Valorification potential of some fruit processing waste in various new applications

Mona Elena Popa – USAMV Bucharest Romania

GHI Workshop 08.06.2023

This work was supported by contract 186/2020, project acronym MILDSUSFRUIT. The authors acknowledge the financial support for this project provided by transnational funding bodies, partners of the H2020 ERA-NETs SUSFOOD2 and CORE Organic Cofund, under the Joint SUSFOOD2/ CORE Organic Call 2019.

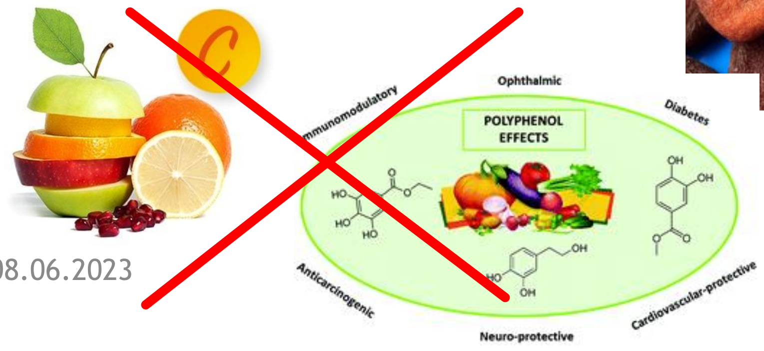
Why are ‘organic’ products often considered ‘old fashion’ ones, to be produced ‘as in the past’?

Case example A: Preserves!

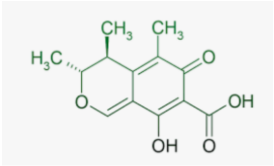
Case example B: Dehydrated Fruit!

Poor sensorial quality!

Thermal Degradation!



Safety issues!



- 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

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

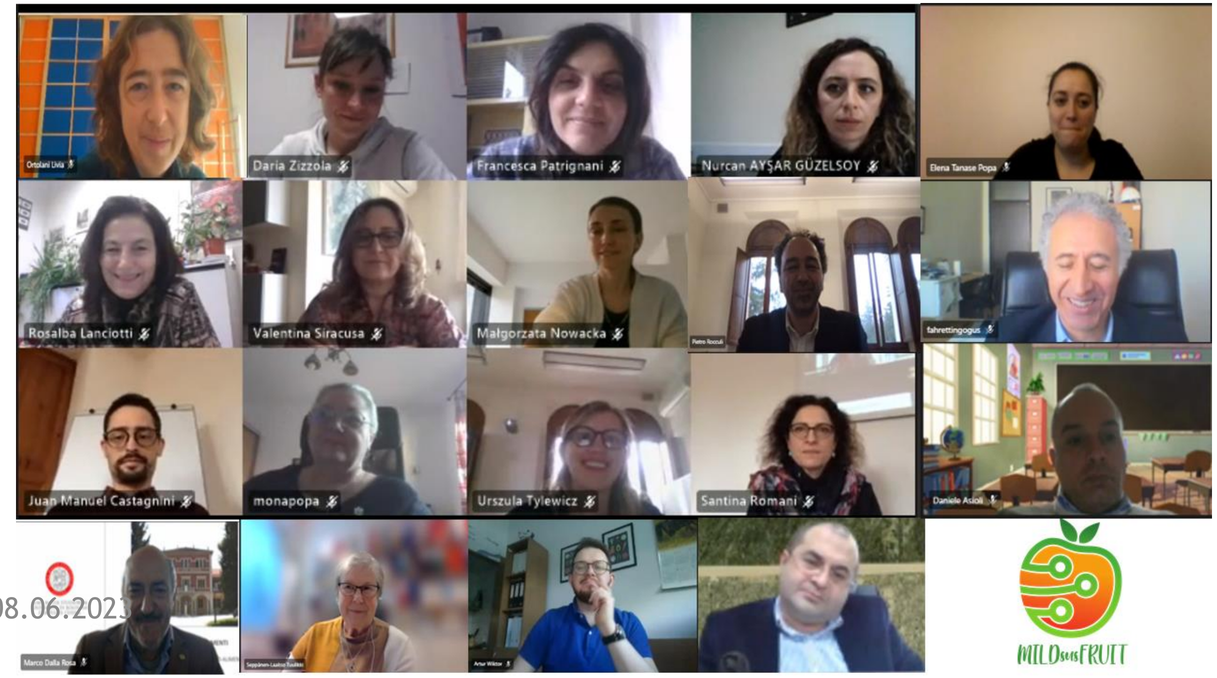
MILDSUSFRUIT

Coordinator: UNIBO (IT)

Partners

USAMV RU GU CRIFFG SGGW VTT

Nov 2020 - Nov 2023



Project Logo

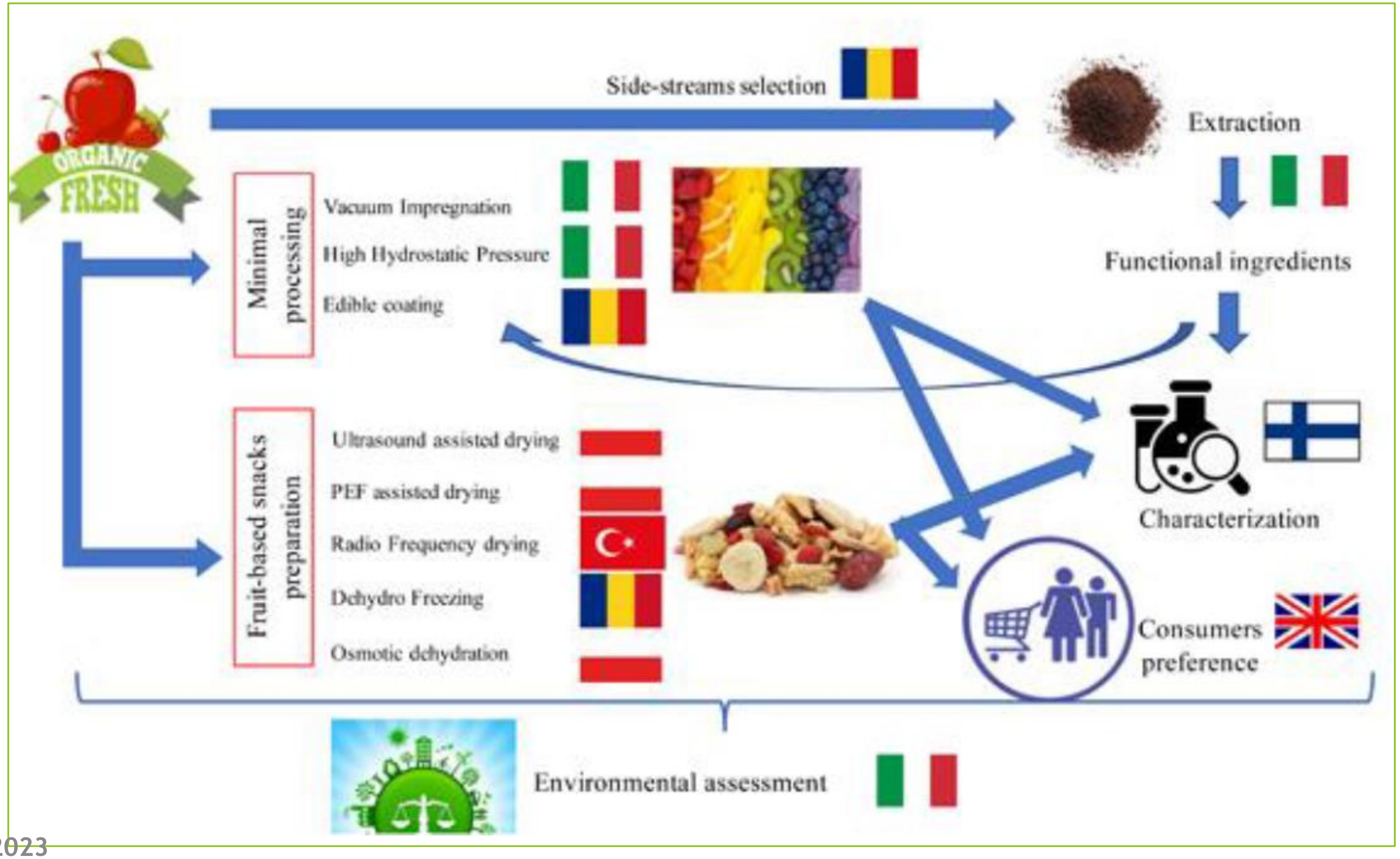
Main Objective

- 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

- 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 **valorization of by products**.

General project idea and contribution of the involved partners



WP 1 Processing technologies for MPF

Urszula Tylewicz (UNIBO)

Objectives

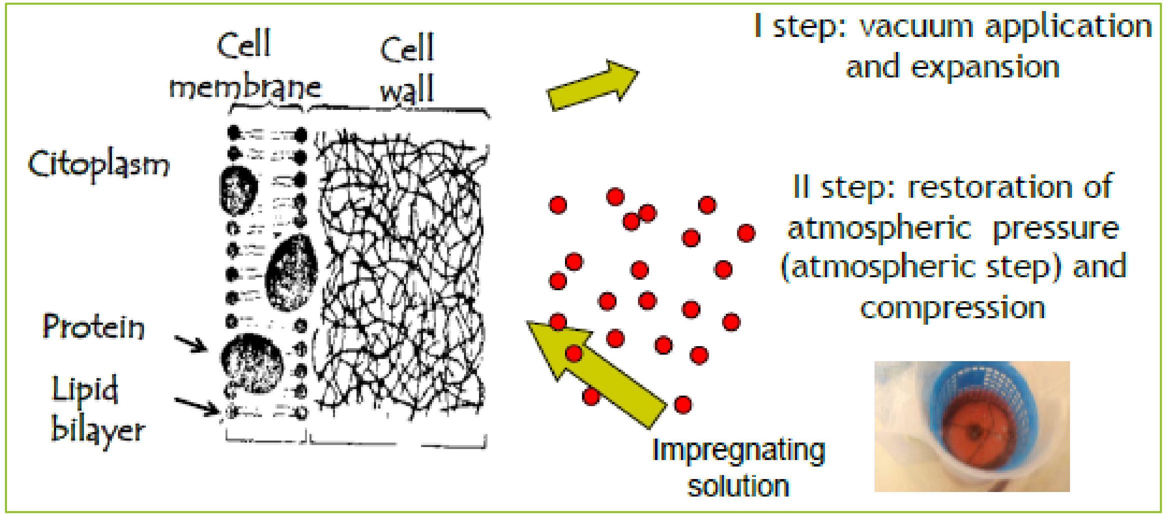
The main aim of WP 1 is to develop and optimize tailored processing technologies for the sustainable preparation of high quality fortified minimally processed organic fruit product in order to respond to increasing consumer demand for food products with added value.

For each raw material, the most appropriate process parameters will be selected with the aim of maximizing quality, stability, nutritional and functional properties of obtained final products.

