



Università
di Genova

DIFAR DIPARTIMENTO
DI FARMACIA

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Ecofriendly microwave extractions from agrifood of potential cosmetic ingredients

Green Cosmetic Lab

- Green", can't only mean "botanical". Ingredients can't be considered "greener" "or safer" simply when they come from plants.
- A multidisciplinary approach to analyze, quantify, and then minimize the environmental/resource-depleting impact of any process and technology is needed.





THE SCIENTIFIC MILESTONES

- Green Chemistry
Green Extraction

RENEWABLE SOURCES

WASTE REDUCTION AND RECYCLE

ALTERNATIVE ENERGETIC SOURCES

SOLVENT USE REDUCTION

COSTS REDUCTION



A close-up photograph of a green leaf with several water droplets of varying sizes. The leaf is vibrant green, and the droplets are clear and reflective. The background is softly blurred, showing more of the leaf and droplets.

THE SCIENTIFIC MILESTONES

Green Chemistry

- Green Extraction

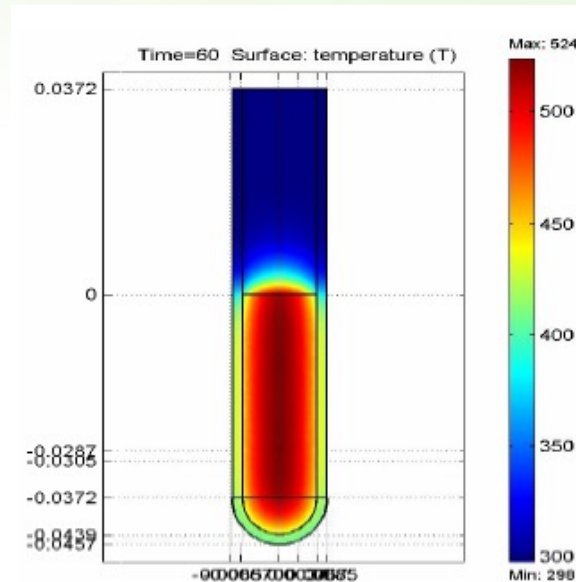
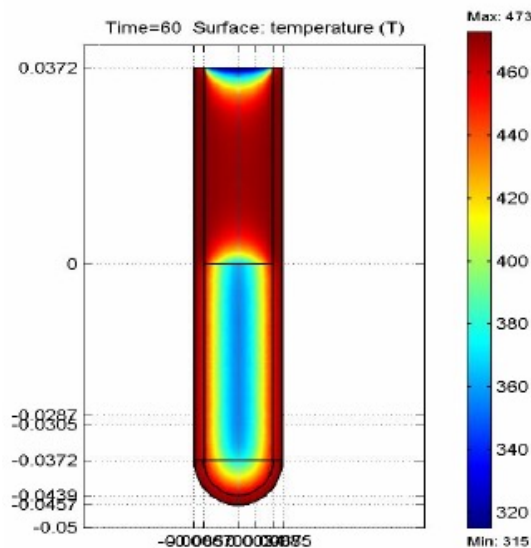
*“Green Extraction is based on the discovery and design of extraction processes which will **reduce energy consumption, allows use of alternative solvents and renewable natural products, and ensure a safe and high quality extract/product**”.*

CONVENTIONAL HEATING

- You heat what you don't want to
- Heat transfer
- Latency time (Not instant on/off)
- Overheated vessels
- Energy dispersion

MICROWAVE IRRADIATION

- NON-IONIZING radiations = SAFE
- Energy transfer
- Direct in-core , volumetric
- Fast: increasing T till 10° /sec
- Instant on - off
- Energetic efficiency
- Precise T control: software



MICROWAVE ENERGY EFFICIENCY

(200g H₂O from 16.5° C to 66.5° C)

$$\Delta H = 4.18 \text{ J/g } ^\circ \text{ C}^{-1} \times \text{H}_2\text{O weight (200g)} \times \Delta T (50^\circ)$$

$$\Delta H = 42218 \text{ J} = 42.22 \text{ kJ}$$



BUNSEN (Flow $19.9 \cdot 10^{-3} \text{ L/s}$)

Caloric Power $35.817 \text{ KJ/L} = 7127. \text{ J/s}$

HOTPLATE

Caloric Power 698 J/s

MICROWAVE

Caloric Power 1000 J/s



$$\Delta H = 42.22 \text{ kJ}$$



(0.713 KJ/s)



(0.698 KJ/s)



(1 KJ/s)

TIME	245 sec	378 sec	62 sec
RELEASED ENERGY	175 kJ	263.8 kJ	62.0 kJ
EFFICIENCY	24.2%	16.0%	68.1 %
COST	0.146 c	0.495 c	0.116 c

