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FunctionalizedTomatoProducts

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COMPARATIVE STUDY ON PHYSICOCHEMICAL PROPERTIES OF TOMATO JUICES WITH NON-IRRADIATED AND IRRADIATED SUPPLEMENTS: OLIVE POWDER AND SUGAR-BEET LEAVES PROTEIN

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PRIMA
PARTNERSHIP FOR RESEARCH AND INNOVATION IN THE MEDITERRANEAN AREA

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The Mediterranean Diet (MedDiet) involves a set of skills, knowledge, rituals, symbols and traditions concerning crops, harvesting, fishing, animal husbandry, conservation, processing, cooking, and particularly the sharing and consumption of food. (https://ich.unesco.org/en/RL/mediterranean-diet-00884)

UNESCO
United Nations Educational, Scientific and Cultural Organization
Intangible Cultural Heritage
Intangible cultural heritage

The Mediterranean Diet, recognized as an **Intangible Cultural Heritage** of Humanity by UNESCO, focuses on vegetables, so **plant-based protein powders** which can be considered as a good ingredient for MedDiet. (Davis C, Bryan J, Hodgson J, Murphy K. Definition of the Mediterranean Diet; a Literature Review. Nutrients. 2015, 7(11),9139-53. doi: 10.3390/nu7115459.)

Mediterranean Diet

SUGAR BEET

- The **sugar beet** is one of the most cultivated crops in the world.
- In addition, sixty percent of the World's production belongs to Europe.
- The sugar beet tubers are used in sugar production, while the **leaves** are the waste of sugar-producing companies that are normally used as livestock or left on the land.
- Although the sugar beet leaves are considered as waste, they have a potential to be a **good protein source** due to their high protein content.

(Akyüz, A., Ersus, S., Optimization of enzyme assisted extraction of protein from the sugar beet (Beta vulgaris L.) leaves for alternative plant protein concentrate production, Food Chemistry (2020), doi: https://doi.org/10.1016/j.foodchem.2020.127673)

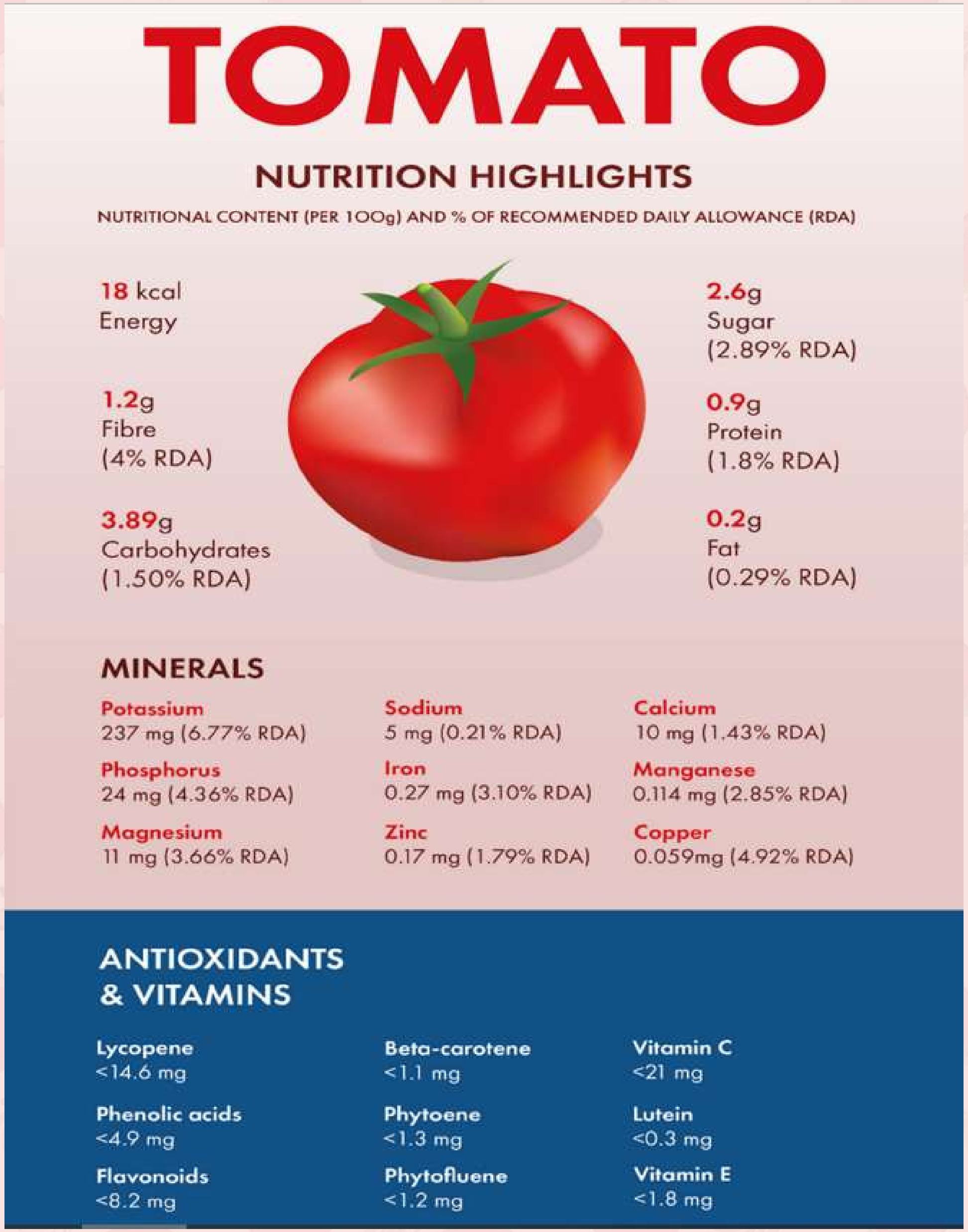
https://www.ecowatch.com/sugar-beet-leaves-create-vegan-protein-alternative-1882013864.html

- **Olive** is another indispensable ingredient for Mediterranean Diet.
- It can be consumed in the form of:

- table olives,
- olive powder or
- olive oil which is the most common form.

