30 YEARS POLYPHENOL RESEARCH

Is extra virgin olive oil a good fat for cooking?

Dra. Maria Pérez Bosch

Seminari de Recerca, 16 de març 2023

INSA Institut de Recerca en Nutrició i Seguretat Alimentària UNIVERSITAT DE BARCELONA

EXCELENCIA MARÍA DE MAEZTU

30 YEARS POLYPHENOL RESEARCH

Virgin Olive oil and its phenols

Effects of cooking and processing

Take home message

Polyphenol Research Group

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Extra Virgin Olive Oil (EVOO)

EVOO is the fatty fraction of olive juice extracted only by mechanical and physical processes, without any refinement

Extra Virgin Olive Oil (EVOO)

The main source of fat in a Mediterranean diet

Distinguished by its high content of nutritional and antioxidant compounds compared to other vegetable oils

Over the last 60 years, EVOO production worldwide has tripled

EVOO elaboration process

Collection

Cleaning

Extraction

Separation

- Harvesting
- Manipulation, storage and transport
- Grading and washing
- Crushing, milling and pitting
- Malaxation
- Separation (Decantation/centrifugation)
- Filtration

EVOO

Free acidity < 0.8%

No organoleptic defects

Fruitiness

EVOO composition

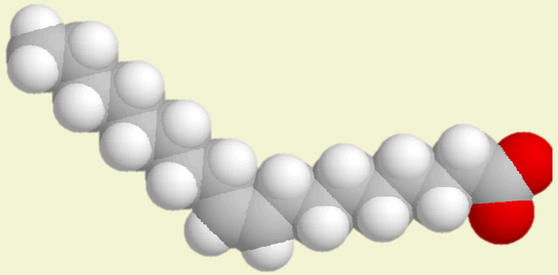
Major fraction

Triglycerides

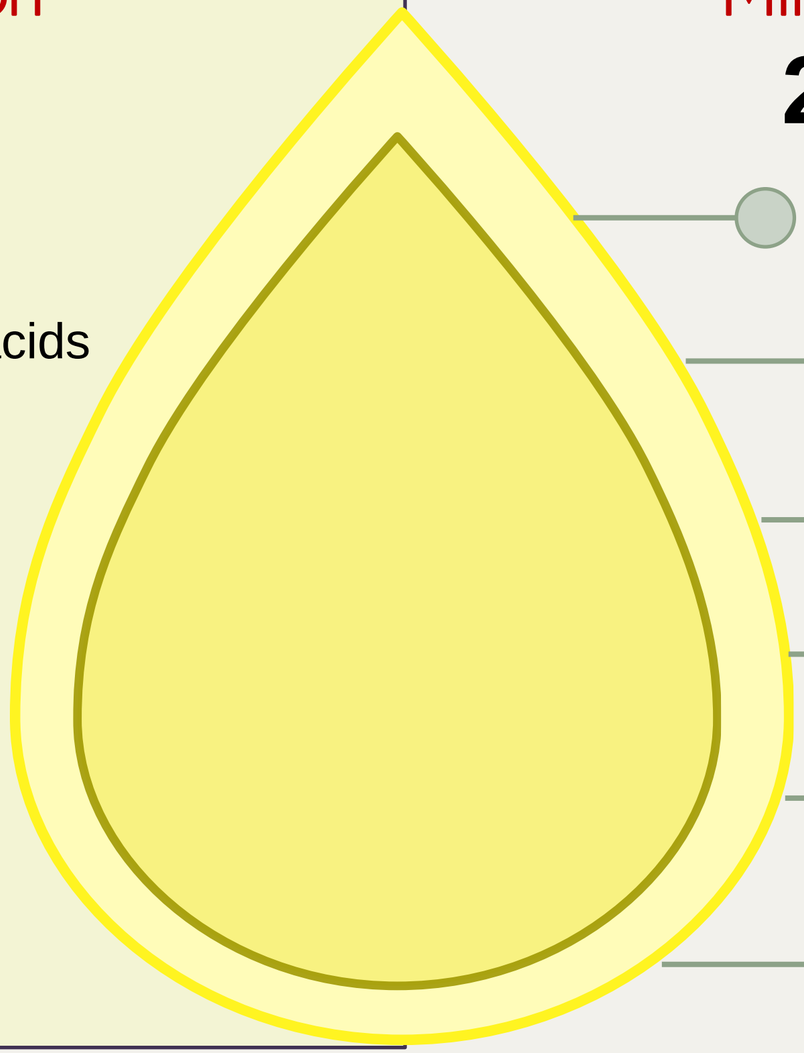
95-98%

Monounsaturated fatty acids

55-83%



Oleic acid



Minor fraction

2–5%

- **Phenolic compounds**
- Triterpenic compounds
- Tocopherols
- Hydrocarbons
- Pigments (chlorophylls and carotenoids)
- Sterols

EVOO claims

According to MUFA's levels

U.S. FOOD & DRUG ADMINISTRATION

'Olive oil may reduce the risk of coronary heart disease due to the monounsaturated fat'

23 g olive oil intake every day

efsa European Food Safety Authority

20 g olive oil intake every day... when it contains at least 5 mg of hydroxytyrosol

According to polyphenol levels

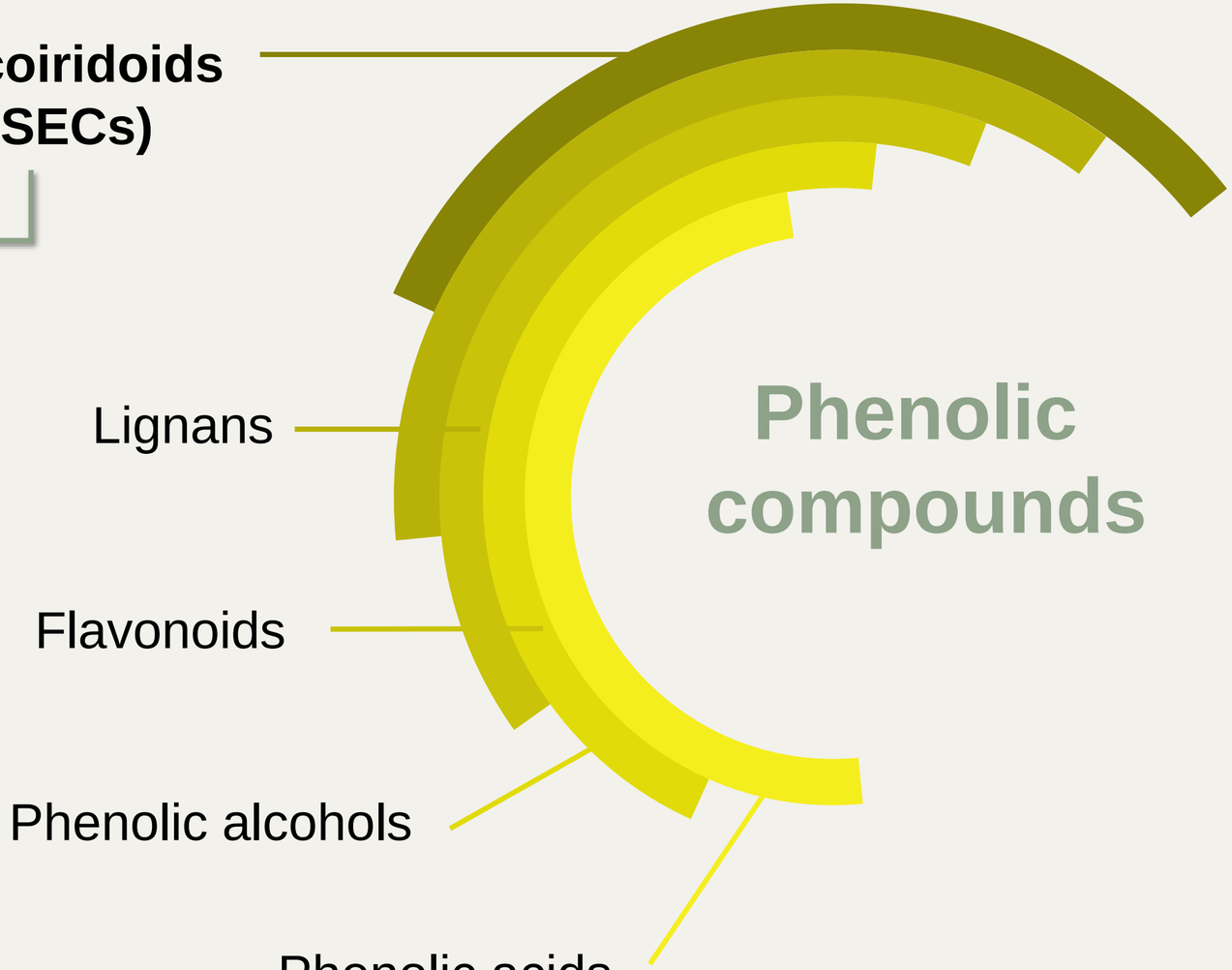
'Olive oil polyphenols contribute to the protection of blood lipids from oxidative stress'

