MILDSUSFRUIT
Innovative Mild Processing Tailored to Ensure Sustainable and High Quality Organic Fruit Products

Pietro Rocculi

Coordinator

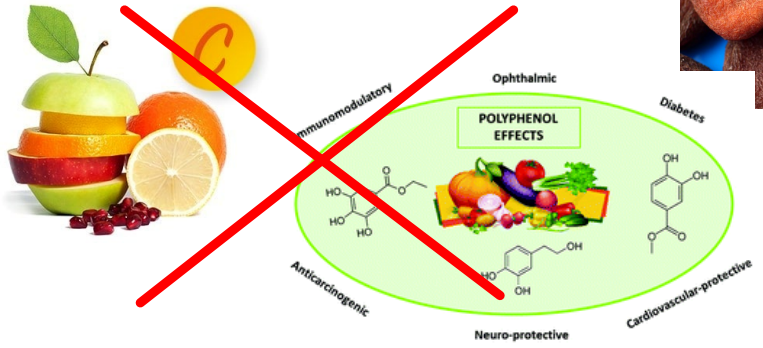
Why are ‘organic’ products often considered ‘old fashion’ ones, to be produced ‘as in the past’?

Case example A: Preserves!

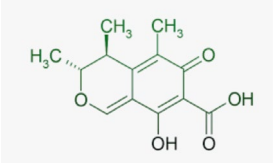
Case example B: Dehydrated Fruit!

Poor sensorial quality!

Thermal Degradation!



Safety issues!



Innovative Mild Processing Tailored to Ensure Sustainable and High Quality Organic Fruit Products

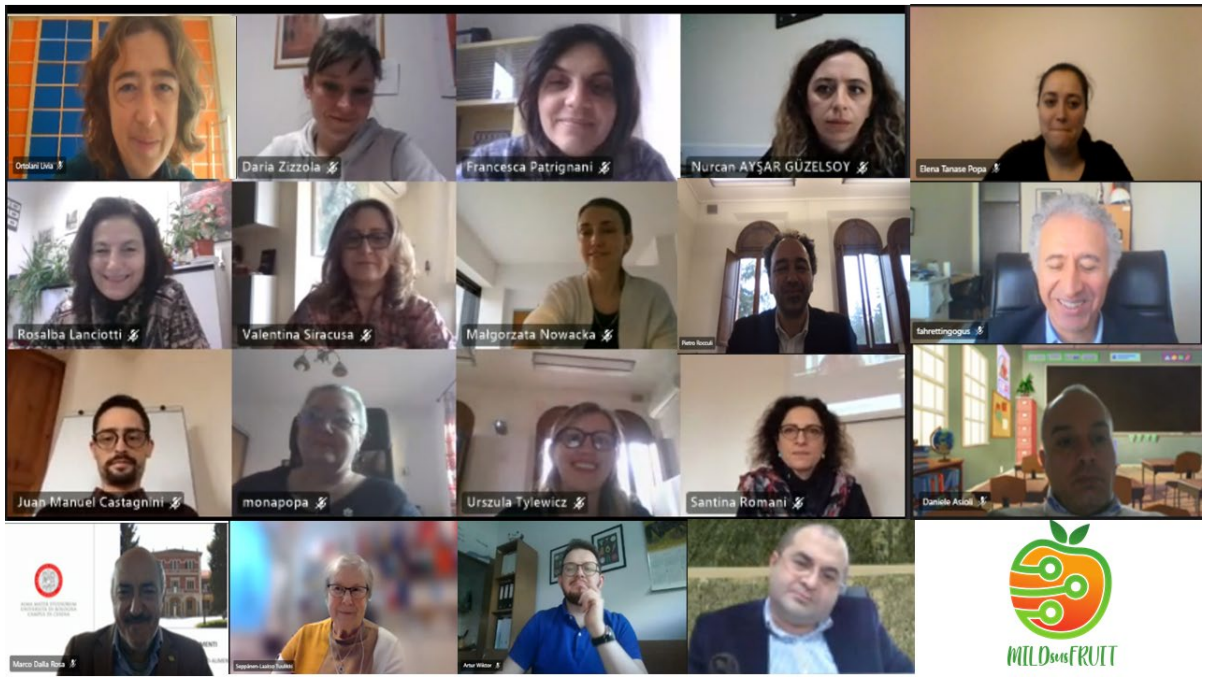
MILDSUSFRUIT

Coordinator: UNIBO (IT)

Partners

USAMV RU GU CRIFFG SGGW VTT

1st November 2020 to 31st October 2023



MILDsusFRUIT

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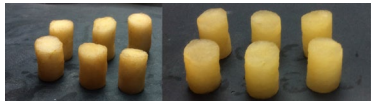
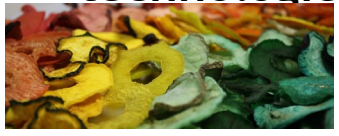
Project idea

- High nutritional quality
- No pesticides

- High perishability
- Reduced range of products

Application of **Mild Processing technologies**





By-products valorization

Novel processed organic products

Wider range of organic products

Increased shelf-life

Reduction of waste

High nutritional quality

Increased consumer acceptability

Reduced environmental impact

Project main objectives (1)

Main objective

Improve the competitiveness of the organic sector, increasing the level of quality, sustainability and consumer confidence of organic processed fruit (**apple, citrus and berries**) products.