OLIVE

https://www.internationaloliveoil.org/olive-world/table-olives/
https://www.anadolive.net/en/product/olive-powder/
https://www.britannica.com/topic/olive-oil



TOMATO

- **Tomato** is one of the main components of the **traditional Mediterranean diet**.
- **Benefits**: health protection and longevity, reduced risks of some types of cancer and other diseases.
- **Antioxidant content** of the fruit, particularly carotenoids (lycopene and β-carotene), ascorbic acid, and phenols…

Collins, Edward J., Cressida Bowyer, Audrey Tsouza, and Mridula Chopra. 2022. "Tomatoes: An Extensive Review of the Associated Health Impacts of Tomatoes and Factors That Can Affect Their Cultivation" *Biology* 11, no. 2: 239. https://doi.org/10.3390/biology11020239

TOMATOES + OLIVE POWDER + SUGAR-BEET LEAVES

Tomatoes, **olive powder** and **sugar-beet leaves** proteins can be merged in the form of a juice to formulate the **functional food**.

This mix could play a **role in inhibiting free radicals**, i.e., **oxidative stress.**

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TOMATOES
OLIVE POWDER
SUGAR-BEET LEAVES

- Considering their beneficial properties and addition to tomato products, further studies on **tomato juices and powders prepared by non-thermal methods** are required.

- Aim of this study is **to monitor the changes of the physicochemical properties of tomato juices with supplements**: **olive powder** and **sugar-beet leaves protein powder after irradiation treatments**.

- As the powder must satisfy consumers demand in terms food safety with a longer shelf life, **preservation with ionizing gamma radiation have been applied**.

TOMATOES
OLIVE POWDER
SUGAR-BEET LEAVES

- The main objective of our investigation was **to compare physicochemical properties of tomato juices** prepared with addition of the different concentrations of olive powder and sugar-beet leaves protein that **were and were not exposed to irradiation treatment**.

(INTERNATIONAL ATOMIC ENERGY AGENCY, Irradiation of Spices, Herbs and Other Vegetable Seasonings (International Consultative Group on Food Irradiation Established under the Aegis of FAO, IAEA, WHO), IAEA-TECDOC-639, IAEA, Vienna, 1992)

TOMATOES
OLIVE POWDER
SUGAR-BEET LEAVES

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- **The irradiation dose** has been chosen according to IAEA regulative and in the amount allowed to be presented on the market without **Radura symbol**, **to avoid fear of customers and mistrust to usage of irradiation in food processing** even accepted and establish irradiation technology continues to generate controversy.

(INTERNATIONAL ATOMIC ENERGY AGENCY, Irradiation of Spices, Herbs and Other Vegetable Seasonings (International Consultative Group on Food Irradiation Established under the Aegis of FAO, IAEA, WHO), IAEA-TECDOC-639, IAEA, Vienna, 1992)

NON-IRRADIATED AND IRRADIATED

- **IAEA-TECDOC-639** was prepared in response to the requirement of the **Codex General Standard for Irradiated Foods** and associated Code that radiation treatment of food be justified on the basis of a technological need or of a need to improve the hygienic quality of the food.

- Among food irradiation applications, **radiation decontamination of spices, condiments and dried herbs** has the most immediate application potential in many countries.

NON-IRRADIATED AND IRRADIATED

- The health- and/or spoilage-hazards presented by a food ingredient must be evaluated always in the context of its use.

- **The problem of microbial contamination** is of particular concern in the case of foods which are **not heat-treated effectively before consumption**.

RADIATION DECONTAMINATION

- technically feasible
- economically viable
- safe physical process
- well controllable technology
- requires no additives
- highly efficient

NON-IRRADIATED AND IRRADIATED

- **Radiation processing**, particularly **with gamma rays**, is moreover a relatively simple technology.
- Materials to be treated are exposed to a controlled amount of radiation (ionizing energy) from a permissible radiation source (**panoramic 60Co gamma irradiation facility at the Ruđer Bošković Institute in Croatia; dose 1 kGy;** 1 Gy = 1 J/kg).
- Appropriate radiation sources and conditions of radiation treatment are defined in the **Codex General Standard for Irradiated Foods** and the associated **Recommended International Code of Practice for the Operation of Irradiation Facilities used for the Treatment of Foods.**

WHAT IS GAMMA IRRADIATION PROCESS?

- It is the **application of ionizing radiation to foods or products**.
- It involves a high technology that improves the safety and prolongs the shelf life of foods by decreasing or eliminating microorganisms and insects.
- **Food irradiation** can make a supply safer to eat for the consumer.
- Depending on the dose, microorganisms, bacteria, and viruses present are destroyed, slowed down, or rendered incapable of reproduction.

WHY DO WE NEED TO IRRADIATE FOODS? (1/2)

•It prevents foodborne diseases.
It helps in effectively eliminating organisms that can cause foodborne diseases such as Escherichia coli and Salmonella.

•It extends the shelf life of products or supplies.
It is an effective form of product or food preservation. It destroys organisms that can cause spoilage of foods by inactivating them. Thus, it prolongs the shelf life of foods.

•It controls the insect infestations.
It kills insects on tropical fruits such as mango products that are imported into our conutries. It also reduces the requirement for other harmful pest control practices.

https://www.symecengineers.com/what-is-gamma-irradiation-and-irradiated-foods/

WHY DO WE NEED TO IRRADIATE FOODS? (2/2)

- **It increases the life of the fruits or sprouting of plants such as spice plants and potatoes.**

To help prolong the longevity of fruit products, this method is effective. The method can slow down the sprouting of plants such as potatoes and ripening of fruits.