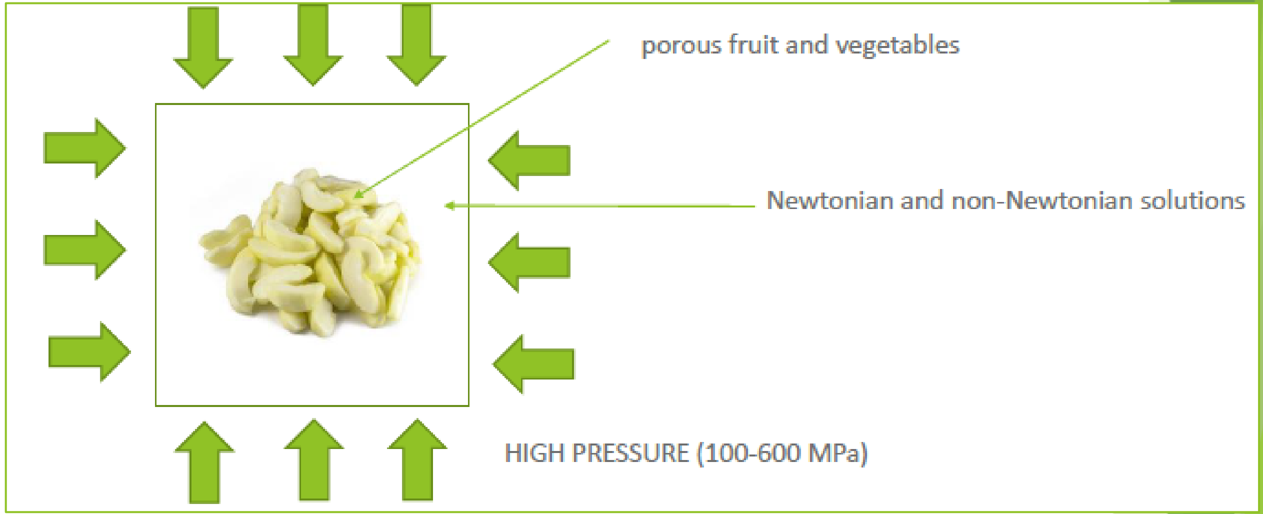
WP 1 Processing technologies for MPF

Urszula Tylewicz (UNIBO)

TASK 1.1 Vacuum Impregnation



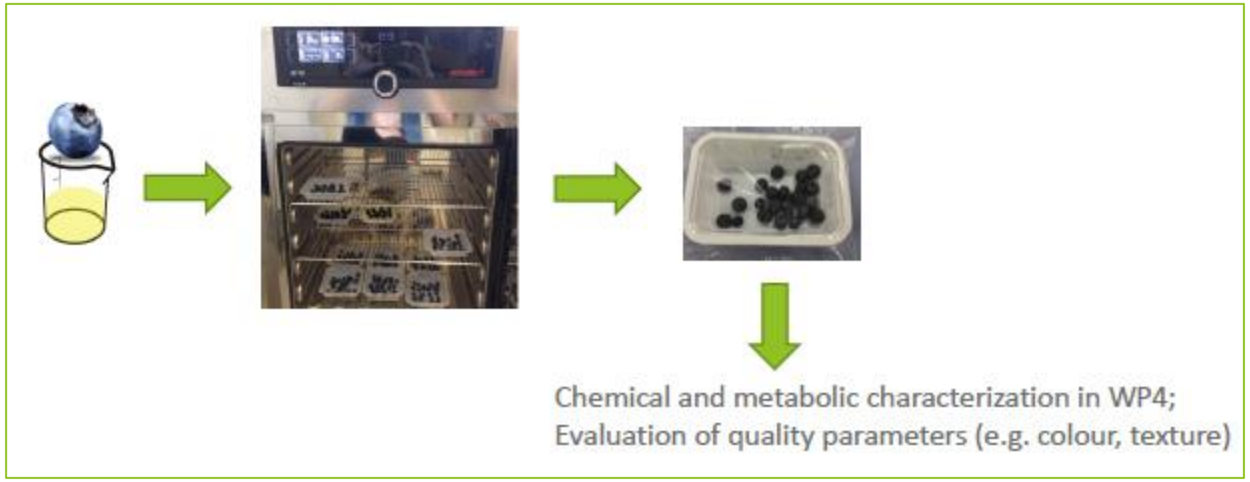
TASK 1.2 High pressure impregnation



WP 1 Processing technologies for MPF

Urszula Tylewicz (UNIBO)

TASK 1.3 Edible coating



WP 2 Preparation of functional ingredients

Mona Popa (USAMVB)

Objectives

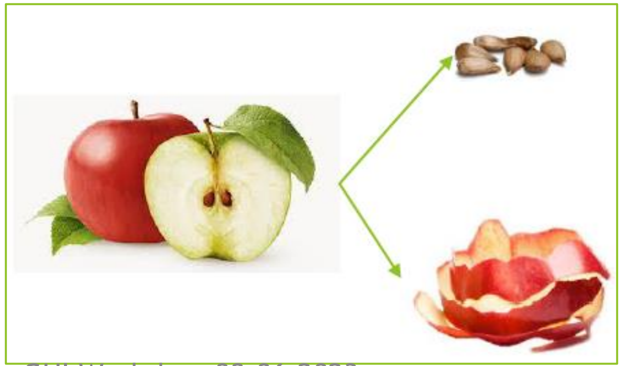
The main aim of WP2 is the side streams valorization by the recovery of the valuable compounds using green separation/extraction technologies.

The side streams utilization from organic fruit processing will bring valuable/functional compounds back into the human food chain, enabling production of environmentally sustainable and value-added products, in line with organic production principles, in order to satisfy consumer expectations and to positively impact the environment and human health.

WP 2 Preparation of functional ingredients

Mona Popa (USAMVB)

TASK 2.1 By-products selection



The selection has been performed on the basis of chemical composition in bioactive compounds (total phenolic content, anthocyanins, vitamin C, fatty acids, dietary fiber, antioxidant capacity) in raw materials (plants parts such as leaf’s, stems, roots, bagasse, and fruit and vegetables parts such as peels, seeds) in order to obtain the most rich and convenient source of bioactive compounds which will be potentially used for the extraction of high added value functional ingredients.

WP 2 Preparation of functional ingredients

Mona Popa (USAMVB)

TASK 2.2 Selection of extraction methods

Pressurized liquid extraction (PLE), Pulsed Electric Fields (PEF) and Ultrasound (US) provide the possibility to extract bioactive components using low amount of nontoxic solvents. Moreover, extraction at low temperature and in the absence of light and oxygen can reduce the risk for the degradation of valuable components.

TASK 2.3 Technological Assessment

The technological assessment of obtained functional ingredients on model systems will be performed Suitable food matrices will be identified for the incorporation of specific nutrients and phytochemicals.

WP 3 Processing technologies for fruit snacks optimization

Malgorzata(Gosia) Nowacka (WULS-SGGW)

Fresh fruit

apple, citrus and berries

Osmotic dehydration →

Semi-dried processed fruit

Freezing
and dehydro-freezing →

Frozen fruits

Drying →

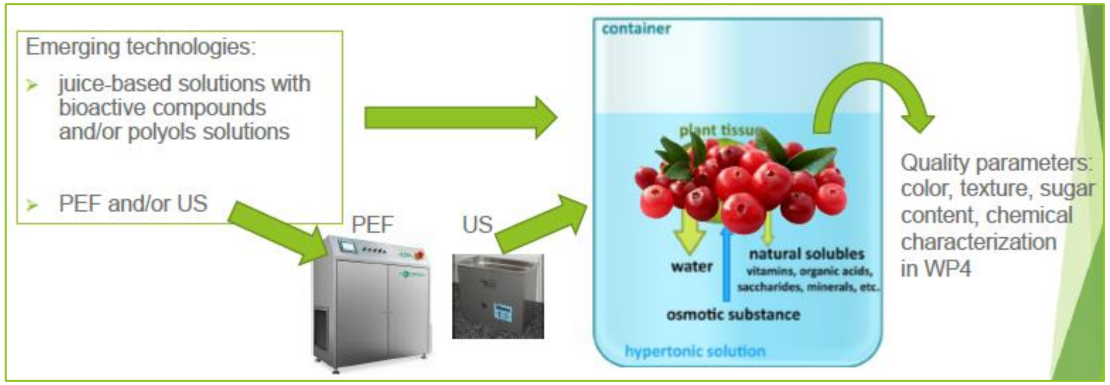
with RF (radio-frequency)
US (ultrasound)
PEF (pulsed electric field)

Dried fruits

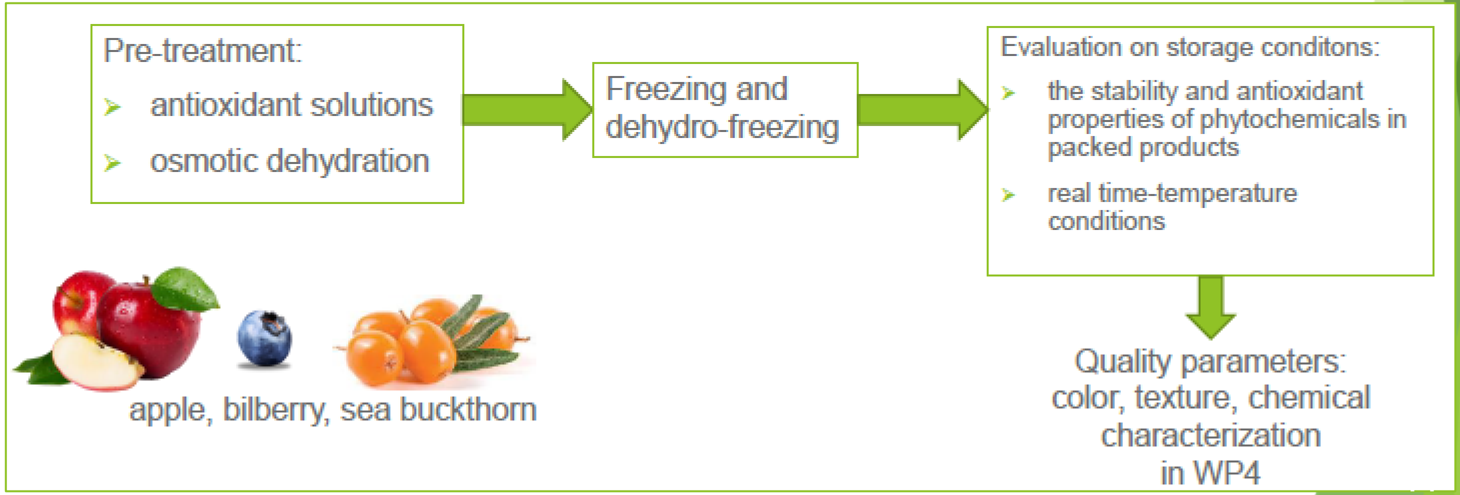
WP 3 Processing technologies for fruit snacks

Malgorzata(Gosia) Nowacka (UW)

TASK 3.1 Osmotic dehydration
UNIBO, UW



TASK 3.2 Freezing and dehydro-freezing
USAMVB, UW

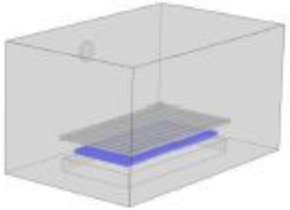


WP 3 Processing technologies for fruit snacks optimization

Malgorzata(Gosia) Nowacka (WULS-SGGW)

TASK 3.3 RF assisted drying (GU)

Emerging technologies:
- Radio Frequency
- Hot air assisted RF

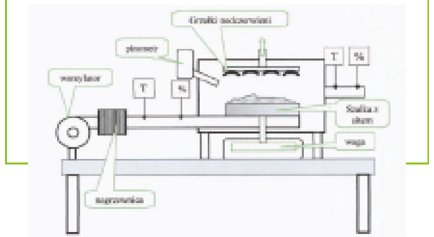


Quality parameters: color, organic acid profile, total phenolic content, antioxidant activity, sugar profile, aroma profile

TASK 3.4 US assisted drying, UW

Emerging technologies:
- US pre-treatment
- US assisted drying

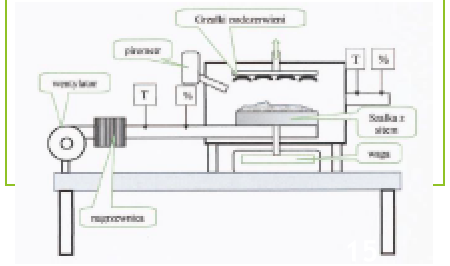
Hybrid drying methods :
- based on hot air drying



TASK 3.5 PEF assisted drying, UNIBO,UW

Emerging technologies:
- PEF pre-treatment

Hybrid drying methods :
- based on hot air drying



WP 4 Products and ingredients analysis

Tuulikki Seppänen-Laakso (VTT)

Tasks

Task 4.1 Chemical characterization

Task 4.2 Metabolic characterization

Task 4.3 Processing effect

Task 4.4 Storage effect

WP 5 Consumer Valuation

Daniele Asioli (University of Reading)

Task 5.1 Quality indexes

Development of simple quality indexes for shelf life assessment of organic fruit products from a consumer point of view will be performed.

Survival analysis: estimation of shelf life of different organic products by consumers' acceptance/ rejection data of samples with different storage times and quality levels.

Task 5.2 Consumers' preferences

Different products will be investigated using the choice experiment technique which is one the most valuable methodology used to elicit consumers' preference and WTP

EXAMPLE of choice experiment task

Here are three types of dried strawberries from organic production. Assuming an equivalent taste, which of these are you most likely to buy (only one choice is allowed)?

WP 6 Life cycle assessment (LCA) application on ORGANIC FOOD and food-preservation emerging technologies

Valentina Siracusa (UNIBO)

Tasks

Task 6.1 Early design tool

Task 6.2 Life cycle assessment (LCA)

Task 6.3 Code of practice development

WP 7 Dissemination, communication and exploitation

Objectives

- To disseminate the project results and
- To transfer the generated knowledge to relevant stakeholders, while raising awareness on the project towards a wide audience.

This WP will provide the foundations for effective communication and exploitation of the project's activities developed.
The dissemination of the project results aims finally at increasing the competitiveness of the organic sector and enhance consumer confidence on organic fruit products.