SUSTAINABLE EXTRACTIVE PROCEDURES

**ALTERNATIVE
ENERGY
SOURCE**

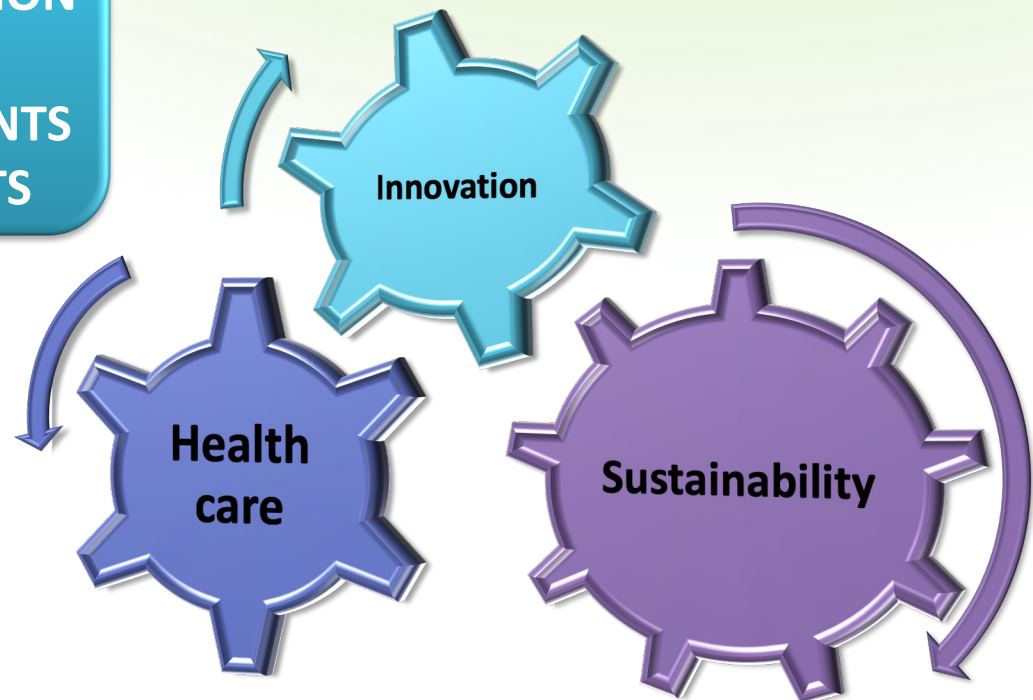
**RENEWABLE
SOURCES**

**GREEN-ER
INGREDIENTS**

**WASTE
REDUCTION
RECYCLE**

**SOLV. REDUCTION
WATER
GREEN SOLVENTS
NO SOLVENTS**

The Research unit, working in the thematic area of clean chemical processes and technologies, handles with the planning and the use of eco-friendly and non conventional procedures to be applied in cosmetic and pharmaceutical fields