- **It is an effective sterilization method.**

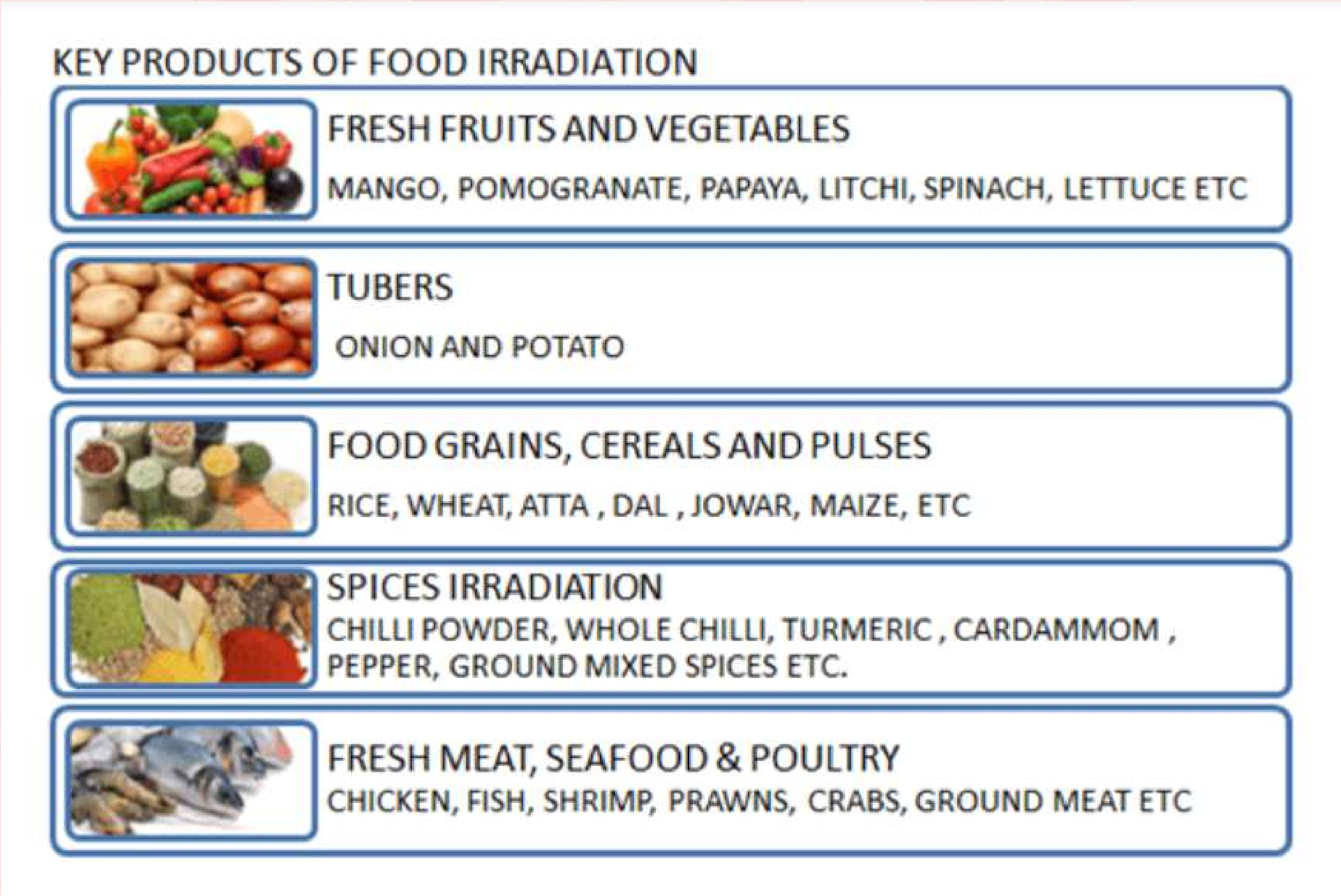
It is also the most effective way to sterilize foods which can be stored for long years without the need to refrigerate.

Sterilized foods are highly useful in hospitals for patients with intensely degree impaired immune systems such as patients' severe illnesses, or patients who are undergoing chemotherapy.

Irradiated foods provide higher levels of treatment than any other approved general use procedures.

https://www.symecengineers.com/what-is-gamma-irradiation-and-irradiated-foods/

KEY PRODUCTS OF FOOD IRRADIATION



https://www.symecengineers.com/what-is-gamma-irradiation-and-irradiated-foods/

OLIVE POWDER

- It is obtained by extracting the antioxidant compounds from olive mill waste-water with new systems and bringing them into consumable form and blending them with olives.
- One can enjoy this product, in which a small amount of green spices is added, as a condiment for every meal of the day.