Specific objectives (1)

- definition and optimization of mild technologies tailored to each organic raw material in order to increase the stability and functionality of a wide range of organic processed fruit products, including **minimally processed**, **semi-dried** and **dried ones**

- definition and optimization of gentle and more sustainable technologies for tailored extraction and stabilization of functional ingredients, developing specific protocols aimed to reduction of waste and valorisation of by-products

Project main objectives (2)

Specific objectives (1)

- characterization and reduction of the environmental impact of the production of organic processed fruit products and functional ingredients, to increase the overall sustainability;

- evaluation of consumer preferences and acceptance in relation to the innovative processed organic fruit products aimed at developing and suggesting improved communication strategies;

- disseminatation of the obtained results and concrete recommendations (development of a Code of Practice) to stakeholders (creation of a Stakeholders Advisory Board) such as farmers, food producers and packers, distributors, retailers and consumers associations.

Main hypothesis

Raw material characteristics and mild processing, for organic fruit products, have to be strictly designed to the specificity of each kind of commodity, through the application/implementation of tailored rules and principles.

This strategy has to be performed both in terms of preservation/fortification of the peculiar functional properties of the raw materials and of the increased sustainability of the overall organic fruit chain, with a consumer-driven approach.

Raw materials and products, innovative technologies and potential MILDSUSFRUIT TRL development

Raw materials	Apple	Berries	Citrus	Fruit and Vegetable By-products
Products				
Minimally processed	X	X	-	-
Semi-dried	X	X	X	-
Dried	X	X	X	-
Functional ingredients	X	X	X	X
Technologies	**TRL development**			
Vacuum Impregnation	5-7	5-7	-	-
High Hydrostatic Impregnation	3-6	3-5	-	-
Edible Coating	4-6	4-6	-	-
Osmotic dehydration	5-7	5-7	5-7	-
Dehydro-Freezing	3-5	3-5	-	-
RF assisted drying	4-6	4-6	4-6	4-6
US assisted drying	4-6	4-6	4-6	4-6
PEF assisted drying	3-5	3-5	-	4-6
Green Extraction Technology	4-6	4-6	5-7	3-6

WP1 - Processing technologies for Minimally Processed Fruits

Phycocyanin enrichment of minimally processed organic

In the present study the natural phycocyanin was used to enrich organic fruits by vacuum-impregnation to obtain a functional IV gamma product. The apples were packed in a micro-perforated film and stored at 4 °C for 9 days.

Recently, **microalgae have become promising resources for obtaining functional ingredients** that can be used to increase the nutritional value of foods[1]. **Spirulina platensis**, also known as spirulina or arthrospira, is a **blue-green**, filamentous, prokaryotic cyanobacterium with a **protein content of 55-70%**, which includes the full range of **essential amino acids**, **vitamins**, **minerals**, **essential fatty acids** and pigments such as **phycocyanin**.

Materials & Methods

1 Organic apples

- *Golden Delicious*
- Slices of 0.5 ± 0.1 cm

2 Solutions

P sample: phycocyanin extract with 4.5% ethanol + trehalose (14° Brix)

C sample: distilled water + trehalose (14° Brix)

3 Treatment

Vacuum impregnation
10 min a 200 mbar +
10 min a 1000 mbar

4 Packaging

Micro-perforated film

P sample

C sample

5 Evaluation of the stability during the shelf-life

- Gas concentration (%)
- Dry matter (%)
- pH
- Colour (CIEL*a*b*)
- Texture (compression test)
- Microbial quality