cosmetics
design

**Circular
Beauty**

Sustainable sourcing
Green chemistry
Eco-design

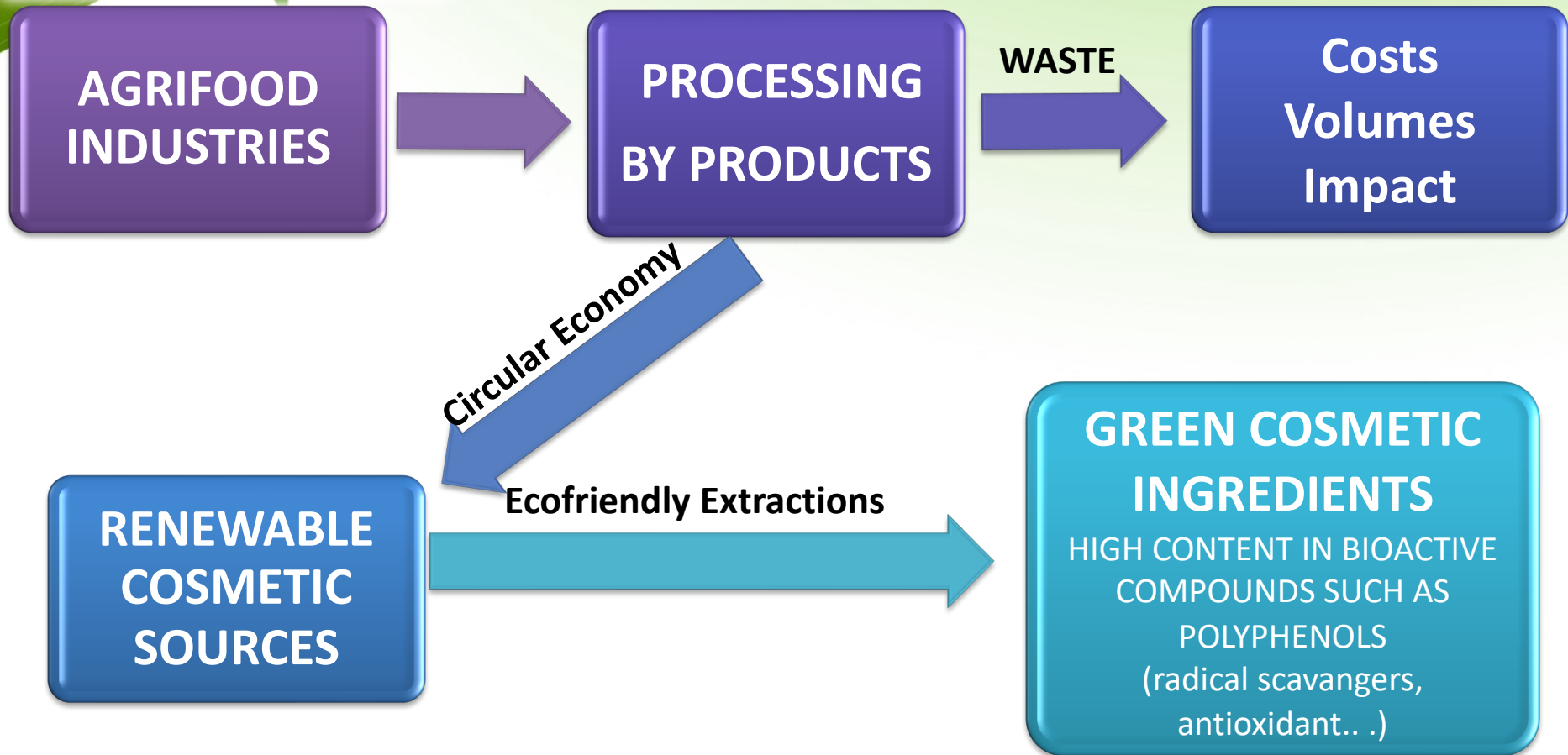
WEBINAR

WEDNESDAY APRIL 14 • 4PM CET | 9AM CT

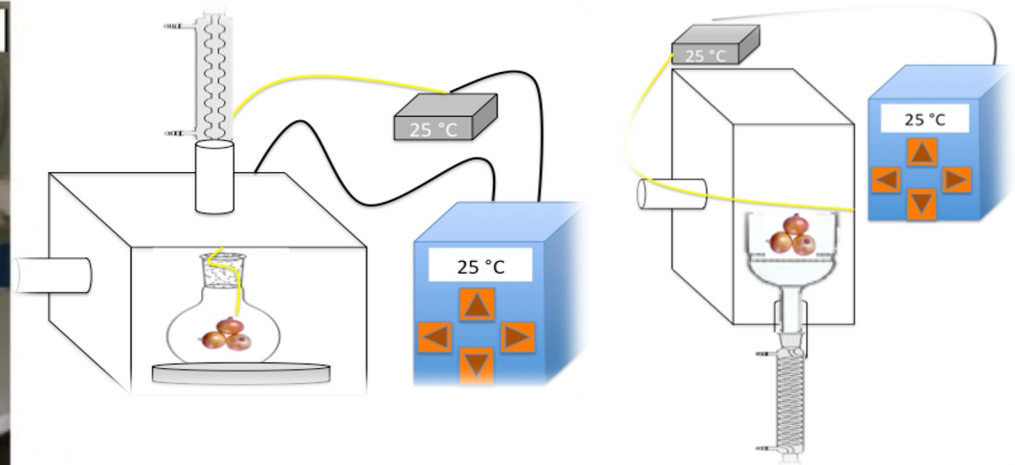
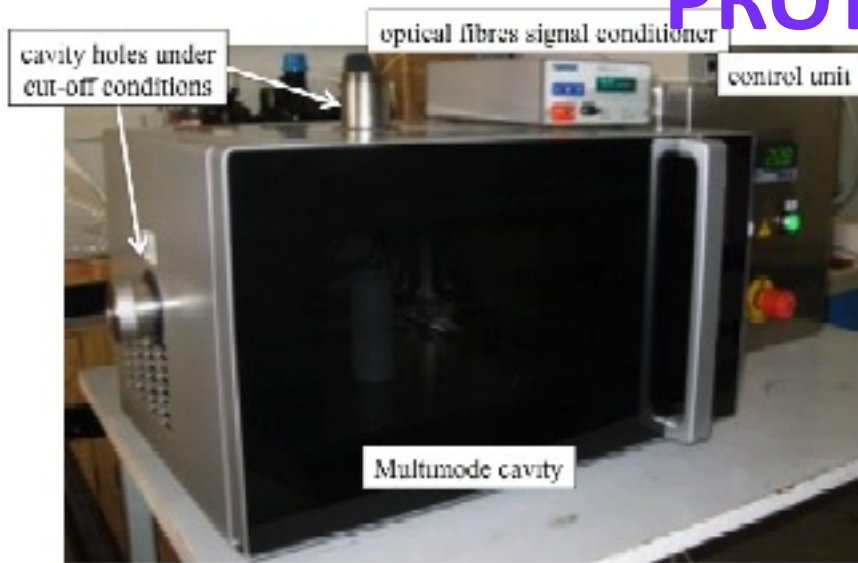




FROM WASTE TO RECYCLED RENEWABLE SOURCE



MULTIPURPOSE MICROWAVE PROTOTYPE APPLICATOR



- **Multimode cavity** equipped with a magnetron operating at 2.45 GHz **two optical fibres** for temperature measurement and control and a specifically designed **control unit** which allows to manage and modulate different parameters of the process such as emitted power, time and temperature.
- Efficient applicator for **MAE MHG etc.** depending on the hole position of the cavity.