https://www.anadolive.net/en/product/olive-powder/

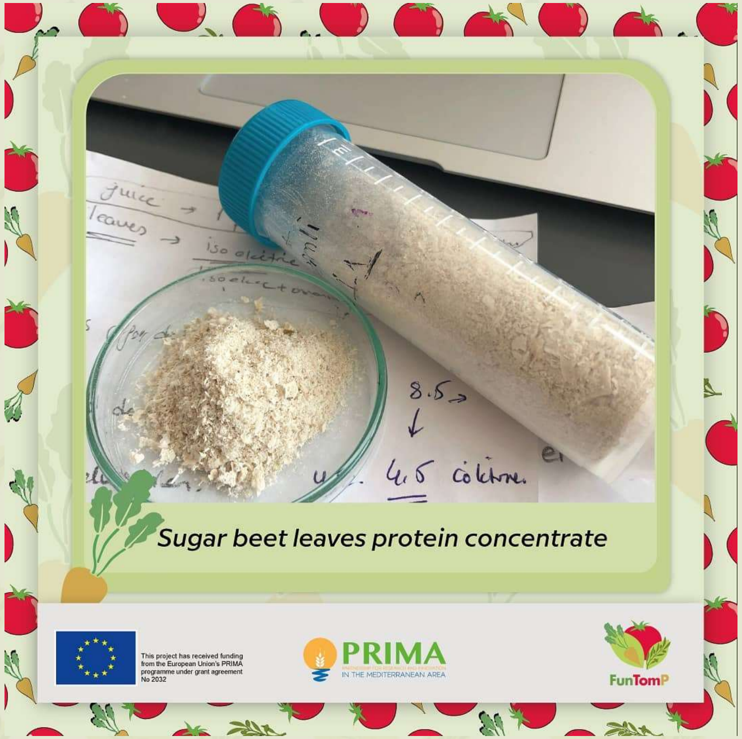
SUGAR-BEET LEAVES PROTEIN POWDER

- The high amount of sugar beet leaves emerges as the wastes of sugar producing companies and with their high protein content, it could be an alternative source for plant protein production.

- The protein yield increased both by enzyme assisted extraction and optimization of the effective extraction parameters such as temperature, time and solvent/solid ratio.

- The protein precipitation method type has an important effect on gaining the highest protein from extract.

FunTomP Partners from **Department of Food Engineering, Ege University, İzmir, Turkey**



Akyüz, A., Ersus, S., Optimization of enzyme assisted extraction of protein from the sugar beet (Beta vulgaris L.) leaves for alternative plant protein concentrate production, Food Chemistry (2020), doi: https://doi.org/10.1016/j.foodchem.2020.127673

TOMATO

Croatian Eco Farming

https://holus.hr/

VRTNI CENTAR BAKOVIĆ

SVETI FILIP I JAKOV

VRTNI CENTAR Bakovic

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Non-irradiated additives in tomato juice

#N	%olive	%beet protein	chlorophyll A mg/100 ml	chlorophyll B mg/100 ml	Lycopene mg/100 ml	Beta-carotene mg/100 ml
1	0	0	0,0147	3,90E-04	0,0795	0,0292
2	0,5	0	0,0757	0,10199	0,1212	0,0190
3	1	0	0,0238	0,01304	0,1053	0,0347
4	1,5	0	0,0388	0,02549	0,1124	0,0309
5	2	0	0,0253	0,05598	0,0888	0,0149
6	0	0,5	0,0352	2,35E-03	0,0873	0,0502
7	0	1,5	0,0976	7,91E-03	0,1027	0,0565
8	0,5	0,5	0,0507	5,95E-03	0,1029	0,0544
9	0,5	1,5	0,0887	9,09E-03	0,0848	0,0431
10	1	0,5	0,0369	7,01E-03	0,0621	0,0344
11	1	1,5	0,0947	0,02450	0,0848	0,0350
12	1,5	0,5	0,0701	0,02739	0,0865	0,0319
13	1,5	1	0,0766	0,01480	0,0583	0,0279
14	2	0,5	0,0831	0,02135	0,0691	0,0437
15	2	1,5	0,0494	0,01159	0,0546	0,0311

Protocol for lycopene and β- carotene: Masayasu NAGATA, Ichiji YAMASHITA Simple Method for Simultaneous Determination of Chlorophyll and Carotenoids in Tomato Fruit. J. Japan. Soc. Food. Sci. Technol. 39(10) 925-927 (1992)

Irradiated additives in tomato juice

#N	%olive	%beet protein	chlorophyll A mg/100 ml	chlorophyll B mg/100 ml	Lycopene mg/100 ml	Beta-carotene mg/100 ml
16	0,5	0	0,1691	0,04337	0,0455	0,0634
17	1	0	0,0236	0,01658	0,0985	0,0463
18	1,5	0	0,0183	6,16E-03	0,1731	0,0921
19	2	0	0,0137	7,18E-04	0,0788	0,0527
20	0	0,5	0,0243	0,01318	0,0434	0,0515
21	0	1,5	0,0315	1,65E-03	0,0515	0,0499
22	0,5	0,5	0,1006	6,93E-03	0,2263	0,0938
23	0,5	1,5	0,0414	3,16E-03	0,1010	0,0800
24	1	0,5	0,2566	0,04085	0,0698	0,0181
25	1	1,5	0,0969	2,93E-03	0,0703	0,0472
26	1,5	0,5	0,0538	3,20E-03	0,0738	0,0466
27	1,5	1,5	0,2163	0,09579	0,2241	0,0596
28	2	0,5	0,2431	0,01922	0,2426	0,1828
29	2	1,5	0,104	0,08749	0,0527	0,0150

Protocol for lycopene and β- carotene: Masayasu NAGATA, Ichiji YAMASHITA Simple Method for Simultaneous Determination of Chlorophyll and Carotenoids in Tomato Fruit. J. Japan. Soc. Food. Sci. Technol. 39(10) 925-927 (1992)

Non-irradiated / irradiated additives in tomato juice: pH value, total dry matter content/Brix

#N	%olive	%beet protein	Bx	Ph	#N	%olive	%beet protein	Bx	Ph
1	0	0	3,6	4,57					
2	0,5	0	4	4,44	16	0,5	0	4,6	4,46
3	1	0	4,2	4,46	17	1	0	4,2	4,44
4	1,5	0	4,4	4,51	18	1,5	0	4,3	4,48
5	2	0	4,6	4,49	19	2	0	4,4	4,54
6	0	0,5	3,9	4,44	20	0	0,5	3,8	4,43
7	0	1,5	4	4,39	21	0	1,5	3,7	4,37
8	0,5	0,5	4,2	4,46	22	0,5	0,5	4,0	4,38
9	0,5	1,5	4,3	4,41	23	0,5	1,5	4,1	4,40
10	1	0,5	4,4	4,46	24	1	0,5	4,1	4,42
11	1	1,5	4,6	4,34	25	1	1,5	4,3	4,34
12	1,5	0,5	4,5	4,36	26	1,5	0,5	4,3	4,44
13	1,5	1	4,6	4,38	27	1,5	1,5	4,3	4,39
14	2	0,5	4,5	4,45	28	2	0,5	4,5	4,32
15	2	1,5	4,6	4,45	29	2	1,5	4,5	4,42