WP1 - Processing technologies for Minimally Processed Fruits

Results

Days	O_2 (%)	Dry matter (%)	pH	L*	b*	Hardness (N)	Total Mesophils (log CFU/g)	Total Entero. (log CFU/g)	Total Yeasts (log CFU/g)
P sample									
0	20.0±0.1	14.2±0.2	3.89±0.08	32.8±2.4	4.0±1.2*	2.50±0.33*	5.5±0.2*	3.8±0.1	-
2	20.3±0.1	13.8±0.9	4.05±0.05	28.7±2.2	5.5±1.7*	3.20±0.60	5.9±0.0*	4.9±0.0	1.9±0.1
4	20.1±0.0	13.2±0.5	4.49±0.11*	26.6±1.5	2.2±0.8*	2.84±0.65	6.7±0.0*	5.5±0.1	1.7±0.1
7	20.1±0.1	13.6±1.1	4.10±0.15	30.2±5.0	5.1±2.9*	2.59±0.64	7.7±0.1	5.4±0.1*	0.9±0.2
9	20.3±0.1	-	4.16±0.07	28.0±0.8	4.5±0.4*	2.64±0.75	-	-	-
C sample									
0	20.0±0.1	13.8±0.2	3.84±0.02	46.1±2.5	21.9±2.7*	1.82±0.25*	2.7±0.1*	-	1.8±0.6
2	20.1±0.1	14.8±0.4	3.86±0.20	39.9±2.3	23.8±2.1*	2.13±0.53	3.0±0.1*	-	2.3±0.2
4	20.5±0.0	15.1±0.5	3.91±0.06*	39.7±2.8	22.2±0.6*	2.18±0.52	3.5±0.1*	-	1.5±0.1
7	20.4±0.1	14.8±0.5	4.14±0.12	38.1±3.4	21.4±2.9*	2.06±0.38	6.4±1.5	3.4±0.0*	-
9	20.4±0.1	-	4.26±0.04	39.8±2.9	24.2±1.0*	1.91±0.6	-	-	-

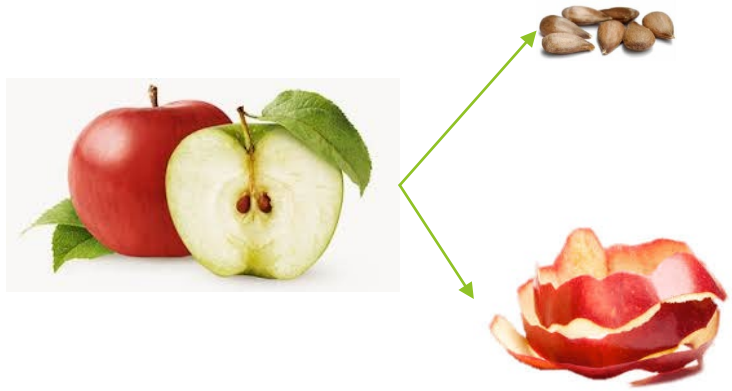
Values between samples P & C at the same storage time found to be statistically different ($p < 0.05$) in the same column are marked with an asterisk (*)

- ✓ The vacuum impregnation of the apple slices resulted in **25% of impregnation yield** for both types of impregnation solutions
- ✓ The shelf-life was set at **7 days**, both for phycocyanin (P) and control (C) apples. The shelf-life of the P sample stopped due to the **increase of Enterobacteriaceae** compared to the C.
- ✓ **Phycocyanin**, being a blue pigment, gives the final product an **unconventional blue-green** colour. Therefore, an **in-depth sensory analysis** might be of interest to assess the overall quality of this product.
- ✓ **Further studies** are needed to evaluate the phycocyanin content of impregnated apples and

Presented @ FCT - 2022 Rome 12-14 October, 2022

WP2 – Preparation of functional ingredients

TASK 2.1 By-products selection



A report was realized based on the scientific literature and the results of the performed analysis on side stream of apples and sea buckthorn.

WP2 – Preparation of functional ingredients

Experimental research

Nine organic apple cultivars (Remo, Rewena, Relinda, Rebela, Freedom, Pinova, Florina, Topaz, Dalienette)

Three organic sea buckthorn cultivars (Mara, Clara, Sorana)

The fruits were processed into juice and the remaining waste was analyzed (whole fruit pomace, peel and pulp pomace for apples and peel+seeds pomace for sea buckthorn).

Prior to analysis, the samples were freeze dried.

Conclusions

- Greater values for total phenolic content, antioxidant activity and anthocyanin content were obtained for the **peel** of the fruits, rather than pulp or the whole fruit.
- For the 9 apple varieties ascorbic acid was found only in the peel of the fruits except for Dalienette variety, for which ascorbic acid was also found in the pulp.
- Sea buckthorn pomace was also rich in TPC, antioxidant activity and ascorbic acid, the greatest values for these parameters being obtained for Mara variety.

WP3 - Processing technologies for fruit snacks

Mechanical treatment

var. Roxana

- washed tap watter
- cut: 5 mm slices

Osmotic dehydration

- Time: 180 min,
- T= 40°C,
- ratio of material to osmotic solution – 1:1

Osmotic solutions:
50% sucrose solution
20%, 30%, 40% sorbitol solutions
20%, 30% mannitol solutions