R. Rosa, P. Veronesi, C. Villa, C. Leonelli,

The concept of a multipurpose microwave oven for several eco-sustainable extractive procedures,
International Conference on Heating by Electromagnetic Sources, Padova, Italy, May 21-24, 2013, ISBN 978-88-89884-25-6

AGRIFOOD WASTE EXTRACTION

- POMEGRANATE PEEL - *Punica granatum*
- GRAPE MARC – *Vitis vinifera*
- SAFFRON FLOWERS – *Crocus sativus*



WATER



**NO
SOLVENTS**



**GREEN
SOLVENTS**



**NO
SOLVENTS**

- ROSE PETALS – *Rosa x damascena* Mill.



WATER

POMEGRANATE

SAMPLE (5 g peel /40 ml H₂O)
10' – 50° C

	MW	Δ
TPY (mg /L GAE)	890,5	360,3
TPC (mg GAE/g waste)	35,6	14,4
RSA% of the extracts diluted 1:10 (DPPH)	45,0	24,0
Ellagitannins (mg/L) titrated as ellagic acid after hydrolysis (by HPLC)	88,1	54,3





GRAPE MARC

- Grapes are one of the largest fruit crops in the world with 73.3 MILLION OF TONS is the world production of grapes in 2017
- China is the largest producer of grapes contributing 13 % of the world's production

GRAPE PART	POLYPHENOLS %
PULP	6
STALK	20
PEEL	36
SEED	38

ITALY IS THE LARGEST PRODUCER OF WINE:
48 millions of hectolitres, 1 MILLION TONS
WASTE: High environmental impact, high
disposal costs, high potential...

MHG

Microwave Hydrodiffusion and Gravity



- Wet matrix
- NO solvents
- NO external water
- Hydrodiffusion: Extraction of the inner water (and hydrophilic actives) of the plant
- The extract diffuse outside the matrix and it is recovered by gravity outside MW applicator
- DIRECT USE OF THE “ESSENTIAL WATERS”[®] as cosmetic ingredient

MHG GRAPE MARC EXTRACTION

500 G wet GRAPE MARC

5 MINUTES 90° C



350 G “ESSENTIAL WATERS”



Barbera Grape

**Essential
Water**

Wine

TPC (g GAE /1L)

5,2

1,5

TPY (g GAE/Kg waste)

2,6

==

RSA% (DPPH)

32,4*

50,5



* 1:10 DILUTION

CARLA VILLA, CHIARA LACAPRA, SILVIA RUM, RAFFAELLA BOGGIA (2015). ESTRATTO OTTENUTO DA MATERIALE VEGETALE, COMPOSIZIONE CONTENENTE DETTO ESTRATTO E DISPOSITIVO PER LA PRODUZIONE DEL DETTO ESTRATTO. 102015000088909, ACCADERMICA SRL



**NO
SOLVENTS**



INCITORI DELLA GARA FILSE, EVENTO DEL FESTIVAL DELLA SCIENZA, PREMIATI IN CAM

Smart Cup, quattro idee che diventeranno lavoro ai "localizzatori" che salvano la vita agli eco-cosmetici

LA STORIA

ANI

giovani ingegneri geno-
i per la pelle, e si sono ag-
eri, (insieme al socio "an-
a Noli e al docente Mau-