Non-irradiated / irradiated additives in tomato juice: color L, a, b, Cab

#N	%olive	%beet protein	L	a	b	Cab	#N	%olive	%beet protein	L	a	b	Cab
1	0	0	99,64	-0,18	-0,28	0,33							
2	0,5	0	86,7	3,1	11,72	12,12	16	0,5	0	86,73	4,04	11,63	12,32
3	1	0	81,86	6,8	20,18	21,3	17	1	0	74,55	8,5	21,69	23,3
4	1,5	0	71,5	12,21	27,45	30,04	18	1,5	0	68,77	12,62	26,29	29,16
5	2	0	64,7	15,49	30,74	34,42	19	2	0	59,23	17,88	32,87	37,42
6	0	0,5	100,16	-1,21	4,22	4,39	20	0	0,5	92,17	-0,73	7,53	7,52
7	0	1,5	103,8	-3,61	8,09	8,86	21	0	1,5	98,13	-3,58	10,42	11,02
8	0,5	0,5	91,58	1,04	14,34	14,37	22	0,5	0,5	82,46	2,56	16,34	16,54
9	0,5	1,5	93,05	0,09	18,04	18,04	23	0,5	1,5	86,23	-0,08	16,7	16,7
10	1	0,5	82,77	5,72	22,63	23,34	24	1	0,5	74,5	4,72	21,1	21,63
11	1	1,5	83,22	3,1	21,78	22	25	1	1,5	74,45	4,2	27,72	22,13
12	1,5	0,5	72,21	8,86	26,17	27,63	26	1,5	0,5	70,37	10,29	28,05	29,87
13	1,5	1	75,43	7,38	26,83	27,83	27	1,5	1,5	70,18	8,13	27,67	28,64
14	2	0,5	58,27	15,96	32,31	36,03	28	2	0,5	63,27	14,76	31,76	35,02
15	2	1,5	59,13	13,8	31,21	34,12	29	2	1,5	60,25	16,54	32,74	36,68

Non-irradiated / irradiated additives in tomato juice: total acidity

#N	%olive	%beet protein	ml TA	TA/% citric acid	#N	%olive	%beet protein	ml TA	TA/%citric acid
1	0	0	3,5	0,35					
2	0,5	0	4,7	0,47	16	0,5	0	3,2	0,32
3	1	0	4,2	0,42	17	1	0	4,2	0,42
4	1,5	0	4,4	0,44	18	1,5	0	4,9	0,49
5	2	0	4,3	0,43	19	2	0	3,7	0,37
6	0	0,5	3,4	0,34	20	0	0,5	3,7	0,37
7	0	1,5	4,2	0,42	21	0	1,5	3,7	0,37
8	0,5	0,5	4,2	0,42	22	0,5	0,5	4,1	0,41
9	0,5	1,5	4,2	0,42	23	0,5	1,5	4,0	0,40
10	1	0,5	4,2	0,42	24	1	0,5	3,7	0,37
11	1	1,5	4,5	0,45	25	1	1,5	4,6	0,46
12	1,5	0,5	4,3	0,43	26	1,5	0,5	4,2	0,42
13	1,5	1	4,6	0,46	27	1,5	1,5	4,5	0,45
14	2	0,5	4,5	0,45	28	2	0,5	4,4	0,44
15	2	1,5	4,2	0,42	29	2	1,5	4,3	0,43

Non-irradiated / irradiated additives in tomato juice: microbiological stability

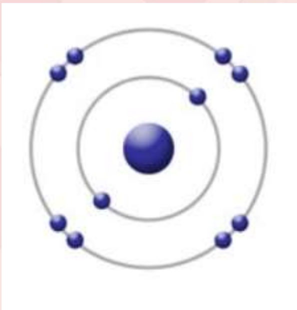
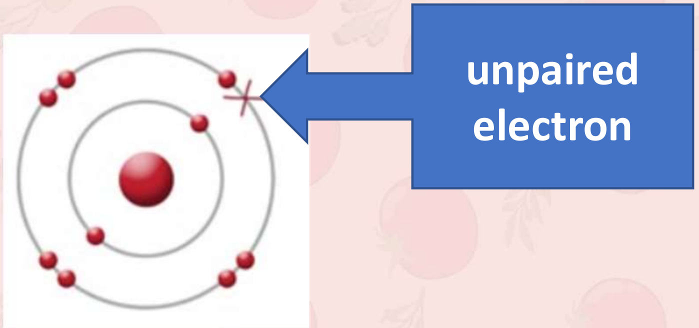
#N	%olive	%beet protein	TBC CFU/ml	TYC CFU/ml	TMC CFU/ml	TYMC CFU/ml	#N	TBC CFU/ml	TYC CFU/ml	TMC CFU/ml	TYMC CFU/ml
1	0	0	120	10	<10	10					
2	0,5	0	70	<10	80	80	16	170	10	50	60
3	1	0	80	<10	30	30	17	91	<10	<10	0
4	1,5	0	130	<10	140	140	18	100	<10	10	10
5	2	0	170	<10	20	20	19	340	<10	<10	0
6	0	0,5	110	10	10	20	20	120	<10	20	20
7	0	1,5	450	40	<10	40	21	91	<10	<10	0
8	0,5	0,5	140	10	20	30	22	60	<10	<10	0
9	0,5	1,5	100	60	<10	60	23	60	<10	<10	0
10	1	0,5	180	20	<10	20	24	100	<10	<10	0
11	1	1,5	210	10	40	50	25	2000	40	<10	40
12	1,5	0,5	130	<10	40	40	26	120	<10	<10	0
13	1,5	1	120	30	<10	30	27	64	<10	<10	0
14	2	0,5	220	10	10	20	28	100	<10	10	10
15	2	1,5	70	10	10	20	29	200	20	10	30

TBC = total bacteria counts, TY C= total yeast counts, TMC = total mold counts, TYMC = total yeast mold counts

WHAT IS EPR?

