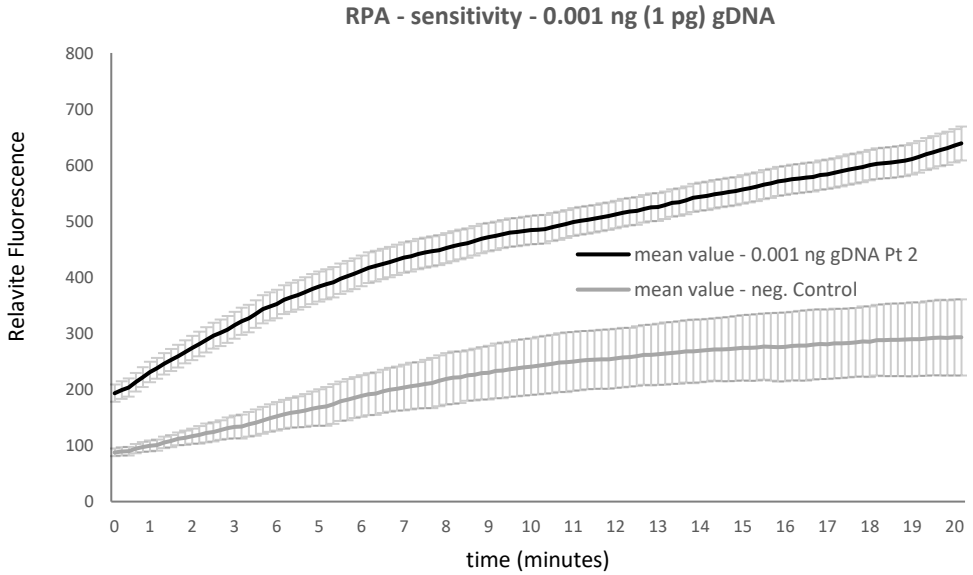
Results of BiOrangePack - WP1

New molecular diagnostic assays to detect pathogens

- Strong sensitivity (ca. 0.001 ng of DNA)
- complete inclusivity;
- complete exclusivity: no detection of ‘untarget organisms’

Plenodomus tracheiphilus

Phyllosticta citricarpa



New methods to detect mycotoxins

Liquid chromatography coupled to the time of flight (TOF) mass spectrometry (LC-MS-TOF)

also on infected oranges

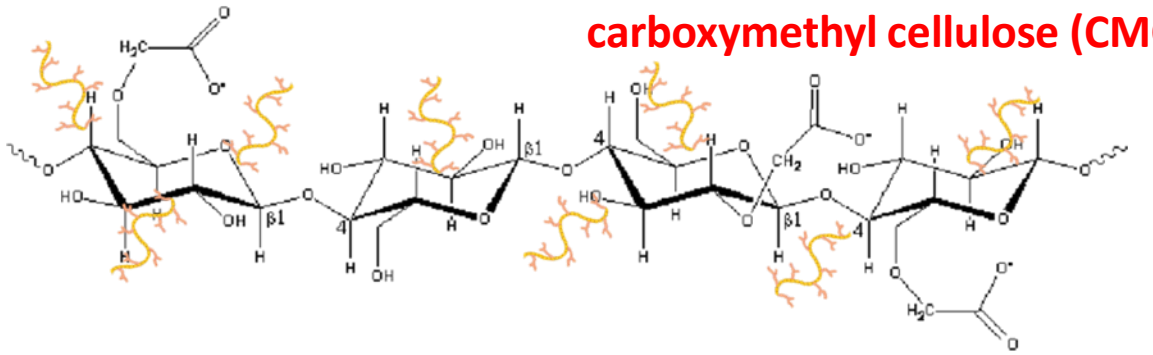
Preliminary results on juices

Compound	n of fruits	% of fruits	n of oranges	n of mandarines	% of oranges	% of mandarines
Averantin	71	88,75	35	36	87,5	90
Tryptoquivaline F	70	87,5	40	30	100	75
Hydroxyaverantin	51	63,75	26	25	65	62,5
Deoxybrevianamide E	33	41,25	16	17	40	42,5
NEO / Neosolaniol	31	38,75	9	22	22,5	55
Fumiquinazoline F	30	37,5		30	0	75
Ustilaxin C	28	35	23	5	57,5	12,5
Fulvic acid	26	32,5	17	9	42,5	22,5
Brefeldin A	25	31,25	1	24	2,5	60
Curvularin	24	30		24	0	60
AME / Alternariolmethylether	22	27,5	13	9	32,5	22,5
Citromycetin	21	26,25	12	9	30	22,5