Drying process

freeze-drying

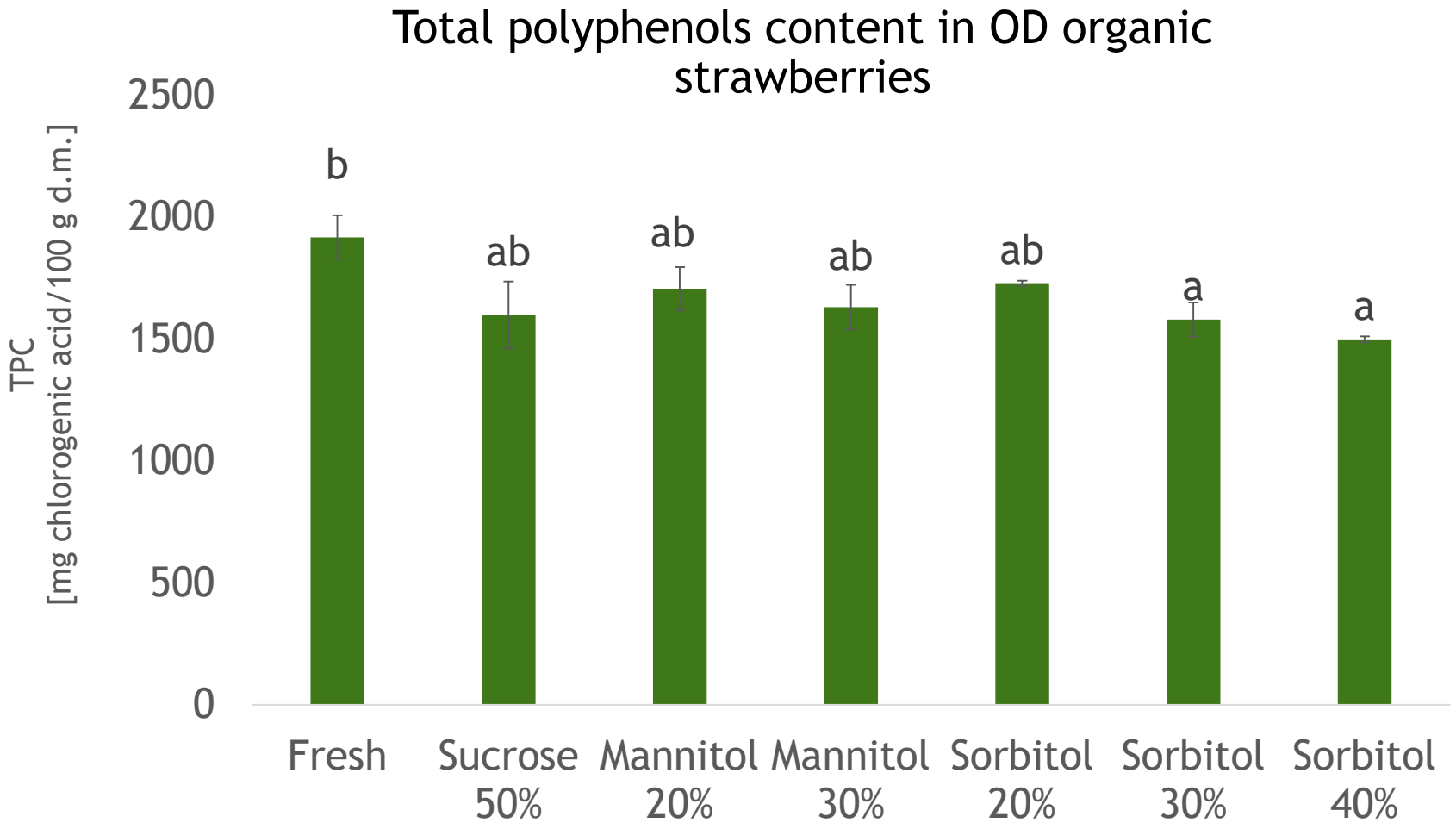
- T_1= - 40 °C
- T_2 = 30 °C
- P: 63 Pa

Measurements

- Total polyphenols content
- Total anthocyanins content
- Antioxidant activity (DPPH, ABTS, RP)
- Sugars content