ELECTRON PARAMAGNETIC RESONANCE (EPR)
OR
ELECTRON SPIN RESONANCE (ESR)
OR
ELECTRON MAGNETIC RESONANCE (EMR)

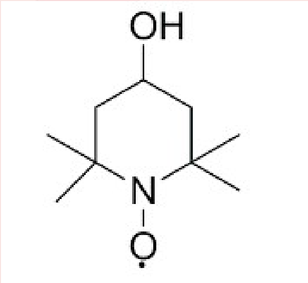
- **Spectroscopy** - magnetic resonance technique that detects ***UNPAIRED ELECTRONS*** (transition metal ions (Fe, Cu, Mn, Co, Ni....); free radical – typically species with O, N, C; defects – semiconductors, light, radiation induced etc.)
- only technique that unambiguously detects ***FREE RADICALS*** - no possibility of false positive results

stable, i.e., ”healthy” molecule	unstable molecule, i.e., ”free radical”
	

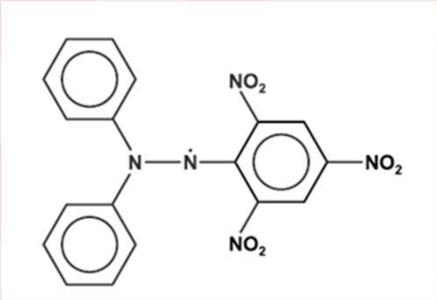
QUANTIFICATION

EPR signal intensity ~ **concentration of radical species**
(endogenous present or externally induced/added)

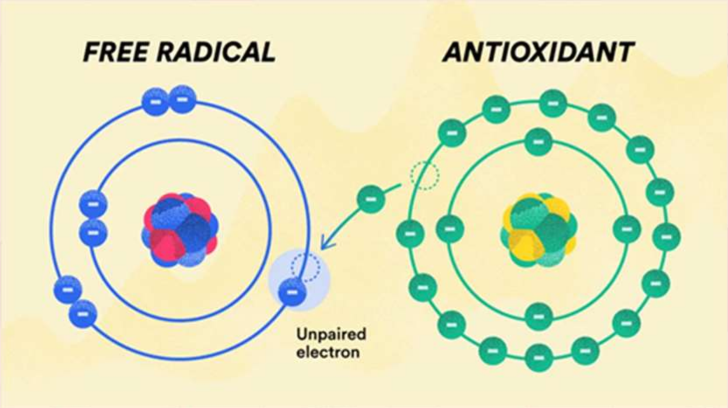
Addition of radicals for the determination of the antioxidant capacity