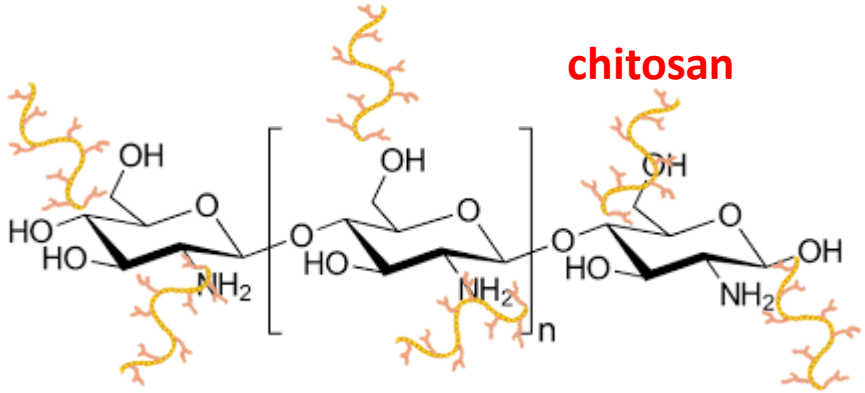
Results of BiOrangePack – WP2

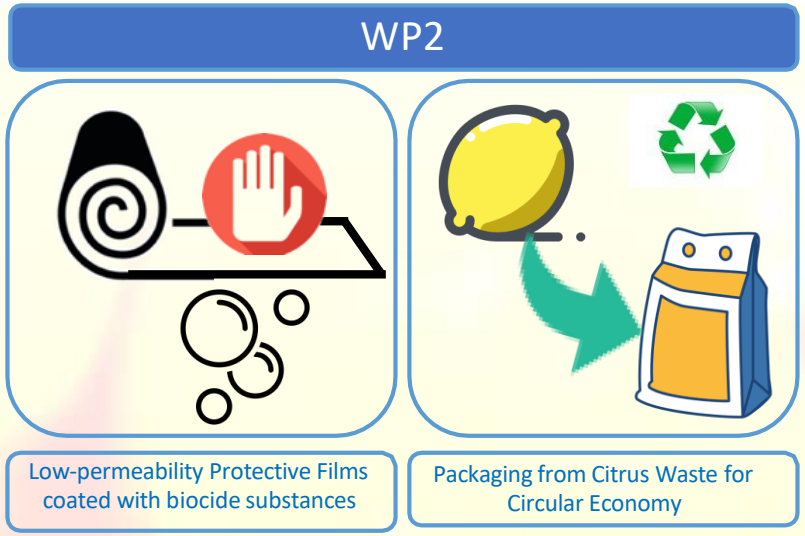
WP2 aim: Produce innovative smart packaging with improved "barrier properties" to extend the shelf-life of citrus fruit

carboxymethyl cellulose (CMC)



chitosan





Film and coatings in biobased, biodegradable polymers (chitosan, CMC, alginate) modified with echo-friendly antifungal formulas (supplied from WP1) by using chemical immobilization methods.

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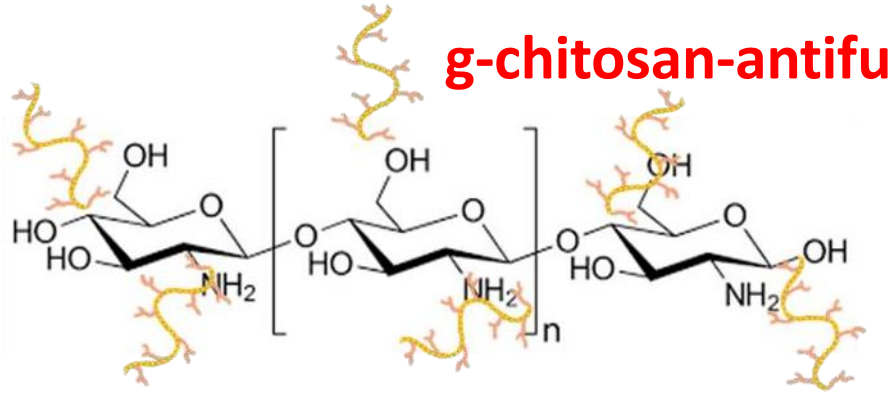
Results of BiOrangePack – WP2