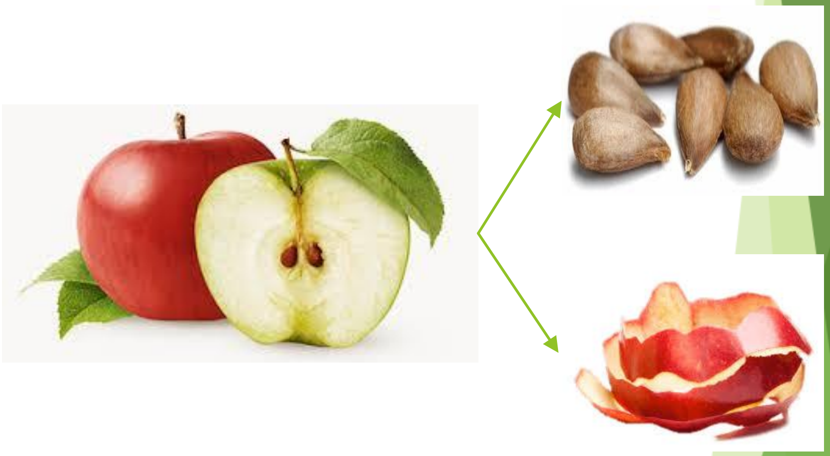
WP 8 Coordination and management
Pietro Rocculi (UNIBO)

Objectives

Project management that will ensure a smooth performance of the project and a satisfactory communication with the SF2 CO Cofund and within the Consortium.

Ensure the professional management and good governance of the project with a proper balance between participation and decisiveness A clear structure led by an experienced coordinator team and project managers will be established.

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.

Conclusions

As it resulted from the literature review, fruit waste (peel, seeds, pomace, etc.) have significant amount of valuable nutrients, being a great source of bioactive compounds that could be further used in food industry, pharmacy, cosmetics, etc.

Stabilizing and converting fruit waste into nutritious ingredients or valuable bioactive compounds represents an attractive option for business, society and planet health.

Their return to the food supply chain and not only, ensures the fact that the rich source of nutrients in fruits is not wasted but recovered for the production of safe, nutritious and consumer-acceptable foods. Also, the efficient use of fruit in terms of food production could lead to a more sustainable use of all the other resources, such as water, fertilizers, soil,etc.

TASK 2.2 Selection of extraction methods

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.

Description

- Pressurized liquid extraction (PLE), Pulsed Electric Fields (PEF) and Ultrasound (US) provide the possibility to extract bioactive components using low amount of non-toxic solvents. Moreover, extraction at low temperature and in the absence of light and oxygen can reduce the risk for the degradation of valuable components.
- Suitable separation technologies (e.g. PLE, PEF- and US- assisted extraction) will be selected and optimized according to the properties of each side stream typology (selected in Task 2.1) and target compounds.

Technologies tested

- **ASE extraction (Accelerated solvent extraction)** - established protocol to be tested by USAMVB
- **US assisted extraction (Ultrasound)** - established protocol to be tested by USAMVB

- Materials used to compare the ASE extraction with ultrasound assisted extraction are dried sea buckthorn leaves which represent the waste after harvesting the fruits (Figure 1).

Figure 1. Visual aspect of tested samples

Extraction of natural biocompounds by ASE

- The extraction of powder samples was conducted by the **accelerated solvent extraction** (ASE) using a Dionex ASE 350 system equipped with a solvent controller (Dionex, Sunnyvale, CA, USA see fig. 2).

Figure 2. Dionex ASE 350 system

- About 0.2 g of sample was mixed with 0.04 g of diatomaceous earth and then placed into 10 mL stainless-steel extraction cells that contained a glass filter at the bottom of each cell. Different ethanol concentration, **temperature and extraction time ranges were used in order to identify optimal conditions for natural biocompounds extraction** (table 1).
- The extraction conditions were pressure (1500 psi), rinsing volume (50%), nitrogen purge time (90 s), and heat time (5 min). The set extraction volume (20 mL) was stored at - 80 °C in the dark prior to analysis.

Extraction of natural biocompounds assisted by US

➢ The extraction of powder samples was conducted by US assisted extraction using a Biobase UC-40A system. 0.2 g of sample was mixed with 20 ml ethanol and then placed into 50 mL Falcon conical tubes. Different ethanol concentration, temperature and extraction time ranges were used in order to identify optimal conditions for natural biocompounds extraction (Table 1). The set extraction volume (20 mL) was stored at - 80 °C in the dark prior to analysis.

Table 1. Extraction conditions based on a 2^3 -level full factorial design

Run	X_1	X_2	X_3
	Temperature °C	Time (min)	Ethanol concentration (%)
1	-1	-1	-1
2	1	-1	-1
3	-1	1	-1
4	1	1	-1
5	-1	-1	1
6	1	-1	1
7	-1	1	1
8	1	1	1

	-1	1
Temperature °C	40	60
Time (min)	5	15
Ethanol concentration (%)	50	70

Results

Total phenolic content (TPC) and antioxidant activity (Aa) of resulted extracts for **ASE 350 extraction**

Sample	Experimental conditions (temperature (ºC), time (min), solvent concentration (%))	TPC (mg GAE/g)	Aa (mg Trolox eq / g)
1	40;5;50	97.72	1889.91
2	60;5;50	118.24	1903.94
3	40;15;50	111.04	1900.30
4	60;15;50	115.21	1906.29
5	40;5;70	97.02	1887.47
6	60;5;70	99.79	1909.69
7	40;15;70	91.76	1872.97
8	60;15;70	108.39	1905.47

Total phenolic content (TPC) and antioxidant activity (Aa) of resulted extracts for **US extraction**

Sample	Experimental conditions (temperature (ºC), time (min), solvent concentration (%))	TPC (mg GAE/g)	Aa (mg Trolox eq / g)
1	40;5;50	102.51	1857.118
2	60;5;50	106.15	1881.248
3	40;15;50	106.81	1897.239
4	60;15;50	108.70	1906.719
5	40;5;70	75.60	1620.556
6	60;5;70	98.20	1880.913
7	40;15;70	96.95	1874.306
8	60;15;70	89.50	1787.026

Conclusions

Overall, for antioxidant activity the values obtained by both extraction methods are similar. The highest value of antioxidant activity was obtained for extractions performed at 60°C. For the Total Phenolic Content, the highest value were obtained for ASE extraction method. The best performance of the extraction methods in term of quality of extracts were in two cases: 40°C; 5min; 50% and 60°C; 15min; 50%.

TASK 1.3 Edible coatings (EC)

Description:

Edible coatings represent an alternative and/or additional way for fruit preservation, because of their ability to reduce moisture and solute migration, respiration and transpiration rate, to maintain firmness and generally delay senescence of fruits on which they are applied. They have high potential for carrying active and functional ingredients which can enhance the nutritional values and the stability of products during their shelf-life. In this task the optimization of edible coating formulations enriched with functional ingredients (task 2.2) to develop ready-to-eat organic fruit products, with high nutritional quality and convenience will be carried out. The edible films will be developed based on chitosan/casein/gelatine solution. The obtained products will be subjected to chemical and metabolic characterisation in WP4; moreover, the quality parameters (e.g. colour, texture) will be evaluated.

Water extracts of SB were obtained as follows:

- 5g dried SB pomace in 30 ml of distilled water, US for 15 min at 40°C
- 5g dried SB pomace in 30 ml of distilled water, US for 30 min at 40°C
- 5g mild grinded SB pomace in 30 ml of distilled water, US for 15 min at 40°C
- 5g mild grinded SB pomace in 30 ml of distilled water, US for 30 min at 40°C

The obtained extracts were filtered, and the obtained filtrate was further characterized. The results are presented in Table below.

Analysing the obtained results, it was observed that there are no significant differences of antioxidant activities between the extracts when it comes to the US time, so it was decided to go further with the dried **SB pomace extract, US for 15 min at 40°C.**

Sample	Antioxidant activity (QE/100 ml)	Total polyphenolic content (mg GAE/100 ml)
Dried SB pomace extract, US 15 min	1124.82 ± 2.43	573.8 ± 11.31
Dried SB pomace extract, US 30 min	1124.82 ± 2.43	556.3 ± 6.36
Mild grinded SB pomace extract, US 15 min	1111.38 ± 11.60	713.3 ± 98.28
Mild grinded SB pomace extract, US 30 min	994.45 ± 151.40	1081.3 ± 116.67

- An edible coating (Figure below) was obtained based on 3g pectin/100 ml sol, 1ml glycerol/100ml sol and 99 ml of dried SB pomace water extract (which replaced distilled water in the coating formulation). Pectin was first solubilized in the SB water extract under heating, and after the mixture cooled down, glycerol was added.

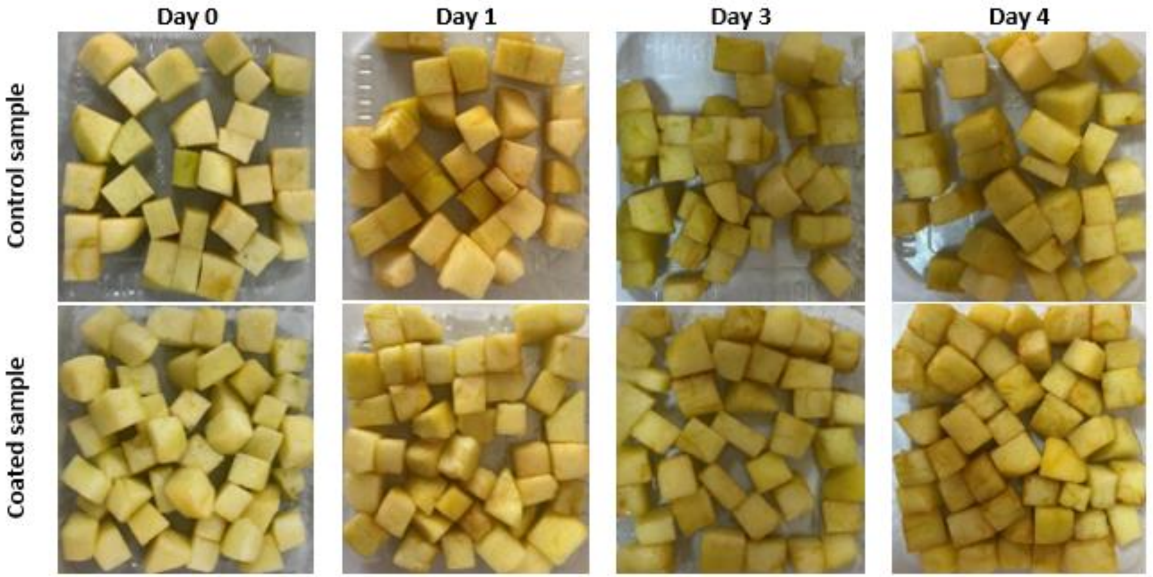
Apples from Dalinette variety used in the experiments

Apple cubes were cut with the side of 1 cm and immersed into the coating solution for 2 min and then removed and kept at room temperature for 45 min and then with ventilation at room temperature for another 45 min, in order to obtain a dry coating (Coated sample). Fresh apple cubes were used as Control sample. The obtained samples were then stored in refrigeration conditions (at 4°C) and further analysed on a period of 4 days.