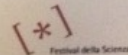
ACADERMIC
universitypharma

ACADEMIC RESEARCH FOR SKIN CARE



vincitore Categoria Agro - Food & Clean - Tech

Genova 31 ottobre 2014



SAFFRON FLOWERS



Cultivation
1000m² of
land

400/500 Kg
flowers

5-8 Kg
fresh
stigmas

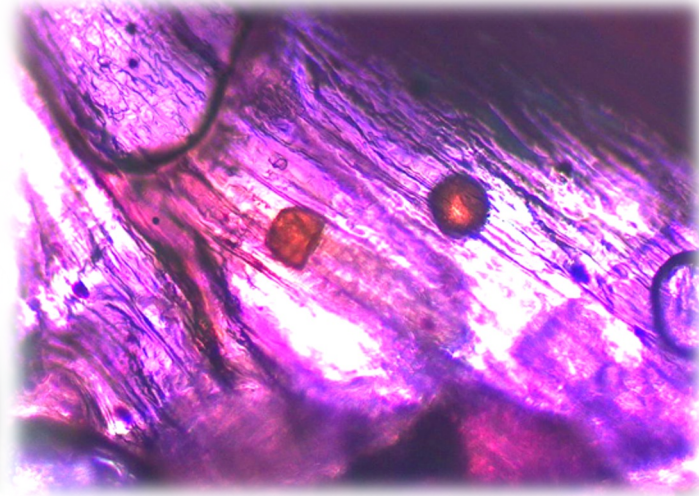
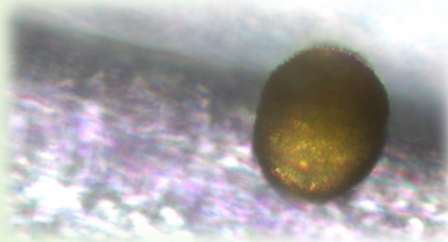
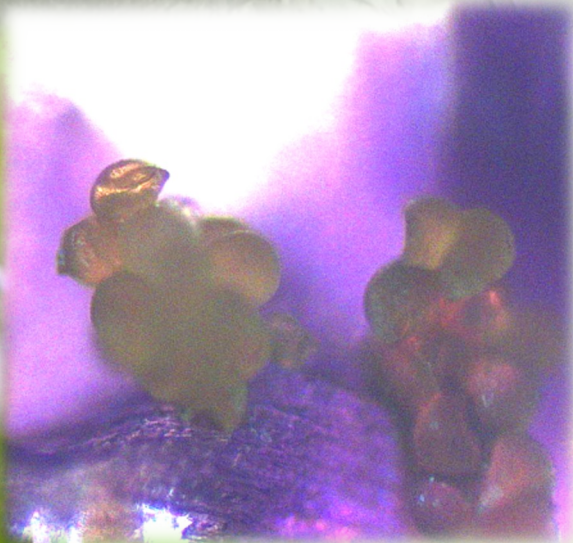
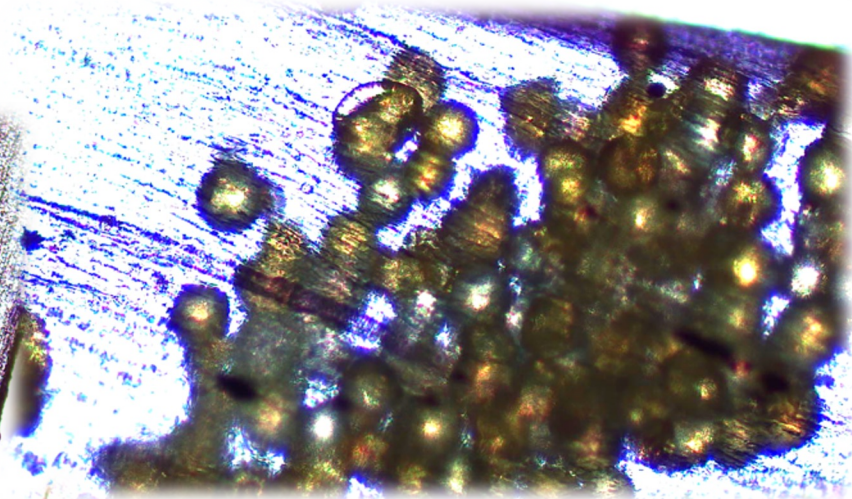
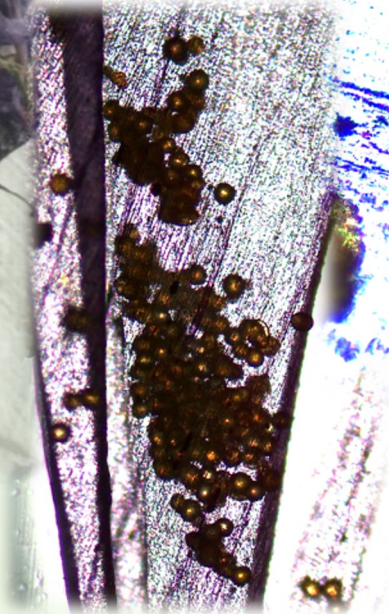
1- 1,5Kg
dry
stigmas