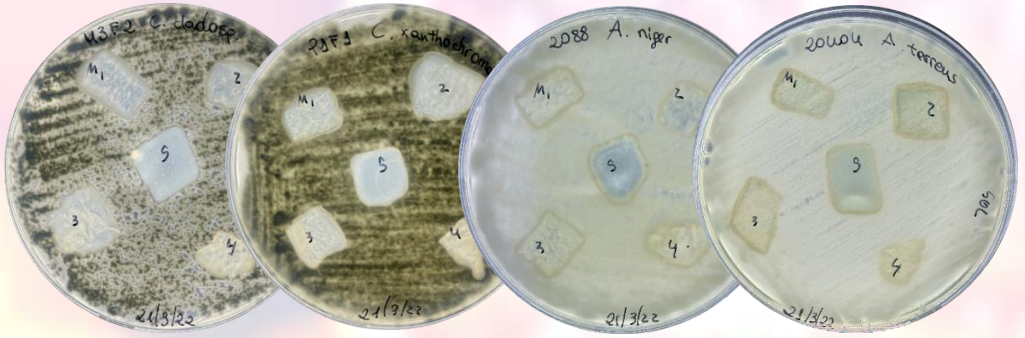
In vitro antifungal activity of modified chitosan film

Fungi	Strain	Control	Matrix 1	Matrix 2	Matrix 3	Matrix 4
A. flavus	ISPA 8111	-	-	-	-	-
A. flavus	n1f2	-	-	-	-	-
A. fumigatus	CECT 20827	-	+	+	-	+
A. niger	CECT 2088	-	-	-	-	-
A. terreus	CECT 20404	-	+	-	-	-
Al. alternata	646	-	-	-	-	-
C. cladosporioides	m3f2	-	+	+	-	-
C. vicinum	of1	-	+	+	-	-
C. xanthochromaticum	p1f1	-	++	++	-	++
F. oxysporum	CECT 2715	-	+	+	+	+
P. commune	151	-	+	+	+	+
P. digitatum	n1f1	-	++	++	++	++
P. digitatum	CECT 2954	-	++	++	++	++
P. digitatum	n2f1	-	+	+	+	-
P. italicum	of4	-	++	++	-	-
P. italicum	332	-	+	+	-	+
P. expansum	95	-	++	++	++	-
Ph. citrophthora	AX1AR	-	-	-	-	-
Ph. nicotianae	pk3f8	-	++	++	++	++

Resultati espressi come: "-" assenza di inibizione, "+" Parziale inibizione, "++" Marcata inibizione

g-chitosan-antifungal





Encouraging results have been achieved *in vivo* with antifungal-g-chitosan films on post-harvest pathogens

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Results of BiOrangePack – WP3

Citrus Navigator

WP3 aim: to develop highly technological solutions for optimizing citrus storage and transportation

Citrus-navigator

Decision support system to optimize fresh citrus fruit shipment according with sensor data

A ICT-based "control" system to continuously monitor the values of key environmental factors favoring deterioration during transportation