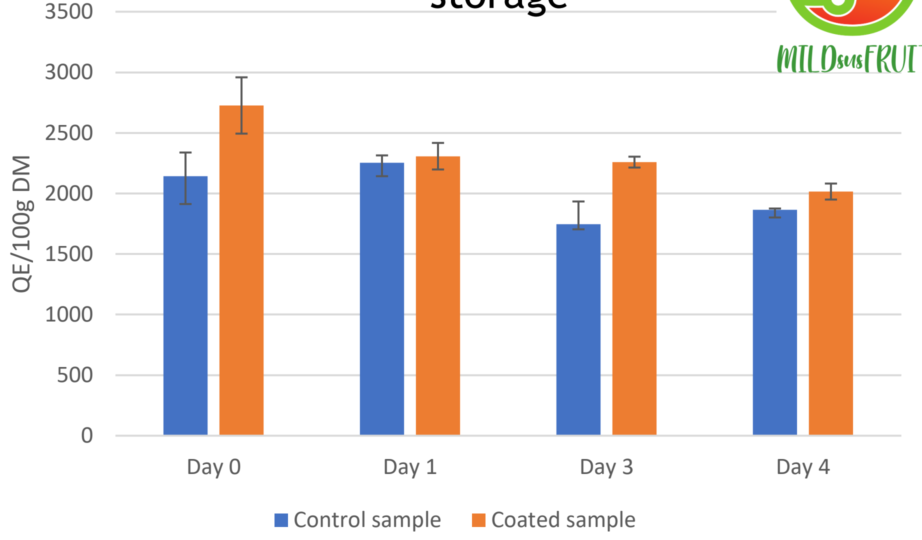
MILD SUS FRUIT

Weight loss values during refrigerated storage

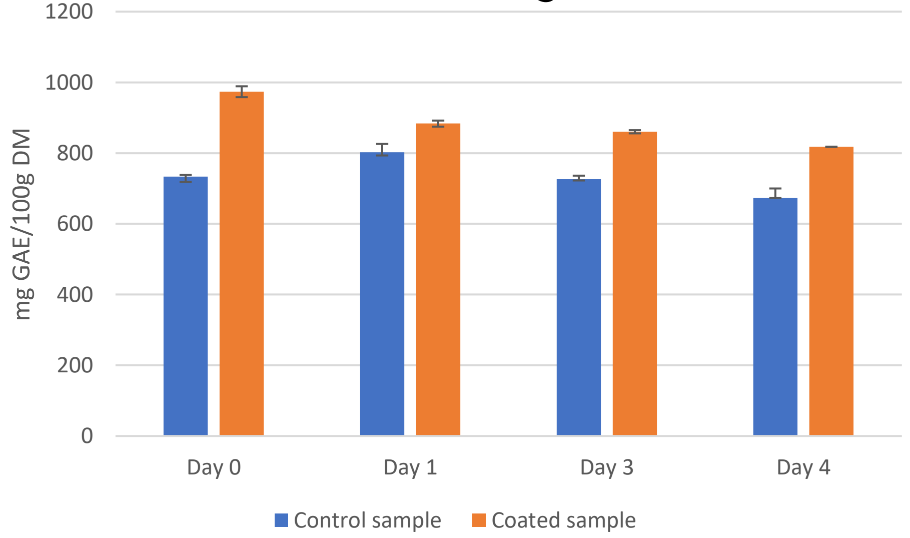
Sample	Day 0	Day 1	Day 3	Day 4
Control sample	0%	2.61%	3.39%	3.52%
Coated sample	0%	2.37%	3.13%	1.97%



Antioxidant activity during storage



Total phenolic content during storage



Conclusions

➢ Functional coatings represent a good alternative to packaging for food preservation and quality maintaining. They also can be used as carriers for different functional ingredients that could lead to an improved functionality of food products.

➢ The results of this study showed that the developed edible coating improved apple functionality, **increasing the antioxidant activity and total phenolic content** of the coated apples. Furthermore, the aspect of the coated samples was maintained during storage at 4^{o}C for 4 days, the browning process being more intense for Control sample, compared to Coated sample.

TASK 3.2 Dehydro-freezing

Description:

Study and set-up of dehydro-freezing to obtain dry organic fruit products with improved functionality and quality will be performed. Preliminary pre-treatments such as dipping in antioxidant solutions, osmotic dehydration will be tested and the optimal process parameters will be identified. The obtained products will be subjected to chemical characterisation in WP4; moreover, the quality parameters (e.g. colour, texture) will be evaluated as well as the dehydrofreezing rate.

To optimize the preliminary treatments, a number of methods have been tested, such as:

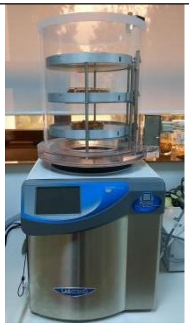
- the method of squeezing the sea buckthorn juice;
- the freezing temperature of the by-products that result from the squeezing of the sea buckthorn fruits;
- the method of placement on the shelves inside the lyophilizer;
- in order to squeeze the sea buckthorn fruits, tests were carried out in parallel with two constructive types of fruit juicer, centrifugal juicer compared to the auger juicer

centrifugal juicer
(U = 53,285 %)

auger juicer
(U = 43,063 %)

Parameters analyzed	Sea buckthorn variety		
	Clara	Sorana	Mara
Raw material quantity	1000 g	1000 g	1000 g
Juice quantity	690 ml	750 ml	700 ml
By-product quantity	234 g	172 g	232 g
Quantity of dry by-product	118 g	58 g	130 g
Flour weight after sifting	46,3 g	44 g	72 g
Losses during processing	76 g	78 g	68 g
	7,6 %	7,8 %	6,8 %

Freeze drying of sea buckthorn waste

		
		
A. Distribution of samples in aluminum trays	**B. Distribution of samples into glass Petri dishes**	

Refrigerator

Hotpoint

Freezing temperature tested:

-18^{0}C, -20^{0}C, -24^{0}C

Climatic Room

Feutron KPK 200

Freezing temperatures tested:

-30^{0}C, -35^{0}C

Freeze drying

The preliminary tests to establish the lyophilization parameters of sea buckthorn by-products were carried out on Mara variety.

- the temperature of the collector varied in the range -46^{0}C : -48^{0}C;
- the temperature of the shelves in the freeze-drying chamber was kept constant at 60^{0}C;
- the pressure varied between 0.200 - 0.800 mbar;
- the lyophilization time tested was 24 hours, 48 hours, and 72 hours, respectively.

No. crt.	Sample	Pretreatments	Lyophilization parameters				Final moisture content of freeze-dried samples (%)
			Collector temperature (^{0}C)	Vacuum (mbar)	Shelf temperature (^{0}C)	Freeze drying time (hours)	
1.	MARA variety	Fruits squeezing, By-products preliminary freezing at - 35^{0}C for 24 hours Ui = 53,285%	- 46,7	0,794	60	24	8,755
2.			- 47	0,233	60	48	7,439
3.			- 47,6	0,237	60	24	10,963
4.			- 47,6	0,240	60	24	9,082
5.			- 46,9	0,297	60	48	8,491
6.			- 47,3	0,290	60	72	8,310

Freeze drying

Following these preliminary tests, the following operating parameters were established and applied to by-products from all three sea buckthorn varieties tested (Mara, Clara, Sorana).

- vacuum: 0,270 mbar;
- collector temperature: - 48^{0}C;
- freeze-drying time: 24 hours;
- temperature of the shelf in the freeze-drying room: 60^{0}C, 50^{0}C, 40^{0}C, respectively 30^{0}C;

The effects of freeze-drying treatment were highlighted by comparison with conventional drying treatment.

Conventional drying with hot air

Conventional drying treatments applied to sea buckthorn by-products

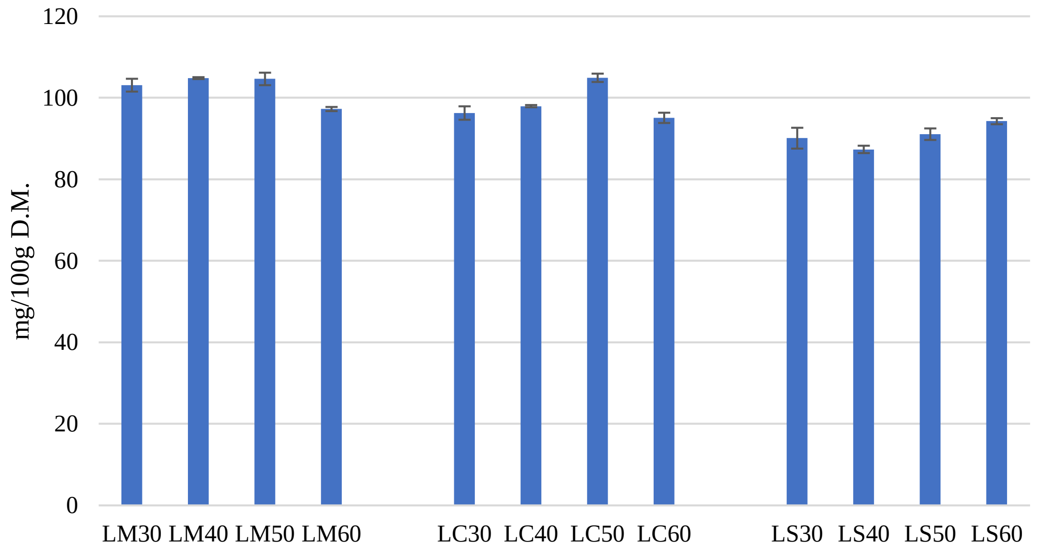
No.crt.	Sea buckthorn variety	Drying temperature (⁰C)	Drying time (hours)	Initial moisture content of samples (%)	Final moisture content of samples (%)	Dry matter of samples (%)
1.	Mara	60	9	48,837	8,252	91,748
2.	Clara			50,276	7,712	92,288
3.	Sorana			51,551	8,006	91,994
4.	Mara	50	12	48,837	9,003	90,997
5.	Clara			50,276	8,155	91,845
6.	Sorana			51,551	8,352	91,648
7.	Mara	40	15	48,837	8,908	91,092
8.	Clara			50,276	7,149	92,851
9.	Sorana			51,551	7,899	92,101
10.	Mara	30	19	48,837	7,816	92,184
11.	Clara			50,276	7,548	92,452
12.	Sorana			51,551	7,121	92,879

Food dryer

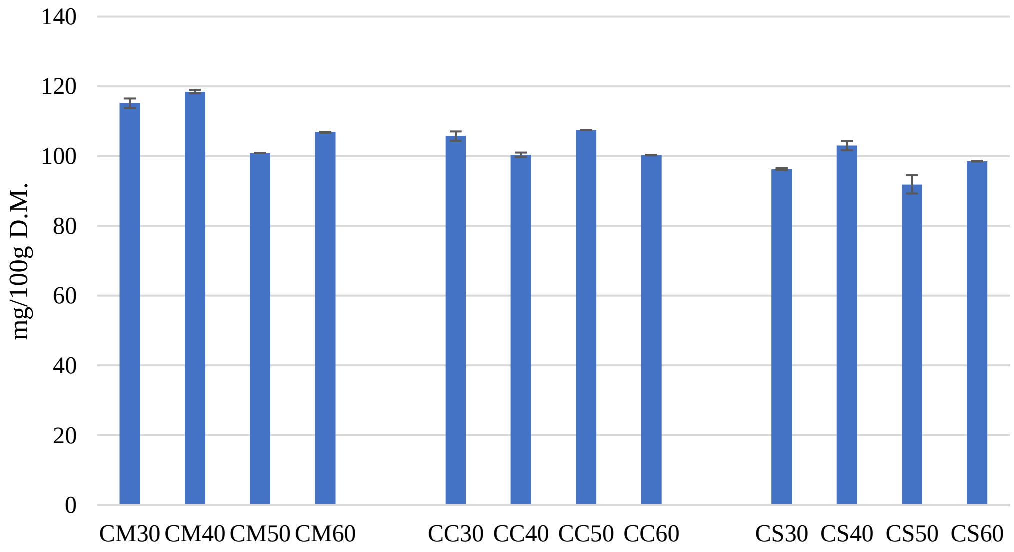
Vitamin C content

According to the results obtained from determination of the vitamin C content for the dehydrated sea buckthorn by-products, it was observed that the values obtained following the application of the studied drying regimes did not vary significantly, the vitamin C content showing close values.