WP3 - Processing technologies for fruit snacks

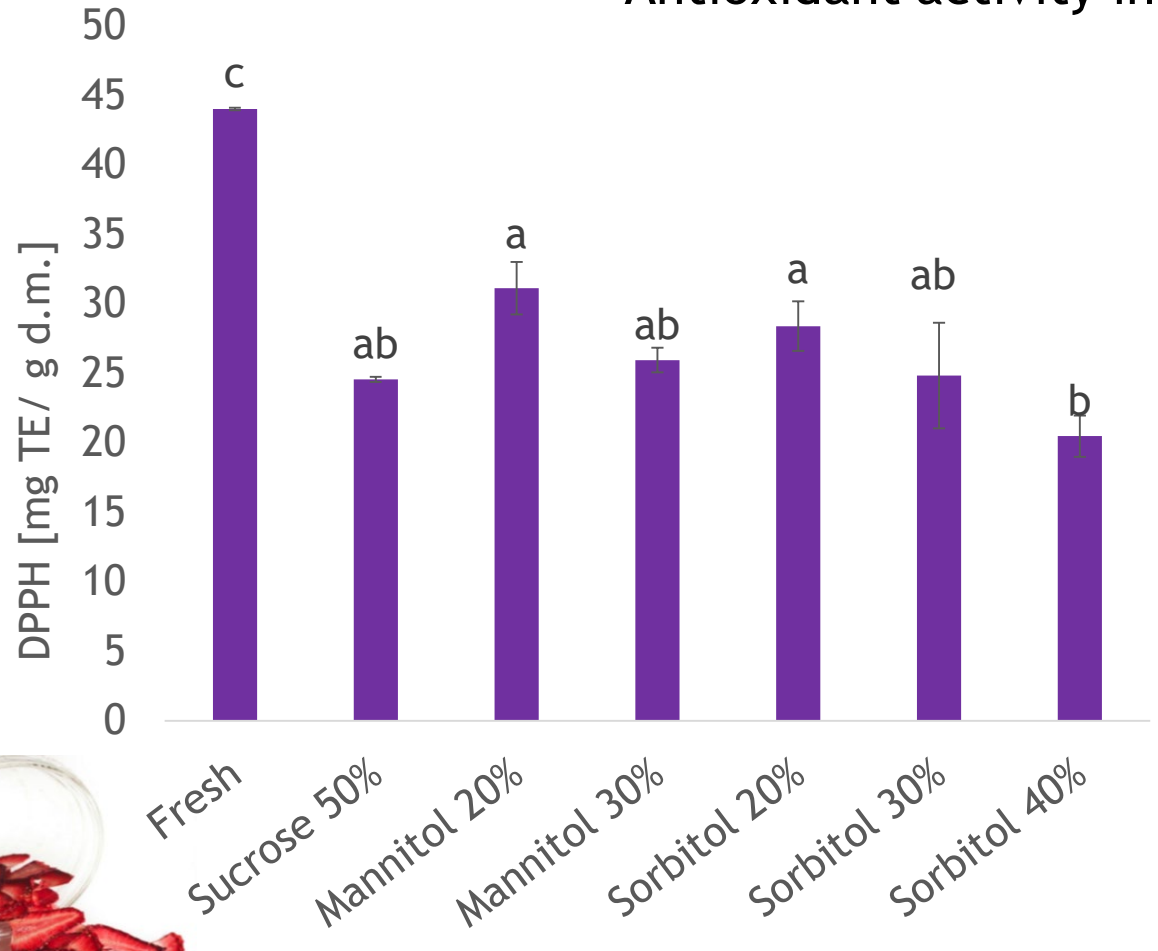
Results - Total polyphenols content

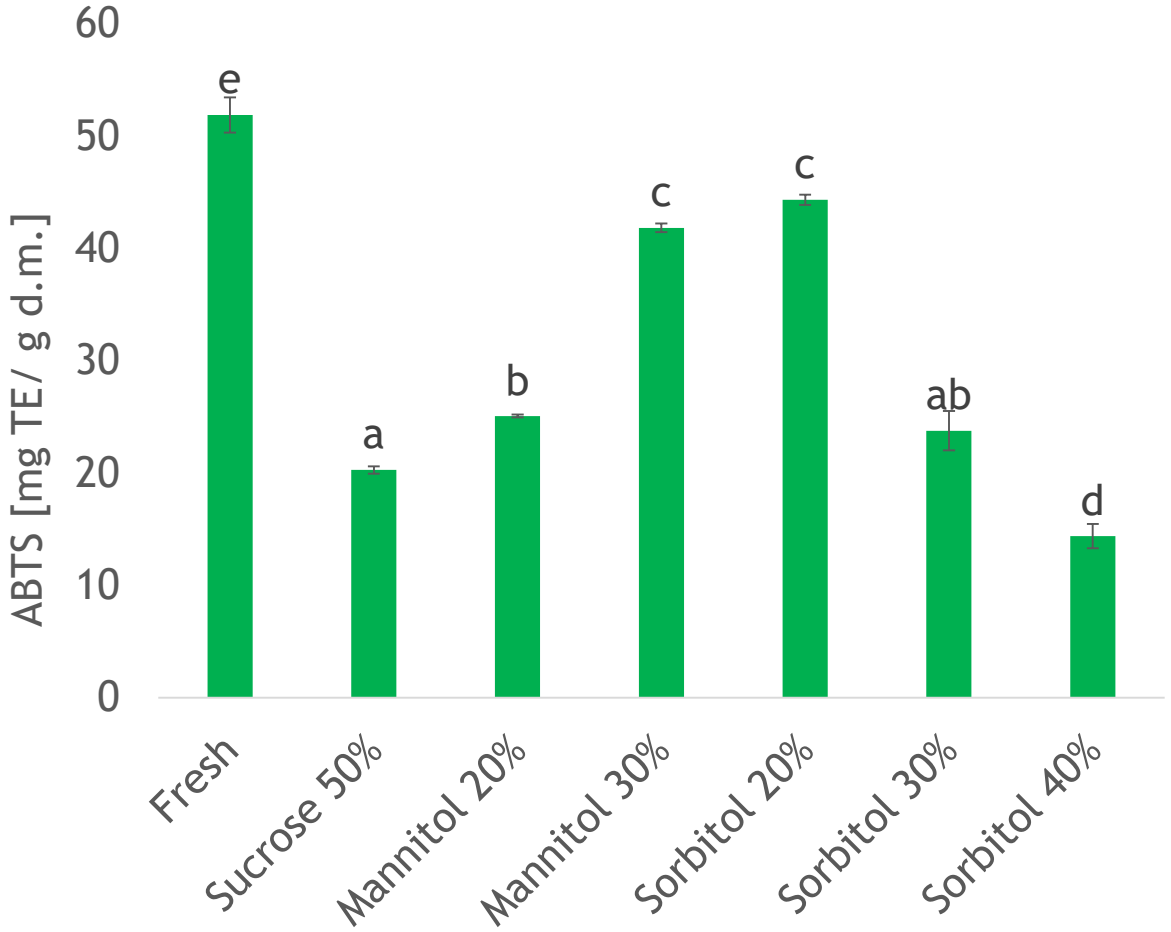


WP3 - Processing technologies for fruit snacks

Results - Antioxidant properties

Antioxidant activity in OD organic strawberries

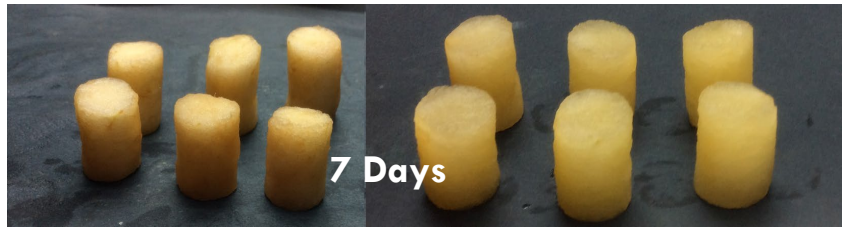




Processing/Product Innovation

PEF Technology

Vacuum Impregnation



Cold fortified MP fruit

Dried fruit snacks

Fruit juices

Ultrasounds

Stakeholder Advisory Board (SAB)