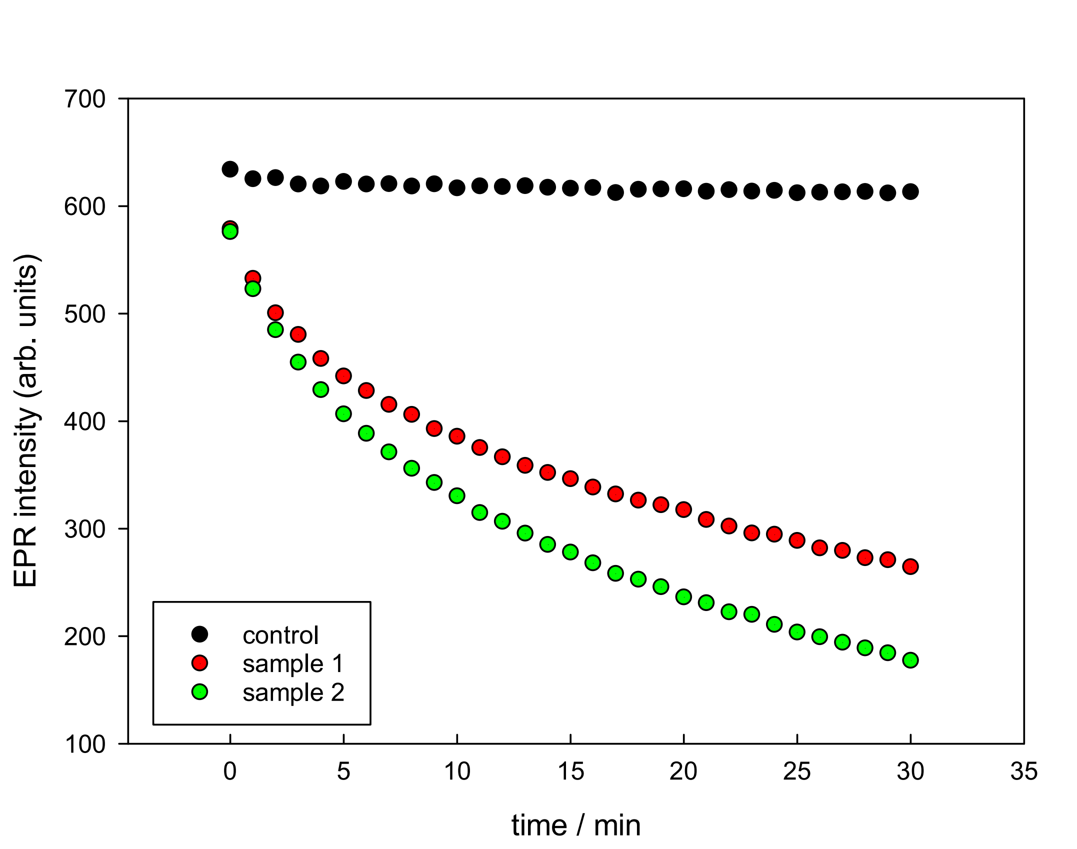


TEMPOL



DPPH





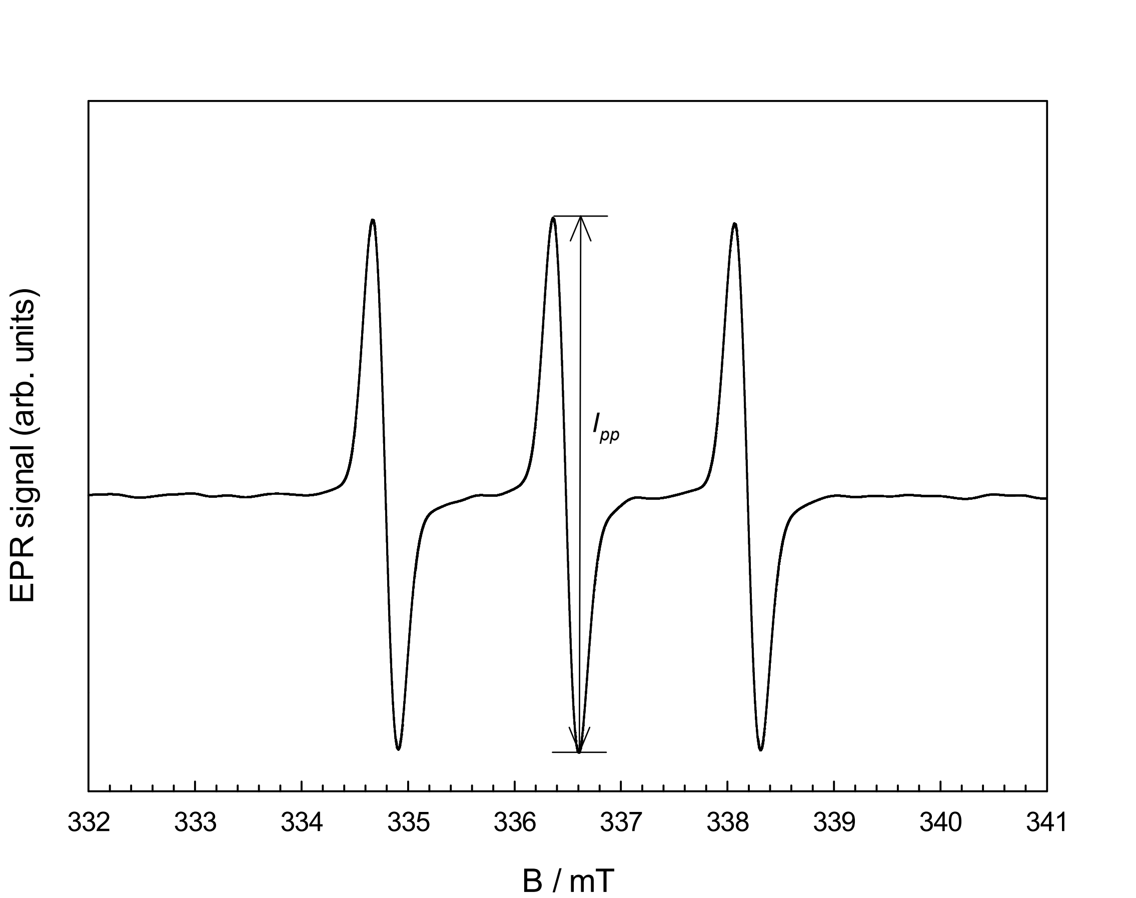
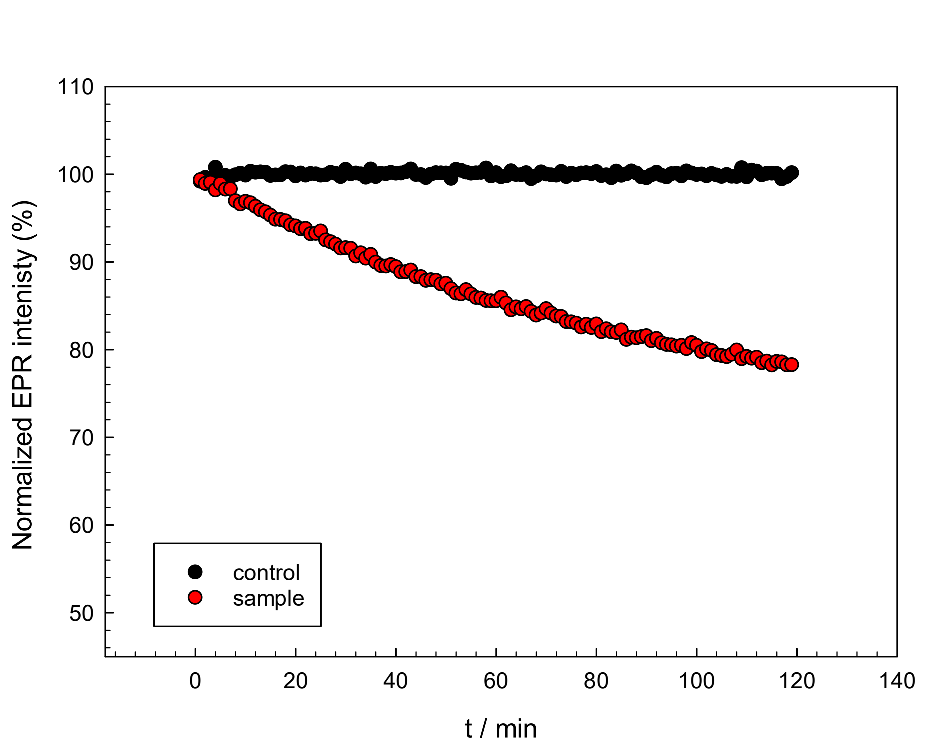


Figure. **EPR spectra** of TEMPOL at the first (1 min) in sample.