Vitamin C content of freeze-dried sea buckthorn by-products

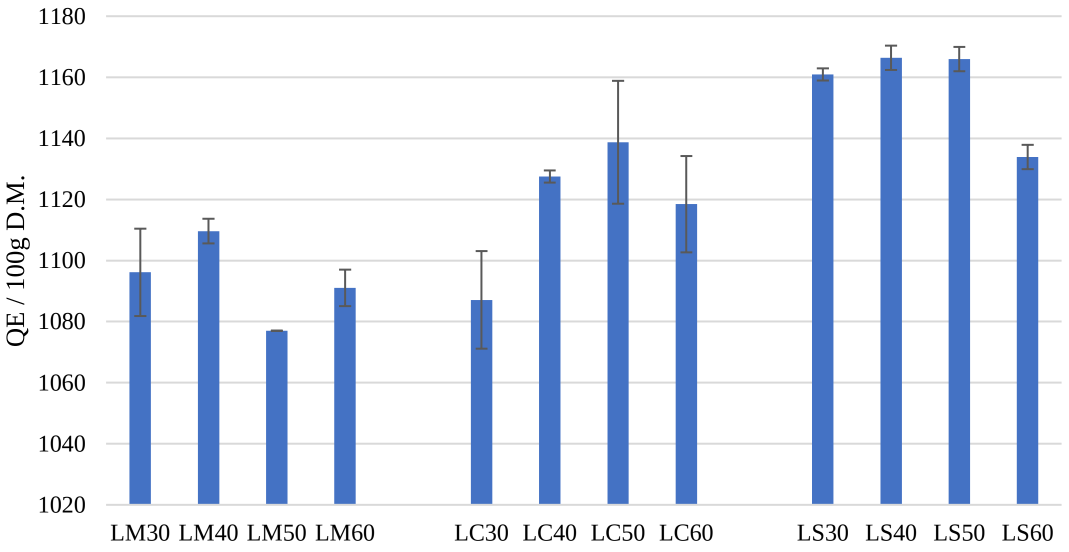


Vitamin C content of conventionally dried sea buckthorn by-products

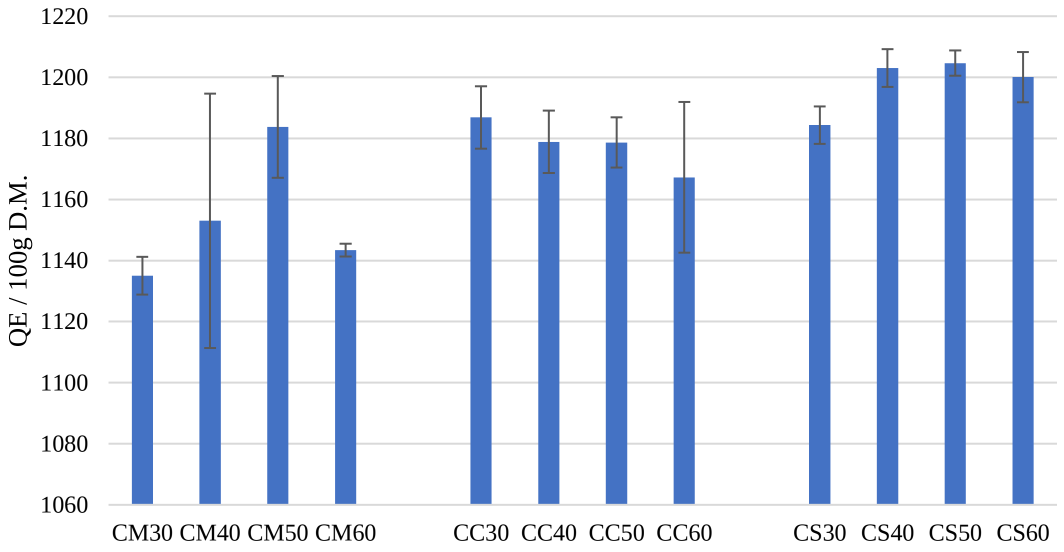


L- lyophilised, M-Mara, C-Clara, S-Sorana, C-conventionally dried, 3,40,50,60 – temperatures for drying

Antioxidant activity (DPPH)



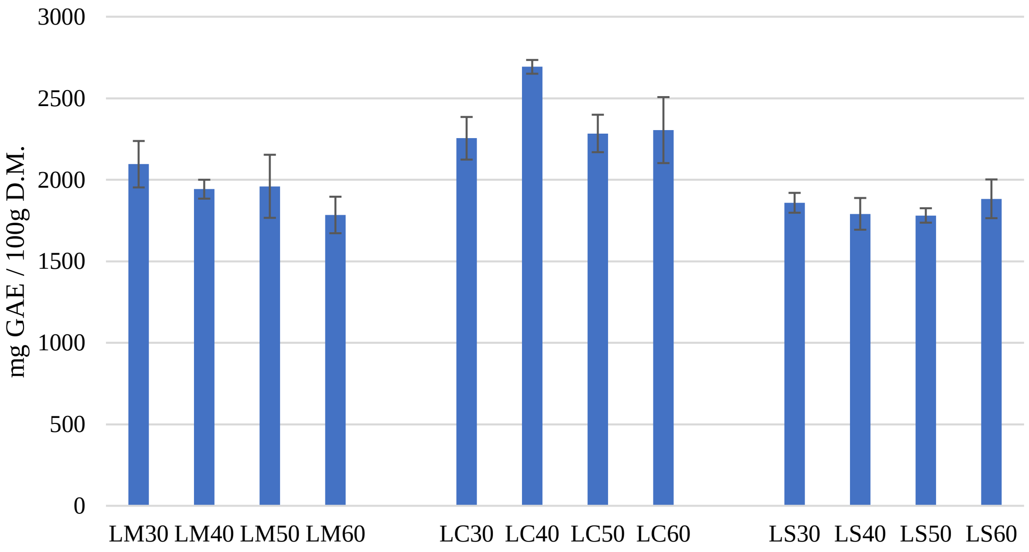
Antioxidant activity of freeze-dried sea buckthorn by-products



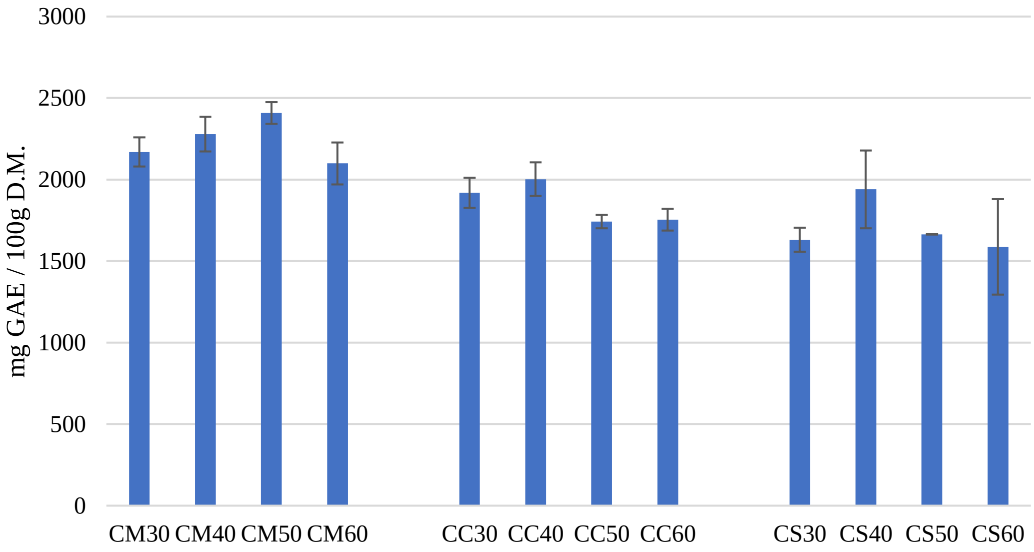
Antioxidant activity of conventionally dried sea buckthorn by-products

Regarding the antioxidant activity of the studied samples, higher values were obtained for the conventionally dried samples compared to the lyophilized samples. In the case of freeze-dried samples, the highest values were obtained for the following temperature regimes: 40°C for the Mara and Sorana varieties and 50°C for the Clara variety. For conventionally dried samples, the highest antioxidant activity values were obtained for samples dried at 50°C for the Mara and Sorana varieties and 30°C for the Clara variety.

Total phenolic content in mg gallic acid (GAE)/l per 100g dry matter



Total phenol content of freeze-dried sea buckthorn by-products



Total phenolic content for conventionally dried sea buckthorn by-products

No significant variations were observed between the two drying regimes, the values obtained for this parameter being similar. In the case of freeze-dried samples, the highest values were obtained for the samples to which the following temperature regimes were applied: 30°C for the Mara variety, 40°C for the Clara variety and 60°C for the Sorana variety. Regarding conventionally dried samples, the highest polyphenol content was obtained for samples dried at 50°C for the Mara variety and 40°C for the Clara and Sorana varieties.

Appearance and color measurements of sea buckthorn berries and of fresh and dried by-products

Sample	L*	a*	b*
CC 30	48.250 ± 0.931	21.425 ± 0.255	46.908 ± 0.984
CM 30	44.289 ± 0.577	19.557 ± 0.491	40.092 ± 0.977
CS 30	37.918 ± 0.281	22.473 ± 0.307	40.869 ± 0.592
CC 40	44.659 ± 0.528	23.137 ± 0.451	45.177 ± 0.537
CM 40	43.788 ± 0.477	19.138 ± 0.309	38.500 ± 0.438
CS 40	38.893 ± 0.465	21.110 ± 0.482	38.647 ± 0.793
CC 50	42.887 ± 1.149	18.982 ± 0.979	39.425 ± 1.443
CM 50	44.215 ± 0.400	17.052 ± 0.242	35.728 ± 0.582
CS 50	39.934 ± 0.599	22.535 ± 0.738	37.704 ± 1.207
CC 60	46.253 ± 0.451	20.610 ± 0.703	43.050 ± 0.880
CM 60	42.950 ± 0.227	18.786 ± 0.300	37.096 ± 0.383
CS 60	40.342 ± 0.367	21.986 ± 0.367	38.440 ± 0.775
Clara berries defrosted	53.603 ± 0.913	31.297 ± 0.529	54.687 ± 0.727
Sorana berries defrosted	43.312 ± 0.404	30.688 ± 0.586	54.767 ± 0.661
Mara berries defrosted	40.287 ± 0.330	35.237 ± 0.482	41.098 ± 0.684
Clara fresh by-product	48.128 ± 0.689	24.438 ± 0.802	51.447 ± 1.917
Sorana fresh by-product	45.101 ± 1.218	22.323 ± 0.929	47.177 ± 1.994
Mara fresh by-product	42.629 ± 0.331	21.465 ± 0.752	39.637 ± 1.523
LC 30	47.563 ± 0.984	12.091 ± 0.822	34.719 ± 2.009
LM 30	52.288 ± 0.884	14.756 ± 0.561	39.674 ± 1.075
LS 30	49.816 ± 0.389	17.431 ± 0.443	42.915 ± 0.802
LC 40	48.738 ± 0.288	15.386 ± 0.141	40.684 ± 0.338
LM 40	55.772 ± 0.889	14.396 ± 0.477	40.535 ± 0.950
LS 40	55.665 ± 0.550	17.570 ± 0.385	46.194 ± 1.181
LC 50	49.416 ± 0.463	15.902 ± 0.223	41.726 ± 0.575
LM 50	55.684 ± 0.967	14.384 ± 0.619	42.273 ± 1.156
LS 50	56.216 ± 0.171	17.382 ± 0.400	42.543 ± 1.730
LC 60	51.236 ± 0.759	15.296 ± 0.397	42.543 ± 0.765
LM 60	53.582 ± 0.979	14.911 ± 0.867	42.232 ± 1.333
LS 60	50.026 ± 0.570	17.854 ± 0.523	45.710 ± 0.935

Conclussions

Considering the results obtained, the best lyophilization, respectively drying regime can be considered the regime with the working temperature of 40°C for 24 hours, generally obtaining high values for the samples subjected to this working regime compared to the other regimes tested for all samples studied.

Also, following preliminary tests, the following operating parameters were established for samples lyophilization:

- vacuum: 0.270 mbar;
- collector temperature: - 48°C;
- freeze-drying time: 24 hours.

From the point of view of the efficiency of sea buckthorn fruits juicing, it was found that the losses are lower when using the centrifugal juicer compared to the auger juicer, but in terms of the moisture and the appearance of the by-products, is recommended the use of the auger juicer.

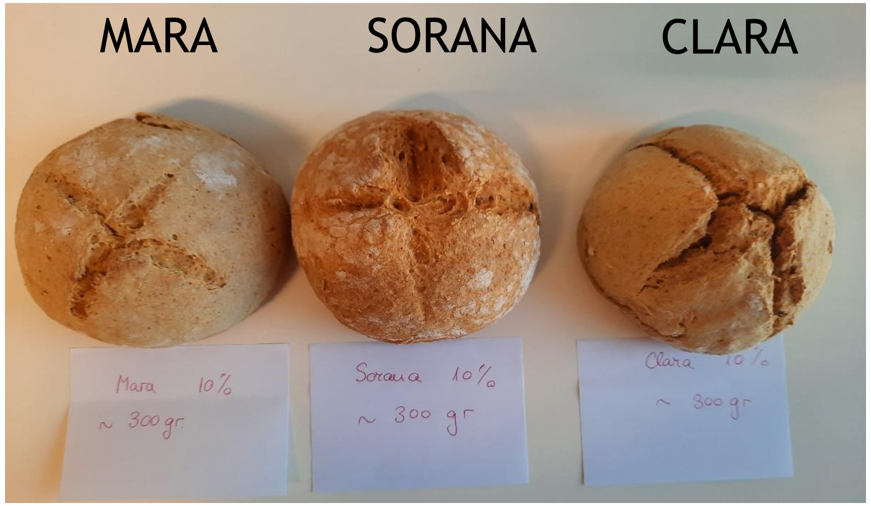
Freezing at -35°C, in the climate chamber, is recommended as the preliminary stage of the lyophilization treatment, for the dehydration of sea buckthorn by-products.