designed to minimize fruit losses

by optimizing

- **delivery times,**
- **routes,**
- **methods**

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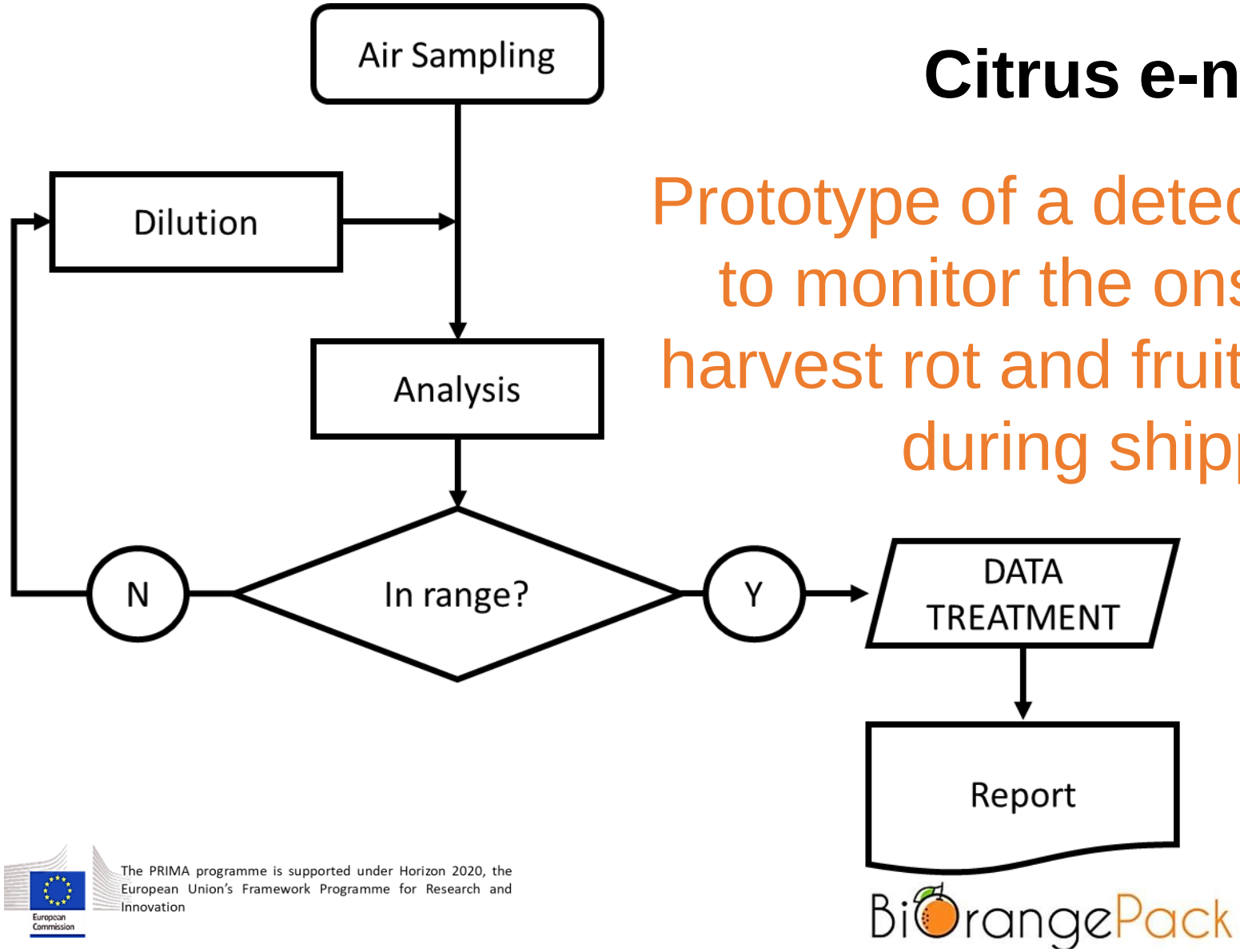
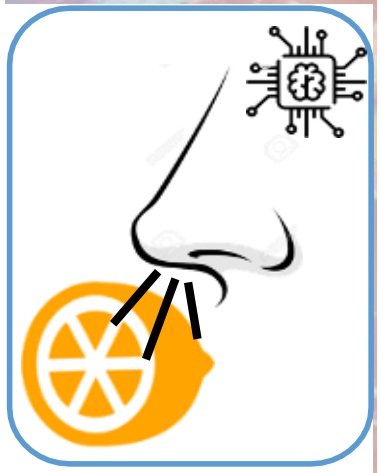
Results of BiOrangePack – WP3



Citrus e-nose

Prototype of a detection platform to monitor the onset of post-harvest rot and fruit degradation during shipping.