The peak-to-peak intensity of the central peak (*Ipp*) is a measure of the relative concentration of the spin probe.



Non-irradiated / irradiated additives in tomato juice: antioxidant activity

#N	%olive	%beet protein	EPR reduction %	#N	%olive	%beet protein	EPR reduction %
1	0	0	54,25				
2	0,5	0	58,55	16	0,5	0	54,22
3	1	0	56,86	17	1	0	52,51
4	1,5	0	38,72	18	1,5	0	54,51
5	2	0	35,44	19	2	0	44,31
6	0	0,5	58,05	20	0	0,5	47,41
7	0	1,5	44,72	21	0	1,5	33,78
8	0,5	0,5	77,16	22	0,5	0,5	59,20
9	0,5	1,5	59,47	23	0,5	1,5	50,82
10	1	0,5	55,51	24	1	0,5	53,13
11	1	1,5	57,69	25	1	1,5	36,39
12	1,5	0,5	54,23	26	1,5	0,5	44,55
13	1,5	1	50,24	27	1,5	1,5	42,89
14	2	0,5	50,57	28	2	0,5	47,62
15	2	1,5	42,41	29	2	1,5	47,14

CONCLUSION

After irradiation, comparative study on changes of physicochemical properties of the powders, analysis of tomato juices such as pH value, total dry matter content, color, total acidity, lycopene content, antioxidative activity and microbiological stability were also investigated and discussed.

The results indicated that the proposed procedures based on tomato juices, and differently preserved olive powder and sugar-beet leaves protein powders with optimization of additive's concentrations can be used for further procedure in process from farm to fork to improve food safety chain.

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FunTomP

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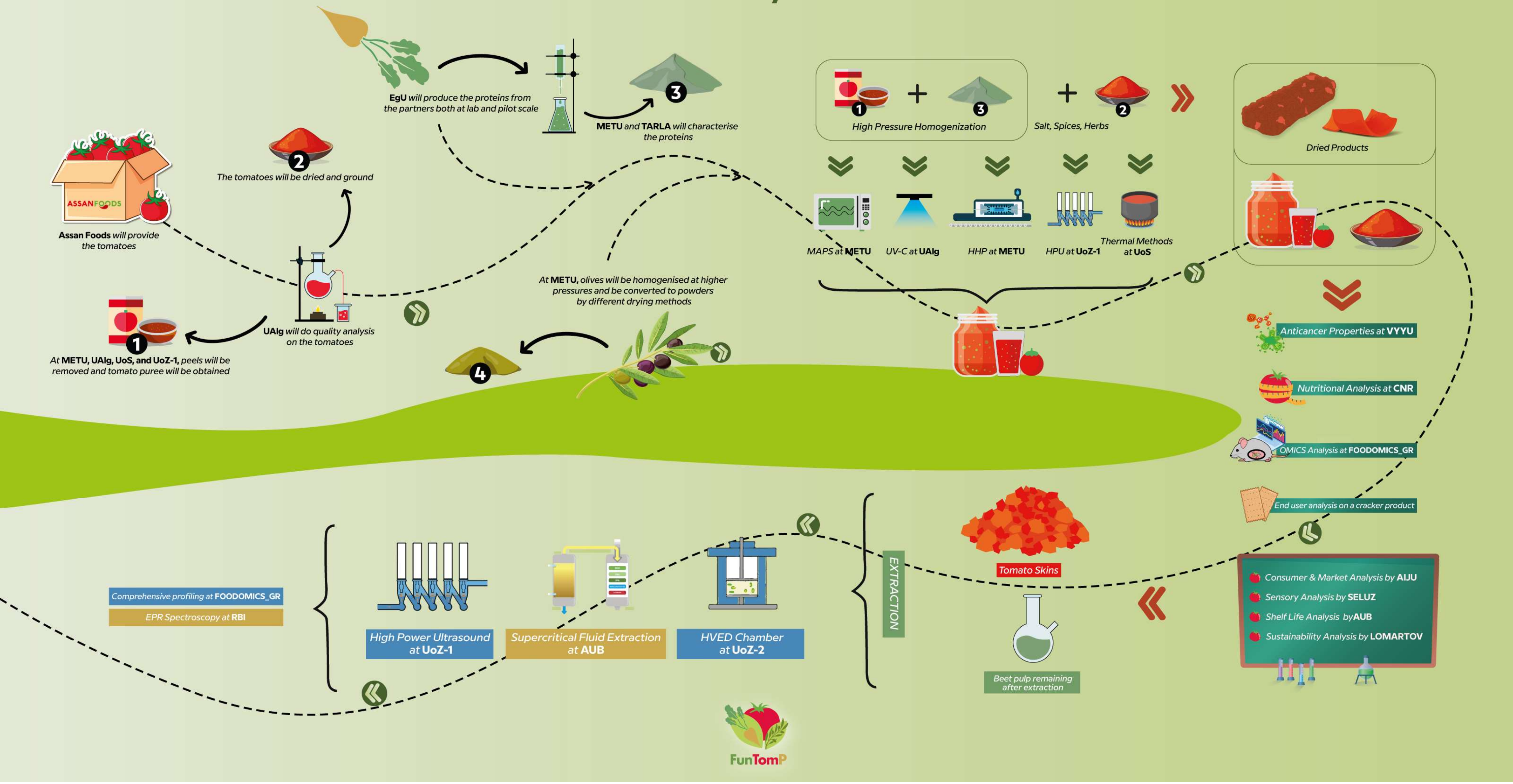
Visual Summary of FunTomP



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