TASK 2.3 Technological assessment

Description

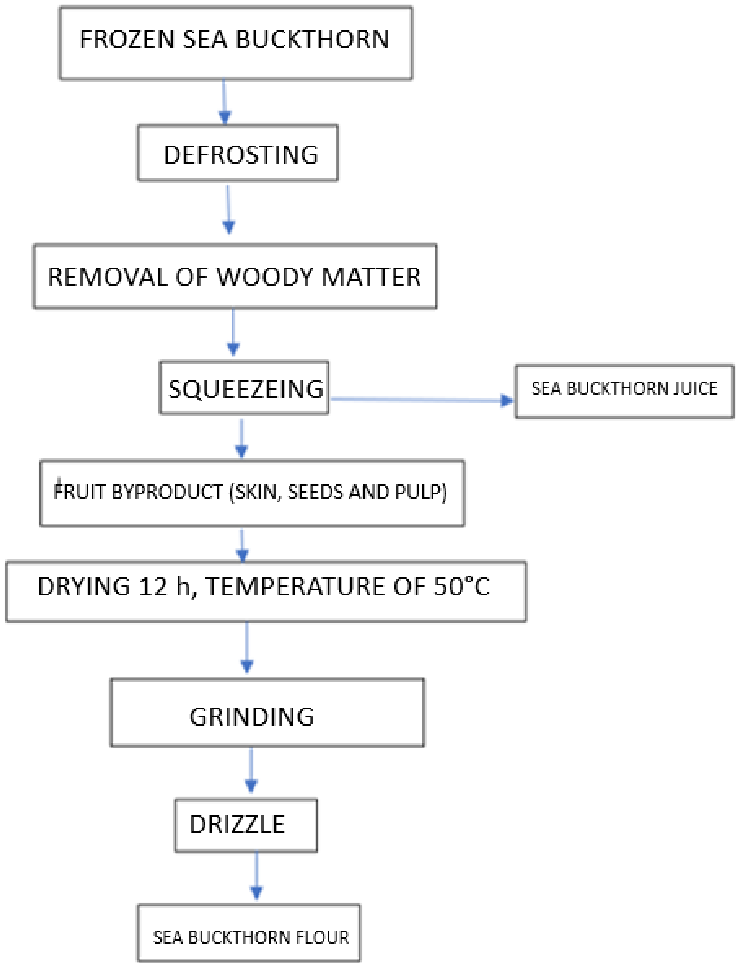
- The technological assessment of obtained functional ingredients on model systems will be performed. Suitable food matrices will be identified for the incorporation of specific nutrients and phytochemicals.

- The impact of various processing technologies on their stability will be assessed at different specific technological steps, including product storage. Individuation and/or testing of the potential utilization of functional ingredients in the organic fruit/food processing (e.g. formulation, impregnation) in food matrices will be performed.



Sea buckthorn waste for flour obtaining

Technological scheme for obtaining sea buckthorn powder



- Sea buckthorn powder was characterized from an organoleptic point of view (taste, smell, color) and from a physical-chemical point of view (moisture, acidity, mineral substances, etc.), according to the standards in force.
- Sea buckthorn powder was obtained by squeezing sea buckthorn berries, drying the fruit byproduct and grinding the dry fruit byproduct.

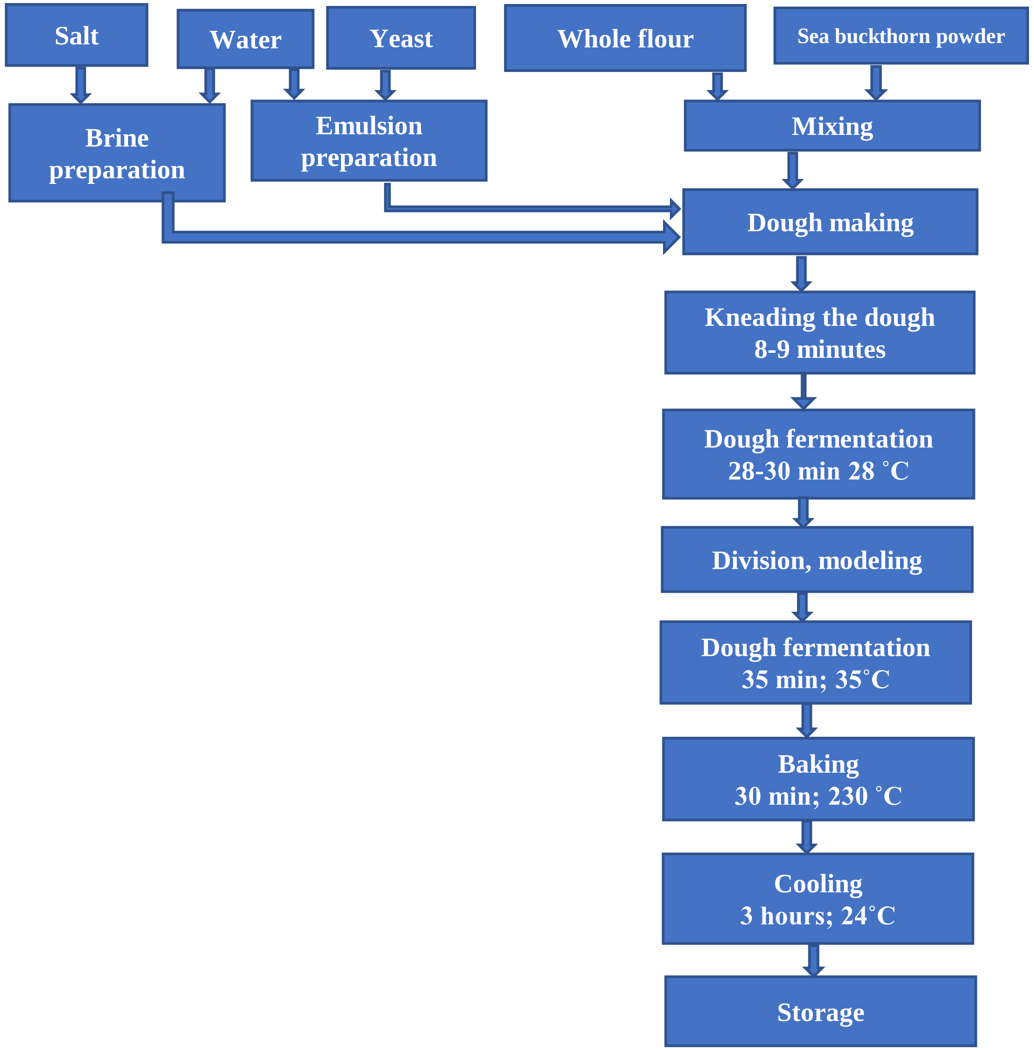
The technological process of obtaining functional bread

8% sea buckthorn flour, Mara variety

8% sea buckthorn flour, Clara variety

8% sea buckthorn flour, Sorana variety

Control

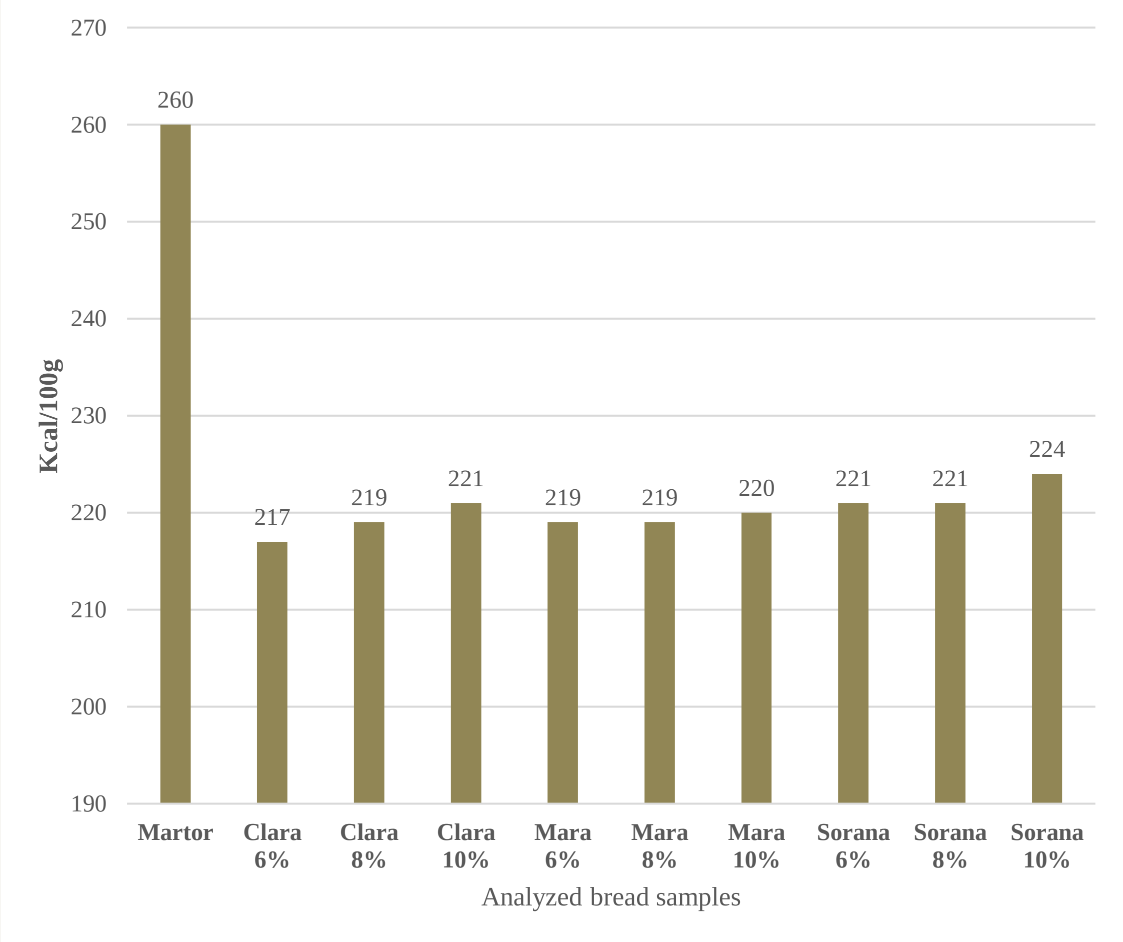


Mara 8% Sorana 8% Clara 8% Control

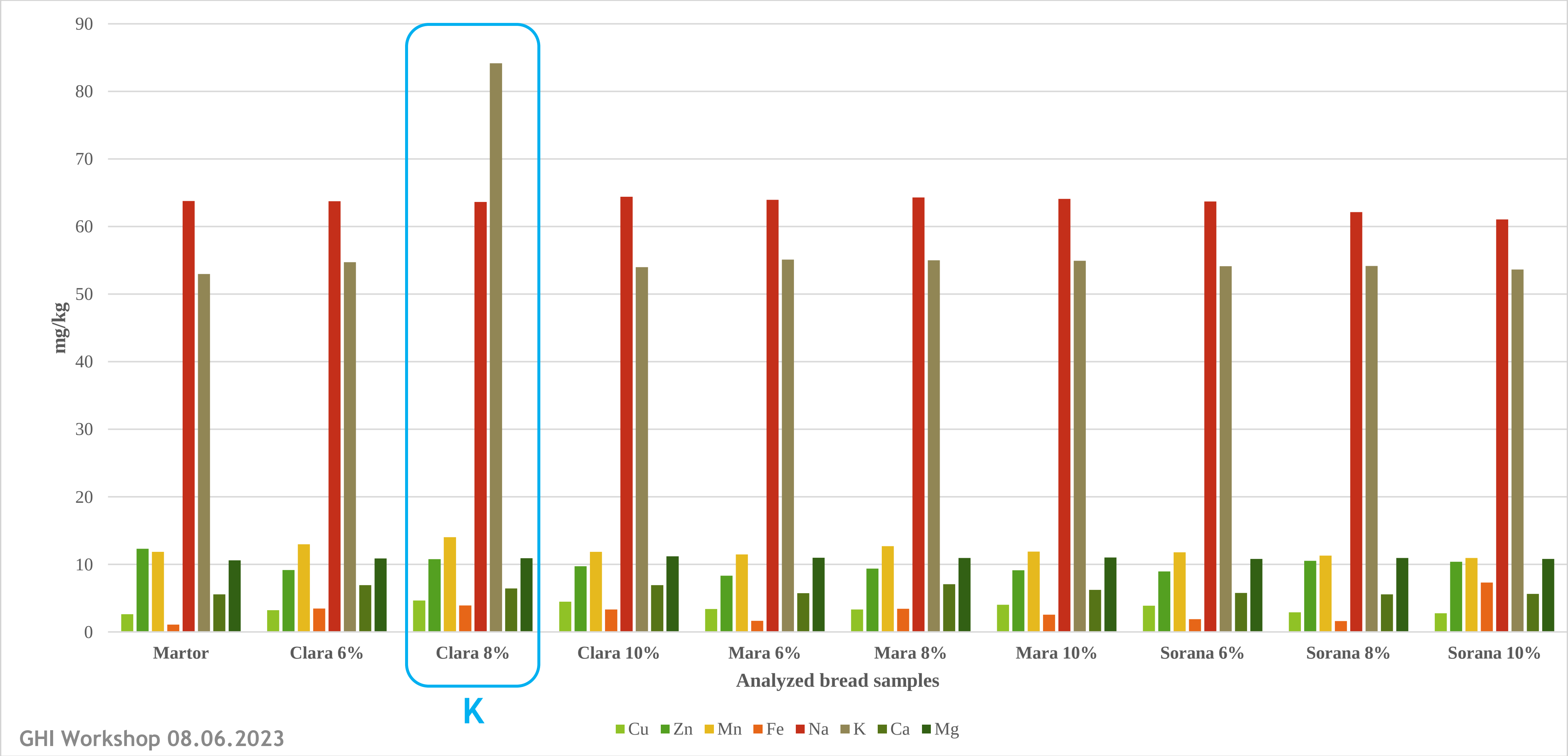
Appearance of functional bread samples with 8% addition of sea buckthorn powder