**99,9 %
LOSS**

RECYCLE AND
VALORISATION OF
WASTE MATERIAL

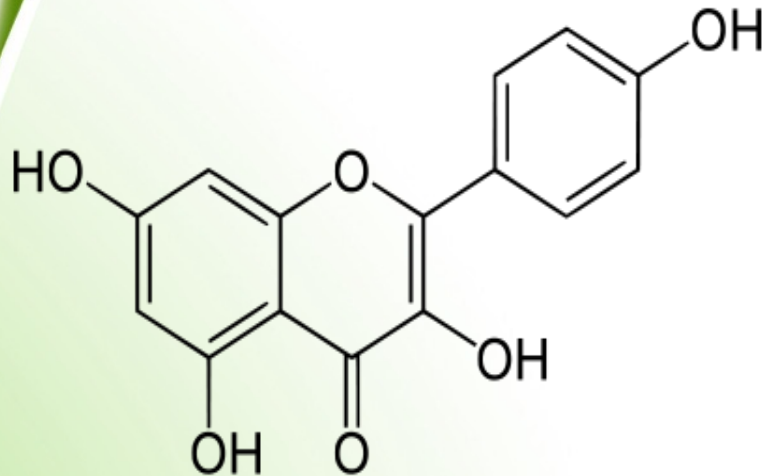


MACROSCOPIC EVALUATION





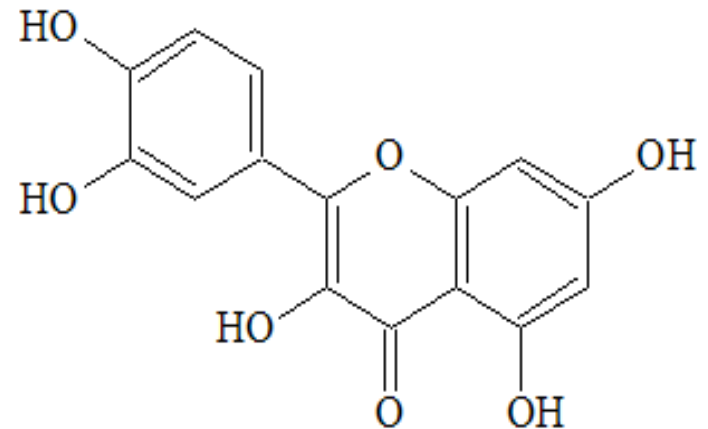
CAMPHEROL



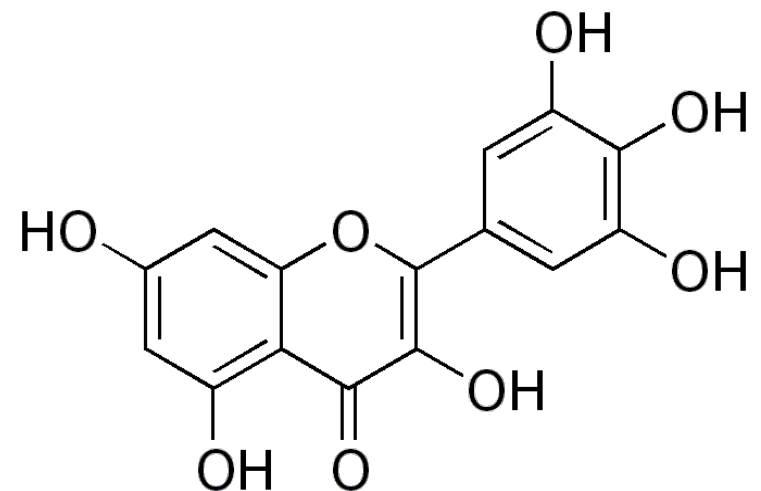
Neuroprotection
Anti-inflammatory
Antioxidant
Antiviral

FLAVONOLS

QUERCETIN

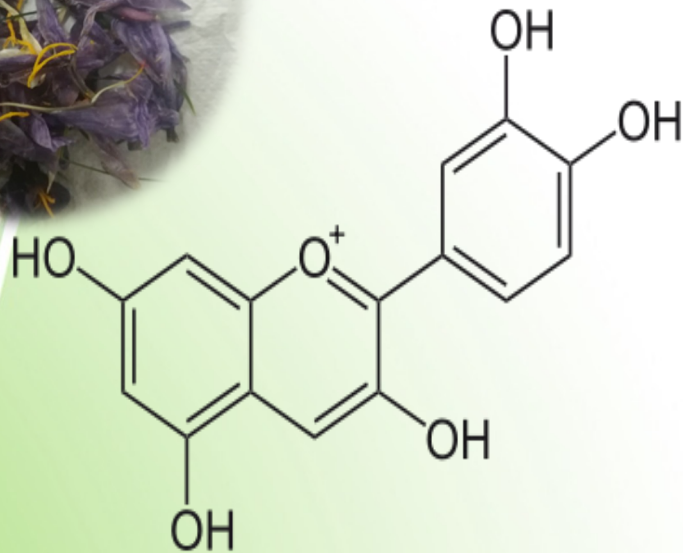


MYRICETIN

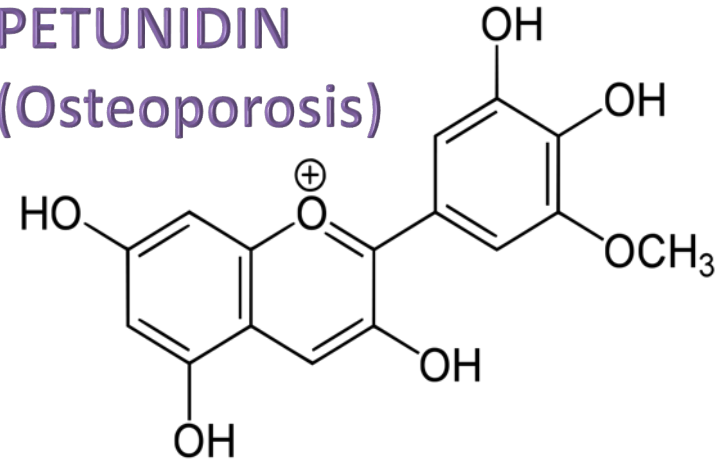


ANTHOCYANINS

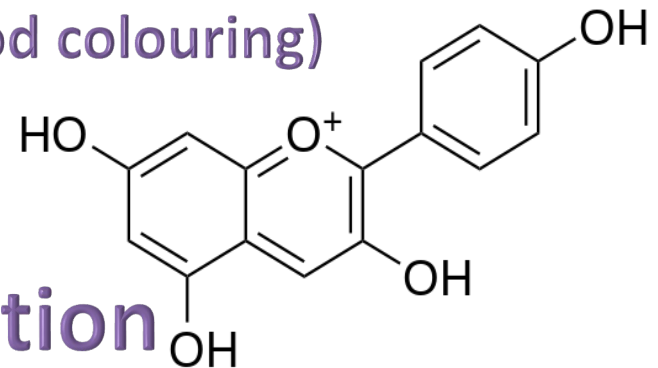
CIANIDINA



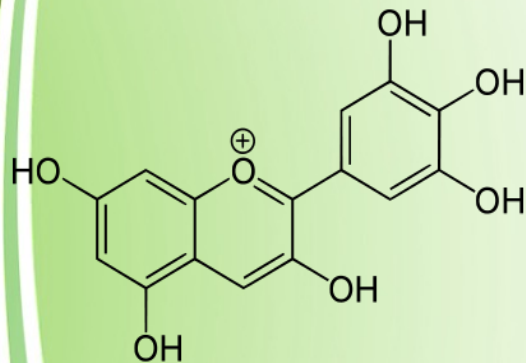
PETUNIDIN
(Osteoporosis)