- Invited external experts and representatives from the industrial sector, farmers, food producers and packers, distributors, retailers and consumers associations.

SAB	Name/Surname	Company	Address	Country
1	Giovanni Gallerani	MACE	Giovanni.gallerani@macefruit.com	
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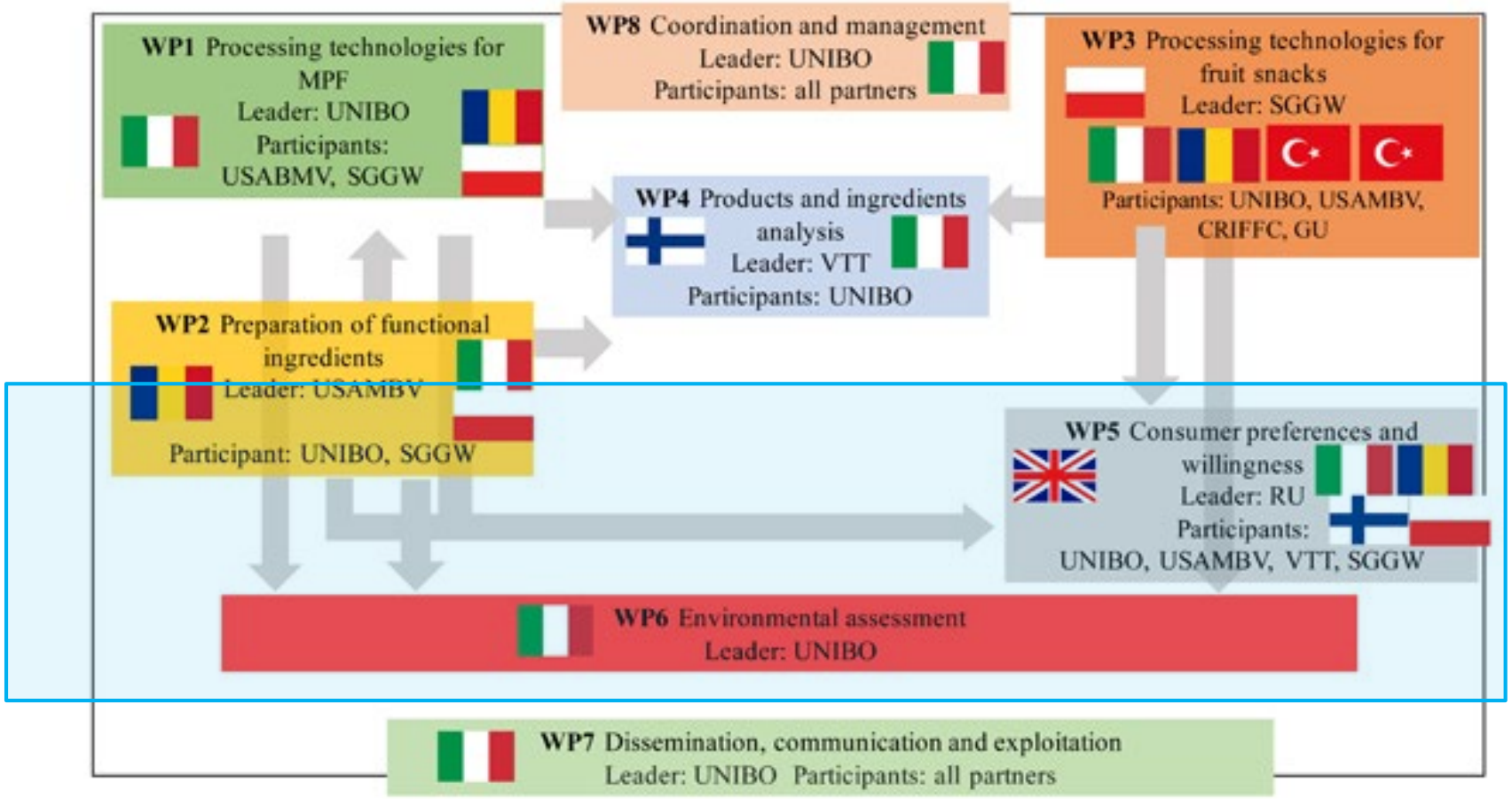
3	Wiesław Broniarz	Brodowski Owoce	artur@brodowskiowoce.pl	
4	Suvi Ryynänen Sari Iivonen Tomi Pousi	Ministry of Agriculture and Forestry of Finland Finnish Organic Research Institute The Union of Fruit and Berry farmers		
5		Worldwide Fruit		
6				