Citrus e-nose

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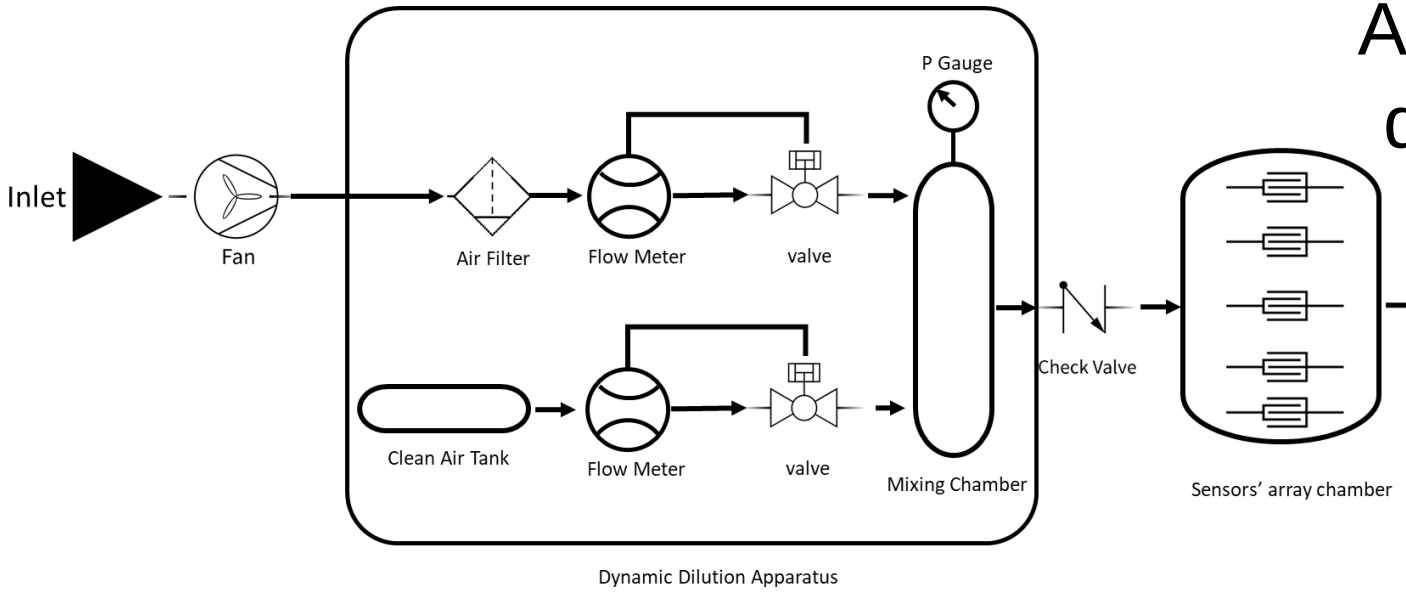
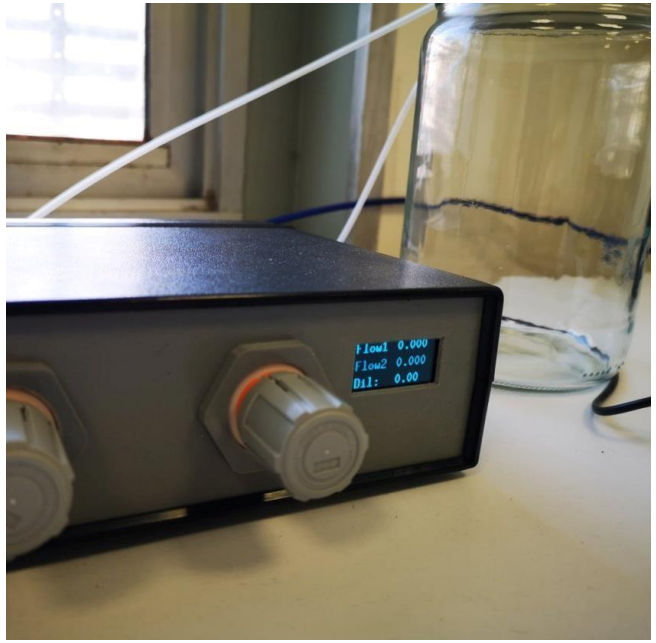
Results of BiOrangePack – WP3



Assembly of the gas dilution and mixing chamber.