PELARGONIDIN
(Food colouring)



DELPHINIDIN



Cytoprotection
Anti-inflammatory
Antioxydant





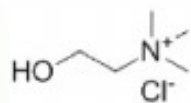
GREEN SOLVENTS

NADES

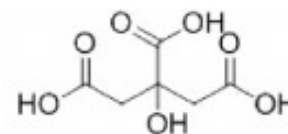
(Natural Deep Eutectic Solvent)

- Two or more compounds that are generally plant based primary metabolites, i.e. organic acids, sugars, alcohols, amines and amino acids, with a melting point significantly lower than that of either individual component
- Eco-friendly, inexpensive, chemically inert, and biodegradable.

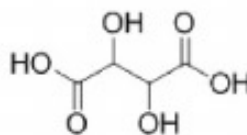
- NADES can be easily prepared from a melt of a first component in which the second is dissolved or from the solid mixture of the two components heated to a predetermined value
- Moreover, microwave heating facilitate the preparation and heating of NADES/water solvents, suitable for MW extractions



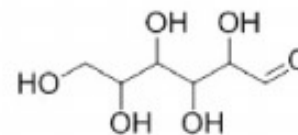
Choline chloride



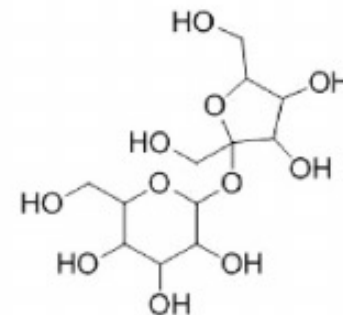
Citric acid



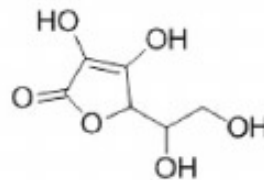
Tartaric Acid



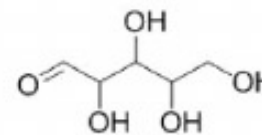
Glucose



Ascorbic Acid



Sucrose

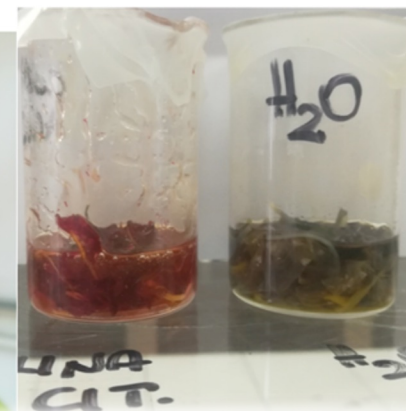


Xylose

SAFFRON FLOWERS EXTRACTION



**GREEN
SOLVENTS**

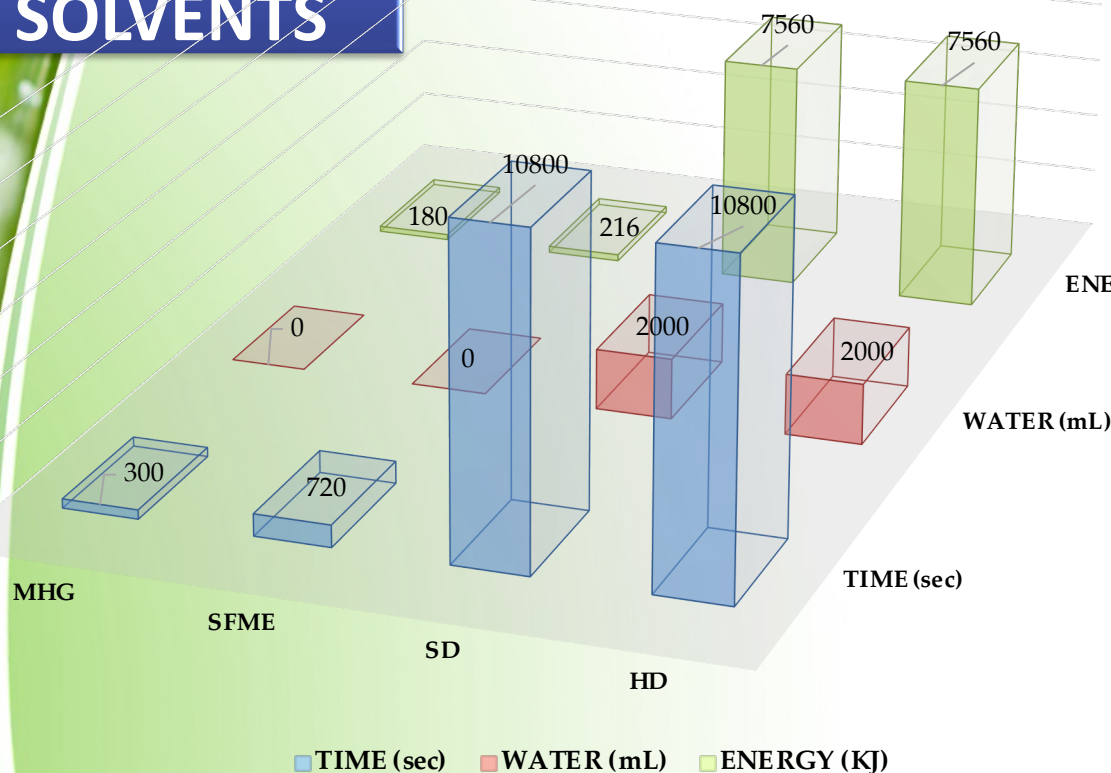


Sample* 5g	SOLVENT* 20 ml	TPC (mgGAE /1L)
N1	H ₂ O	64,6
N2	**Choline chloride/Glycerol 1:1	232,3
N3	**Sorbitol/choline chloride 1:3	281,6
N4	**Betaine/ Sorbitol 3:1	33,5