The organisation EPOK at the Swedish Agricultural University, responsible for communication and dissemination activities within the Core Organic program, will be part of the meetings with SAB.

Future activities



Publications and dissemination activities

Presentations

- Chądzyńska M., Nowacka M., 2021: The influence of polyols used as osmotic agents in osmotic dehydration process, XII International Agriculture Symposium “AGROSYM 2021” (7-10.10.2021 Bosnia and Herzegovina – online), Book of Abstract, 345.
- Chądzyńska M., Nowacka M., 2021: Mass transfer in osmotic dehydration process of organic strawberries in polyols solutions, 8th International Conference “Human – Nutrition – Environment” (13-14.10.2021 Rzeszów, Poland)
- Rybak K., Nowacka M., 2021: Effect of osmotic dehydration process in polyols solutions on bioactive compounds and sugars content of organic strawberries, BUP Symposium 2021, (19-20 October 2021, Sweden – online), Book of Abstract, 58.
- Chądzyńska M., Rybak K., Wiktor A., Nowacka M., 2022: The bioactive properties of apples dehydrated in fruit concentrates solutions, 1st International PhD Student’s Conference at the University of Life Sciences in Lublin, Poland: ENVIRONMENT- PLANT-ANIMAL-PRODUCT (ICDSUPL), (26.04.2022, Lublin, Poland)
- Oral presentation-Mona Elena Popa, 2021. How innovation could be tailored to ensure sustainable and high-quality organic fruit products?, oral presentation at International Conference Agriculture for Life, Life for Agriculture, 3 – 5 June, Bucharest, Romania.
- Oral presentation-Mona Elena Popa, 2021. INNOVATIVE MILD PROCESSING TAILORED TO ENSURE SUSTAINABLE AND HIGH QUALITY ORGANIC FRUIT PRODUCTS - ERA-NET PROJECT, oral presentation at "Food Quality and Safety, Health and Nutrition Congress - NUTRICON", 09 – 11 June, Ohrid, Macedonia.
- Oral presentation- Urszula Tylewicz "Exploring the Yacon juice potential in the fortification of whole organic strawberries" - ISEKI 2021 Conference, 23-25 June 2021