Specific sensors to measure conventional VOCs (atmospheric gases, oxygenated compounds, hydrocarbons, olefins, etc.)

INNOVATIVE SENSORS, based on **silicon carbide substrate**, to measure VOCs over long distances

Citrus e-nose

The Prototype

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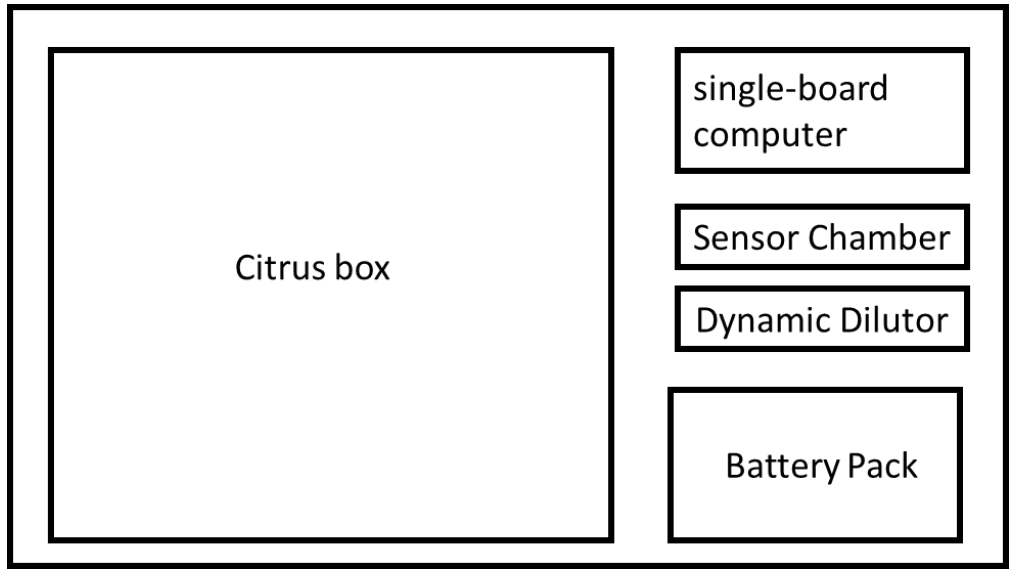
Results of BiOrangePack – WP3

Citrus-pack

Citrus Pack



The box will be designed to be self-sufficient (in terms of energy), shockproof, and inherently safe

New packaging for the transportation of citrus fruits

- **coating films**
- **electronic nose**
- **a set of sensors**

for continuous monitoring of environmental parameters

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Publications in the framework of BiOrangePack

- Stracquadanio et al. (2020). Antifungal activity of bioactive metabolites produced by *Trichoderma asperellum* and *Trichoderma atroviride* in liquid medium. Journal of Fungi, 6 (4)
- Stracquadanio et al. (2021). Inhibition of mycotoxigenic fungi in different vegetable matrices by extracts of *Trichoderma* species. Journal of Fungi, 7 (6)
- El Boumlasy et al. (2021). Inhibitory activity of shrimp waste extracts on fungal and oomycete plant pathogens. Plants, 10 (11)
- Stracquadanio et al. (2021) Inhibition of mycotoxigenic fungi in different vegetable matrices by extracts of *Trichoderma* species. Journal of Fungi, 7(6), 445
- La Spada eta al. (2021). Natural Biostimulants Elicit Plant Immune System in an Integrated Management Strategy of the Postharvest Green Mold of Orange Fruits Incited by *Penicillium digitatum*. Frontiers in Plant Science, 12, art. no. 684722
- El boumlasy et al. (2022) A super absorbent polymer containing copper to control *Plenodomus tracheiphilus* the causative agent of mal secco disease of lemon. Frontiers in Microbiology, 13, 987056
- Hammami et al. (2022) Epiphytic Yeasts and Bacteria as Candidate Biocontrol Agents of Green and Blue Molds of Citrus Fruits. Journal of Fungi, 8(8), 818
- Rovetto et al. (2023) Diversity of Mycotoxins and Other Secondary Metabolites Recovered from Blood Oranges Infected by *Colletotrichum, Alternaria,* and *Penicillium* Species. Toxins,15(7), 407
- Riolo et al (2023) Antifungal activity of selected lactic acid bacteria from olive drupes. Food Bioscience, 52, 102422
- Santonocito et al. (2023) Detection of plant pathogenic fungi by a fluorescent sensor array. Sensors and Actuators B: Chemical, 393, 134305