Gigliobianco, M. R., Cortese, M., Peregrina, D. V., Villa, C. et al. (2021). Development of new extracts of crocus sativus L. by-product from two different italian regions as new potential active ingredient in cosmetic formulations. Cosmetics, Vol. 8 (2), P. 51-68

SFME ROSE PETALS EXTRACTION

**NO
SOLVENTS**



ESSENTIAL OIL YIELD

MHG, 0,28 + 1,3%,

SFME, 0,40 + 1,8%

SD 0,17 + 2,7%

HD 0,22 + 3,4%

C. Villa¹, F.S. Robustelli Della Cuna, E. Russo et al. Conventional Extractions of Volatile Compounds from Rosa x damascena Mill. Fresh Petals for Cosmetic Applications. Molecules , (2022)

SOLVENT FREE MICROWAVE EXTRACTION



Alcoli
Aldeidi
Esteri
Idrocarburi
Chetoni
Terpeni ossigenati
Terpeni
Non identificati



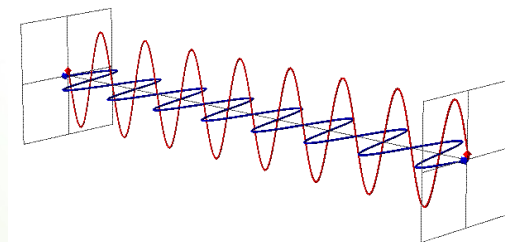
MHG	SFME	SD	HD
%	%	%	%
61.67	46.89	25.84	27.29
1.55	0.25	3.75	2.58
-	0.89	-	-
2.38	3.52	11.31	19.25
0.19	0.28	-	-
33.62	22.65	59.01	50.06
0.44	21.91	0.55	0.81
0.14	3.61	-	-
N. composti	27	45	27
		25	



SFME ROSE PETALS EXTRACTION



**NO
SOLVENTS**



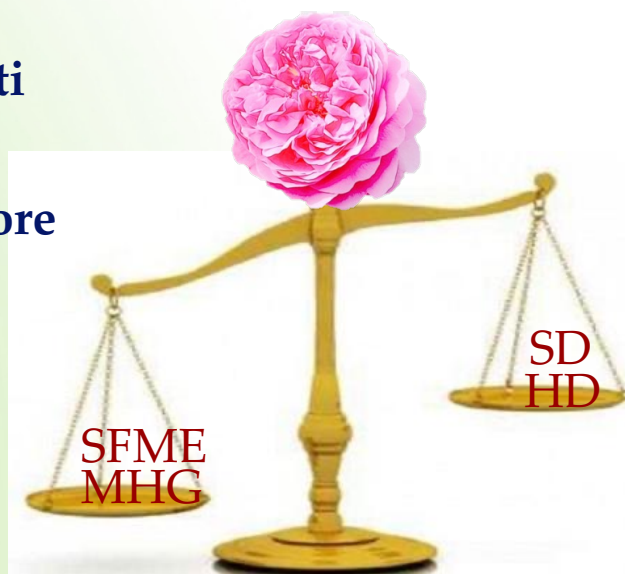
Tempi di estrazione ridotti

Resa di estrazione maggiore

**Consumo di energia
inferiore**

**Numero ridotto di
potenziali allergeni**

**Quantità significativamente
maggiore di 2-fenil-etanolo**



C. Villa¹, F.S. Robustelli Della Cuna, E. Russo et al. Conventional Extractions of Volatile Compounds from Rosa x damascena Mill. Fresh Petals for Cosmetic Applications. Molecules , (2022)



Sustainability and Communication



Thank you for Your kind attention! ✈

**« We do not inherit the Earth from our ancestors,
we borrow it from our children »**

John James Audubon (1785-1851)