Total fibers, protein and fat content of functional breads

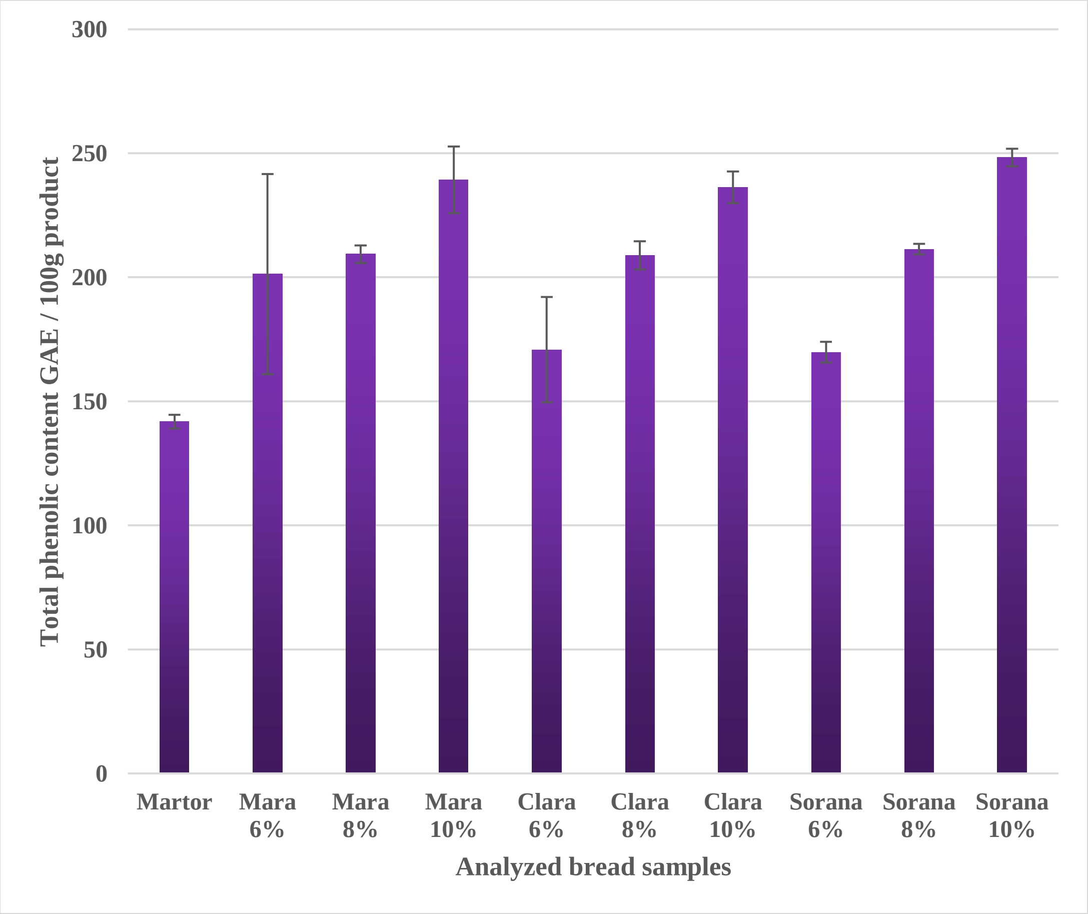
Caloric value of functional breads

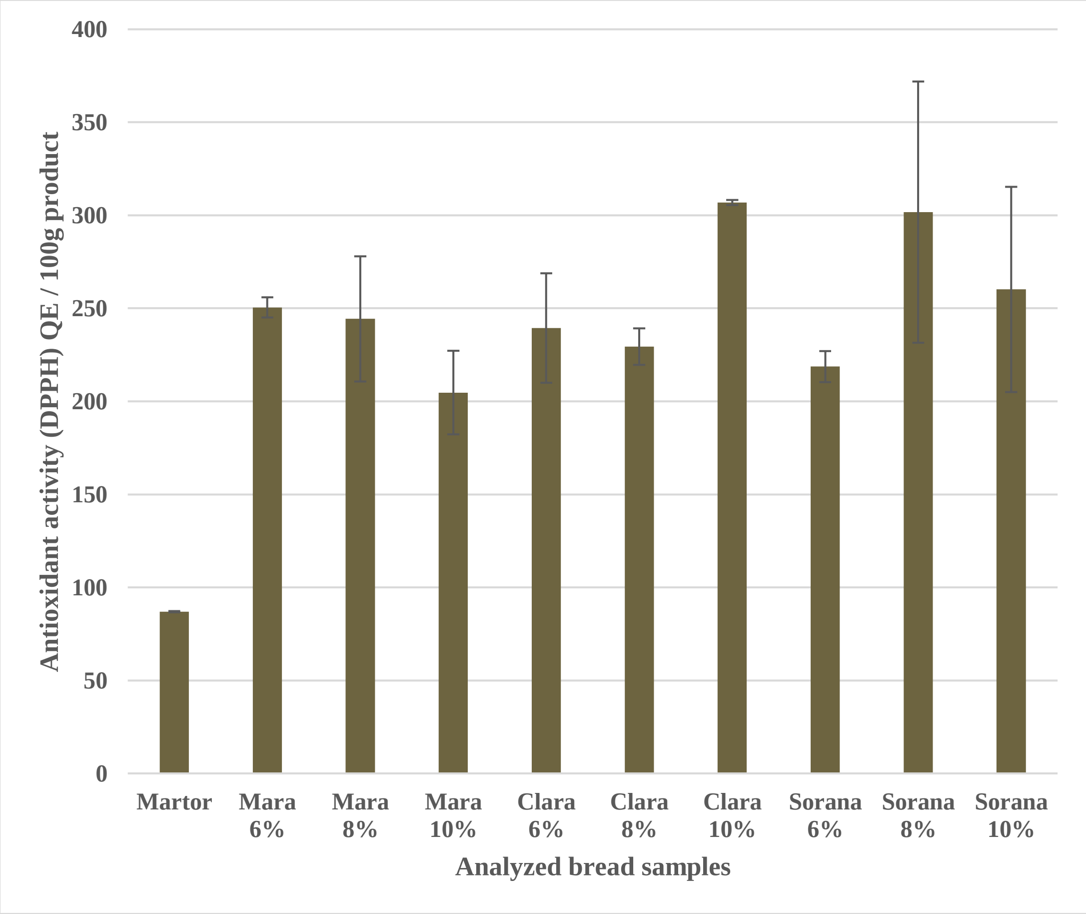


Minerals content determination



Total phenolic content and antioxidant activity determinations for functional bread





Conclusions

- The functional bread has added nutritional value in comparison withe simple bread being enriched in minerals, phenolic compounds and having increased antioxidant activity
- The functional bread samples recorded lower energy values than the control sample
- The crude fiber content of the functional bread samples increased considerably compared to the control sample. Regarding the fat content of the analyzed samples, a significant increase is observed in the functional bread samples compared to the control sample.
- From a sensory point of view, following the acceptability tests regarding the taste of the product, the samples with 8% addition of sea buckthorn powder were unanimously accepted.

Pâine cu 8% pudră de cătină

Conjoint analysis: bread with seabuckthorn

Methodology

- Quantitative online.
- Questionnaire lasting 5 minutes.
- Sample size of 102 persons – homogeneous population of affluent consumers (active women, 30-45 y.o. from Bucharest, the capital city of Romania).
- Data collection: September 2022, via Conjoint.ly platform.

Pe care dintre următoarele produse alimentare l-ai alege?

Produsul A	Produsul B	Produsul C
Marca cunoscuta	O marca noua	O marca noua
• Made in Romania • Reducem risipa alimentara, folosim tot fructul	• Made in EU • Contribuie la valorificarea resturilor alimentare	• Made in EU • Reducem risipa alimentara, folosim tot fructul
		
• Produs imbogatit cu catina	• Contine resturile de catina ramase dupa stoarcerea sucului	• Contine resturile de catina ramase dupa stoarcerea sucului
10.5 lei pentru o paine de 400 g	7.5 lei pentru o paine de 400 g	10.5 lei pentru o paine de 400 g
ALEGE	ALEGE	ALEGE

The Ideal Product resulted from the conjoint analysis

Seabuckthorn claim	Sustainability claim	Price	Brand	Origin
Product enriched with seabuckthorn	We reduce food waste, we use all the fruit	7.5 RON for a bread of 400 g	Familiar brand	Made in Romania

Dissemination activities

MILD SUS FRUIT

CORE organic

SUSFOOD2

MILDsusFRUIT

ISI Articles

1. 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 (FI 4.121/2020)

2. 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).

3. Stanciu I., Dima R., Popa E.E., Popa M.E., 2022. Nutritional characterization of organic seabuckthorn pomace, Scientific Papers. Series B, Horticulture. LXVI(1), ISSN 2285-5653, 913-918.

4. Popa E.E., Anghel A.A., Stanciu I., Mitelut A.C., Popescu P.A., Draghici M.C., Geicu-Cristea M., Popa M.E., 2022. Preliminary research on using organic sea buckthorn powder in bread making, articol acceptat pentru publicare în Agrilife Scientific Journal, nr. 2/2022.

5. Stanciu I., Ungureanu E.L., Popa E.E., Geicu-Cristea M., Draghici M., Mitelut A.C., Mustatea G., Popa M.E., 2023. The Experimental Development of Bread with Enriched Nutritional Properties Using Organic Sea Buckthorn Pomace, Applied Sciences, 13, 6513. (FI 2.838/2021)

BDI Articles

1. 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.

2. Stanciu I., Popa E.E., Popa M.E., 2022. The content of bioactive substances in sea buckthorn and the functional potential of its waste, Journal of Agroalimentary Processes and Technologies, 28(1), 96-103.

3. Popa E.E., Popescu P.A., Mitelut A.C., Draghici M.C., Geicu-Cristea M., Popa M.E., 2022. Edible coating for functionality improvement of minimally processed organic apples, Journal of EcoAgriTourism, 18(2), 125-131, ISSN 1844-8577.

foods MDPI

Review

Latest Developments in Edible Coatings on Minimally Processed Fruits and Vegetables: A Review

Amalia Carmen Miteluț [1], Elisabeta Elena Popa [1,*], Mihaela Cristina Drăghici [1], Paul Alexandru Popescu [1], Vlad Ioan Popa [2], Oana-Crina Bujor [2], Violeta Alexandra Ion [2] and Mona Elena Popa [1]

AgroLife Scientific Journal - Volume 11, Number 2, 2022
ISSN 2285-5718; ISSN CD-ROM 2285-5726; ISSN ONLINE 2286-0126; ISSN-L 2285-5718

PRELIMINARY RESEARCH ON USING ORGANIC SEA BUCKTHORN POWDER IN BREAD MAKING

Elisabeta Elena POPA, Alexandra Andreea ANGHEL, Ioana STANCIU, Amalia Carmen MITELUȚ, Paul Alexandru POPESCU, Mihaela Cristina DRĂGHICI, Mihaela GEICU-CRISTEA, Mona Elena POPA

Scientific Papers. Series B, Horticulture. Vol. LXVI, No. 1, 2022
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

NUTRITIONAL CHARACTERIZATION OF ORGANIC SEABUCKTHORN POMACE

Ioana STANCIU, Ruxandra DIMA, Elisabeta Elena POPA, Mona Elena POPA

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 21, Issue 4, 2021
PRINT ISSN 2284-7995, E-ISSN 2285-3952

STUDY ON CONSUMERS PERCEPTION AND KNOWLEDGE ON VEGETAL ORGANIC BY-PRODUCTS USED AS FUNCTIONAL INGREDIENTS

Mihaela Cristina DRAGHICI[1], Amalia Carmen MITELUT[1], Elisabeta Elena POPA[1], Paul Alexandru POPESCU[1], Vlad Ioan POPA[2], Andreea BARBU[2], Mona Elena POPA[1]

applied sciences MDPI

Article

The Experimental Development of Bread with Enriched Nutritional Properties Using Organic Sea Buckthorn Pomace

Ioana Stanciu [1], Elena Loredana Ungureanu [2,*], Elisabeta Elena Popa [1,*], Mihaela Geicu-Cristea [1], Mihaela Draghici [1], Amalia Carmen Mitelut [1], Gabriel Mustatea [2] and Mona Elena Popa [1]

Dissemination activities

- **Conference participation**

1. Popa M.E., Mitelut A.C., Popa E.E., Draghici M., Stan A., Ion V., Bujor O., Popescu P.A., Popa V.I., Guidea-Danaila S., 2021. Procesare minimală inovativă proiectată să asigure produse din fructe ecologice de calitate bună, poster prezentat la Toamna Horticolă Bucureșteană, 30 Septembrie – 3 Octombrie 2021, București, România.