Publications and dissemination activities

Scientific articles

1. Castagnini, Juan Manuel; Tappi, Silvia; Tylewicz, Urszula; Laghi, Luca and Rocculi, Pietro (2022) Study of Water Distribution, Textural and Colour Properties of Cold Formulated and Air-Dried Apple Snacks. Foods, 11 (5), p. 731.
2. Mannozzi, Cinzia; Glicerina, Virginia; Tylewicz, Urszula; Castagnini, Juan Manuel; Canali, Giada; Dalla Rosa, Marco and Romani, Santina (2021) Influence of Two Different Coating Application Methods on the Maintenance of the Nutritional Quality of Fresh-Cut Melon during Storage. Applied Sciences, 11 (18), p. 8510.
3. Tappi, Silvia; Velickova, Elena; Mannozzi, Cinzia; Tylewicz, Urszula; Laghi, Luca and Rocculi, Pietro (2022) Multi-Analytical Approach to Study Fresh-Cut Apples Vacuum Impregnated with Different Solutions. Foods, 11 (3), p. 488.
4. Castagnini, Juan Manuel; Tappi, Silvia; Tylewicz, Urszula; Romani, Santina; Rocculi, Pietro and Dalla Rosa, Marco (2021) Sustainable Development of Apple Snack Formulated with Blueberry Juice and Trehalose. Sustainability, 13 (16), p. 9204.
5. Mitelut A.C., Popa E.E., Draghici M.C., Popescu P.A., Popa V.I., Bujor O.C., Ion V.A., Popa M.E., 2021. Latest Developments in Edible Coatings on Minimally Processed Fruits and Vegetables: A Review, Foods, 10(11), 2821 (IF 4.121/2020)
6. Draghici M.C., Mitelut A.C., Popa E.E., Popescu P.A., Popa V.I., Barbu A., Popa M.E., 2021. Study on consumers perception and knowledge on vegetal organic by-products used as functional ingredients – acceptat spre publicare în Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development Journal Vol. 21(4) (ESCI).
7. 3. Popa M.E., Mitelut A.C., Popa E.E., Draghici M.C., Popescu P.A., Popa V.I., Danaila-Guidea S., Stan A., 2021. Valuable compounds composition of berries processing side stream, Journal of EcoAgriTourism, ISSN: 1844-8577, 17(2), 54-61
8. Wiktor A., Chadzynska M., Rybak K., Dadan M., Witrowa-Rajchert D., Nowacka M., 2022: The influence of polyols on the process kinetics and bioactive substances contents in osmotic dehydrated organic strawberries, Molecules 2022, 27, 1376. https://doi.org/10.3390/molecules27041376

Dissemination activities

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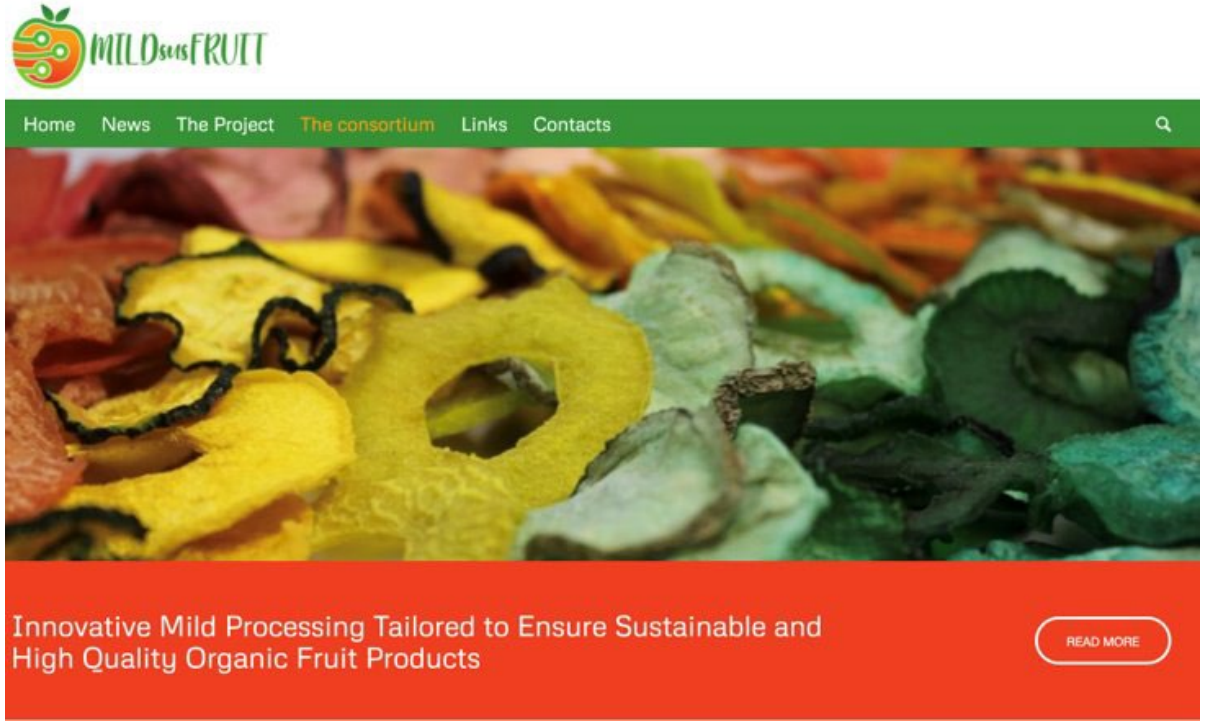

Dissemination activities

https://www.mildsusfruit.com