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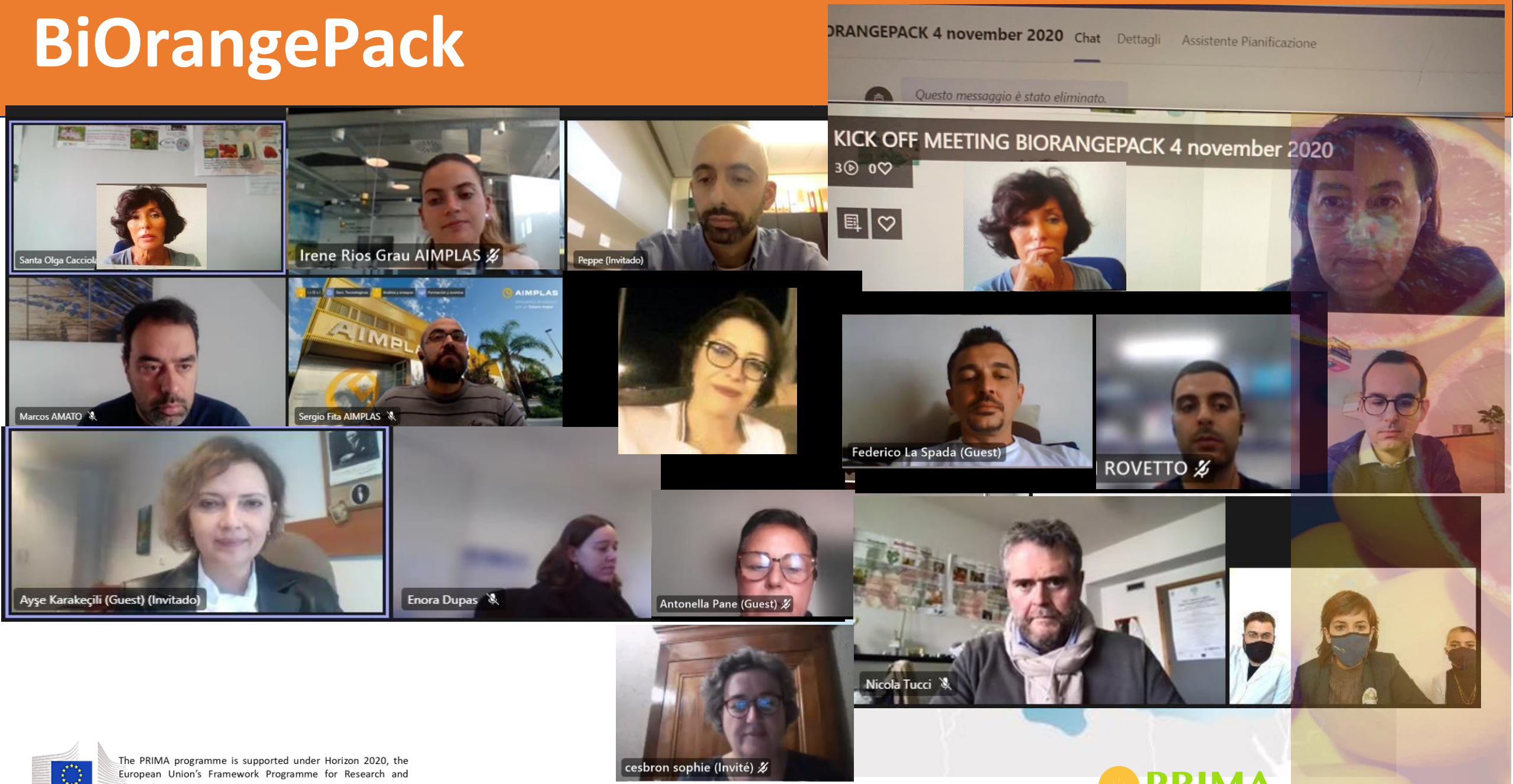

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PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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