2. Popa M.E., Mitelut A.C., Popa E.E., Popescu P.A., Draghici M.C., Popa V.I., Danaila-Guidea S., 2021. Bioactive compounds in sea buckthorn – a review, poster prezentat la 20th International Conference „Life Sciences for Sustainable Development”, 23-24 Septembrie, Cluj-Napoca, Romania.

3. Mitelut A.C., Popa E.E., Popescu P.A., Popa V.I., Popa M.E., 2021. Valorization of fruits by-products as functional ingredients of bakery products, poster prezentat la „Food Quality and safety, Health and Nutrition Congress”, 9-11 Iunie, Ohrid, Macedonia.

4. Popa M.E., 2021. How innovation could be tailored to ensure sustainable and high-quality organic fruit products?, prezentare orală la International Conference Agriculture for Life, Life for Agriculture, 3 – 5 Iunie, Bucharest, Romania.

5. Popa M.E., 2021. Innovative mild processing tailored to ensure sustainable and high quality organic fruit products - ERA-NET PROJECT, prezentare orală la "Food Quality and Safety, Health and Nutrition Congress - NUTRICON", 09 – 11 Iunie, Ohrid, Macedonia.

6. Popa M.E., Screening of valuable compounds from organic apple processing by-products, poster prezentat la IUFoST World Congress 2022, 31.10 – 3.11.2022, Singapore.

7. Popa M.E., Ion V.A., Barbu A., Bujor O.C., Popa E.E., Popescu P.A., Draghici M., Mitelut A.C., Research on comparison between two sustainable extraction methods applied to sea buckthorn leaves, poster prezentat la Food Quality & Safety, Health & Nutrition – NUTRICON, 8-10 iunie 2022, Ohrid, Macedonia.

8. Popa E.E., Anghel A., Stanciu I., Mitelut A.C., Popescu P.A., Draghci M.C., Geicu-Cristea M., Popa M.E., Preliminary research on using organic sea buckthorn powder in bread making, poster prezentat la International Conference „Agriculture for Life, Life for Agriculture”, 2-4 iunie 2022, Bucuresti, Romania.

9. Stanciu I., Dima R., Popa E.E., Popa M.E., Nutritional characterization of organic sea buckthorn pomace, poster prezentat la International Conference „Agriculture for Life, Life for Agriculture”, 2-4 iunie 2022, Bucuresti, Romania.

10. Stanciu I., Popa E.E., Popa M.E., The content of bioactive substances in sea buckthorn and the functional potential of its waste, poster prezentat la Multidisciplinary Conference on Sustainable Development, 26-27 mai 2022, Timisoara, Romania.

Dissemination activities

- **Exhibitions participation**

1. Popa M.E., Mitelut A.C., Popa E.E., Draghici M., Stan A., Ion V., Bujor O., Popescu P.A., Stanciu I., Toader A., Danaila-Guidea S.M., Innovative mild processing tailored to ensure sustainable and high-quality organic fruit products – MILDSUSFRUIT, diploma de onoare INVENTICA 2022 (XXVI-th International Exhibition of Inventics), 22-24 iunie 2022, Iasi, Romania.

2. Popa M.E., Mitelut A.C., Popa E.E., Draghici M., Stan A., Ion V., Bujor O.C., Popescu P.A., Geicu-Cristea M., Stanciu I., Guidea-Danaila S., Procesare minimală inovativă proiectată să asigure produse din fructe ecologice de calitate bună, poster prezentat la GastroPan 2022, 3-5.04.2022, Brasov, Romania.

3. Popa M.E., Stanciu I.L., Geicu-Cristea M., Popa E.E., Draghici M.C., Popescu P.A., Mitelut A.C., Paine funcționala cu adaos de pudră obținută în urma valorificării subproduselor rezultate de la procesarea cătinei, participare la INOVALIMENT – Targ Internațional de Invenții și Inovații, 21-25.11.2022.

4. Popa M.E., Mitelut A.C., Popa E.E., Popescu P.A., Draghici M.C., Geicu M., Stanciu I., 2023. Pâine funcțională cu adaos de pudră obținută în urma valorificării subproduselor rezultate de la procesarea cătinei, poster prezentat la GastroPan 2023, 17-18.03.2023, Brasov, Romania.

- **Awards**

1. Popa M.E., Mitelut A.C., Popa E.E., Draghici M., Stan A., Ion V., Bujor O., Popescu P.A., Stanciu I., Toader A., Danaila-Guidea S.M., Innovative mild processing tailored to ensure sustainable and high-quality organic fruit products – MILDSUSFRUIT, medalie de aur obținută la INVENTICA 2022 (XXVI-th International Exhibition of Inventics), 22-24 iunie 2022, Iasi, Romania.

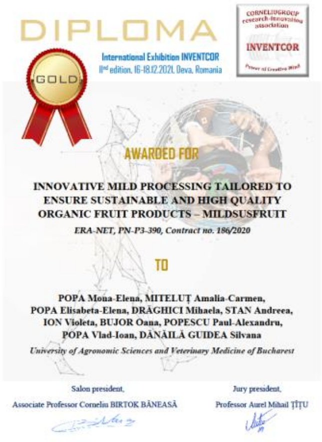
2. Popa M.E., Stanciu I.L., Geicu-Cristea M., Popa E.E., Draghici M.C., Popescu P.A., Mitelut A.C., Paine funcționala cu adaos de pudră obținută în urma valorificării subproduselor rezultate de la procesarea cătinei, premiul I la sectiunea Tehnologii alimentare în cadrul INOVALIMENT – Targ Internațional de Invenții și Inovații, 21-25.11.2022.

3. Popa M.E., Mitelut A.C., Popa E.E., Draghici M.C., Stan A., Ion V., Bujor O., Popescu P.A., Popa V.I., Dănăilă-Guidea S., Innovative mild processing tailored to ensure sustainable and high quality organic fruit products - MILDSUSFRUIT – medalie de aur obținută la International Exhibition INVENTCOR, editia a 11a, 16-18 decembrie 2021, Deva, Romania.

4. Popa M.E., Mitelut A.C., Popa E.E., Draghici M.C., Stan A., Ion V., Bujor O., Popescu P.A., Popa V.I., Dănăilă-Guidea S., Procesare minimală inovativă proiectată să asigure produse din fructe ecologice de calitate bună (MILDSUSFRUIT) - medalie de bronz obținută la Salonul Internațional de Invenții si Inovații „Traian Vuia" Timișoara, 14 octombrie 2021.


SALONUL INTERNAȚIONAL AL CERCETĂRII ȘTIINȚIFICE, INOVĂRII ȘI INVENTICII
PRO INVENT
EDIȚIA XIX, 20-22 OCTOMBRIE 2021
CLUJ-NAPOCA
DIPLOMA
DE EXCELENȚĂ
Se acordă POPA Mona-Elena, MITELUȚ Amalia-Carmen, POPA Elisabeta-Elena, DRĂGHICI Mihaela, STAN Andreea, ION Violeta, BUJOR Oana, POPESCU Paul-Alexandru, POPA Vlad-Ioan, DĂNĂILĂ GUIDEA Silvana
De la Universitatea de Științe Agronomice și Medicină Veterinară București
Pentru PROCESARE MINIMALĂ INOVATIVĂ PROIECTATĂ SĂ ASIGURE PRODUSE DIN FRUCTE ECOLOGICE DE CALITATE BUNĂ (MILDSUSFRUIT)
PREȘEDINTELE SALONULUI, Prof. dr. ing. VASILE TOPA, Rector al Universității Tehnice din Cluj-Napoca
PREȘEDINTELE JURIULUI, Prof. dr. ing. RADU MUNTEANU


SALONUL INTERNAȚIONAL DE INVENȚII ȘI INOVAȚII „TRAIAN VUIA" TIMIȘOARA
Diplomă
SE ACORDĂ MEDALIA DE BRONZ
pentru invenția
Procesare minimală inovativă proiectată să asigure produse din fructe ecologice de calitate bună (MILDSUSFRUIT)
autori
POPA Mona-Elena, MITELUȚ Amalia-Carmen, POPA Elisabeta-Elena, DRĂGHICI Mihaela, STAN Andreea, ION Violeta, BUJOR Oana, POPESCU Paul-Alexandru, POPA Vlad-Ioan, DĂNĂILĂ-GUIDEA Silvana
instituția
USAMV BUCUREȘTI
Președinte juriu Andrei Șos
Președinte salon Remi RĂDULESCU
Data 14 octombrie 2021


DIPLOMA
International Exhibition INVENTCOR
GOLD
AWARDED FOR
INNOVATIVE MILD PROCESSING TAILORED TO ENSURE SUSTAINABLE AND HIGH QUALITY ORGANIC FRUIT PRODUCTS – MILDSUSFRUIT
ERA-NET, PN-P3-390, Contract no. 186/2020
TO
POPA Mona-Elena, MITELUȚ Amalia-Carmen, POPA Elisabeta-Elena, DRĂGHICI Mihaela, STAN Andreea, ION Violeta, BUJOR Oana, POPESCU Paul-Alexandru, POPA Vlad-Ioan, DĂNĂILĂ GUIDEA Silvana
University of Agronomic Sciences and Veterinary Medicine of Bucharest
Salon president, Associate Professor Cornelia BIRTOK BĂNEASĂ
Jury president, Professor Aurel Mihail ȚÎȚU


Diploma of Honor
Offered to GOLD MEDAL
POPA MONA-ELENA[1], MITELUȚ AMALIA-CARMEN[1], POPA ELISABETA ELENA[1], DRĂGHICI MIHAELA[1], STAN ANDREEA[2], ION VIOLETA[2], BUJOR OANA[2], POPESCU PAUL-ALEXANDRU[1], STANCIU IOANA[2], TOADER ALEXANDRU[2], DĂNĂILĂ-GUIDEA SILVANA MIHAELA[1]
University of Agronomic Sciences and Veterinary Medicine of Bucharest
[1]The Faculty of Biotechnologies,
[2]Research Center for the Study of Quality Food Products
INNOVATIVE MILD PROCESSING TAILORED TO ENSURE SUSTAINABLE AND HIGH-QUALITY ORGANIC FRUIT PRODUCTS – MILDSUSFRUIT
In recognition of high scientific contribution and loyalty to the XXVI-th INTERNATIONAL EXHIBITION OF INVENTICS
INVENTICA 2022
Iasi, Romania
22-24 June 2022


INOVALIMENT
DIPLOMĂ
Locul I
Secțiunea Tehnologii Alimentare
Se acordă lucrării "Pâine funcțională cu adaos de pudră obținută în urma valorificării subproduselor rezultate de la procesarea cătinei"
Autori: Mona Elena Popa, Ioana Loredana Stanciu, Mihaela Geicu - Cristea, Elisabeta Elena Popa, Mihaela Cristina Draghici, Paul Alexandru Popescu, Amalia Carmen Mitelut - USAMV - București
Târgul Internațional de Invenții și Inovații "INOVALIMENT" – Ediția a III-a
21-25 noiembrie 2022

THANK YOU!

My team: Elena Popa, Amalia Mitelut, Mihaela Geicu, Mihaela Draghici, Paul Popescu, Mihaela Geicu, Oana Bujor, Violeta Ion, Vlad Popa, Silvana Guidea, Alexandra Jurcoane