EVOO polyphenol content

Secoiridoids (SECs)

> 70%

Oleocanthal
Oleacein

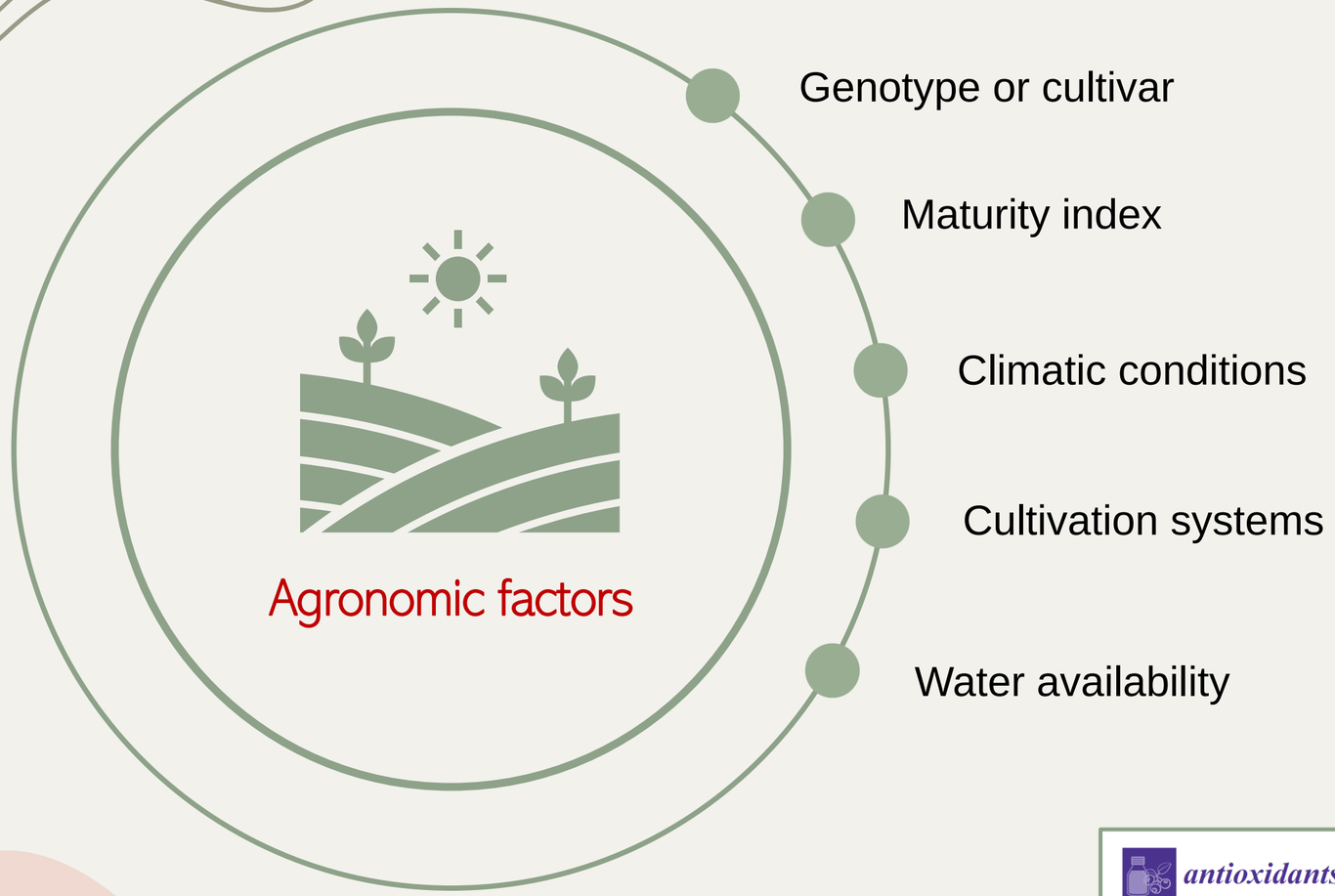


Yield *vs* quality

Agronomic factors

Technological factors

Agronomic factors



‘Picual’ variety have a higher oxidative stability than ‘Arbequina’ or ‘Hojiblanca’, because of the low percentage of linoleic acid and, especially, its high content of phenolic compounds

antioxidants

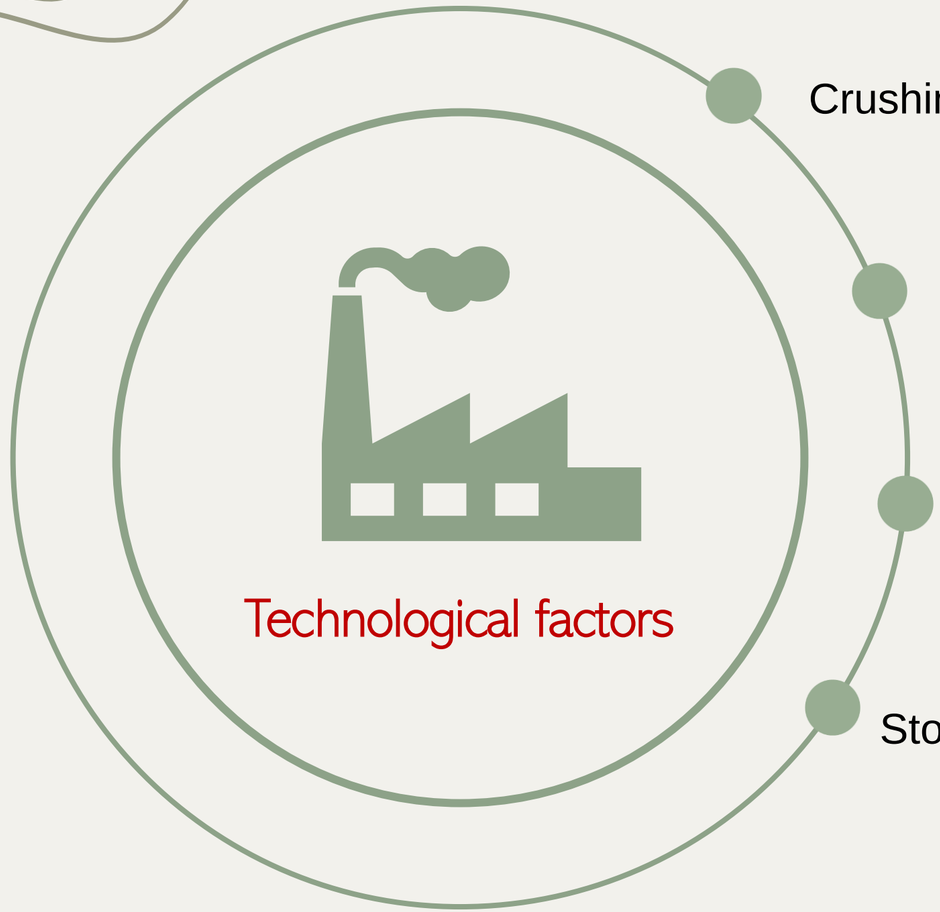
MDPI

Article

Influence of the Ripening Stage and Extraction Conditions on the Phenolic Fingerprint of ‘Corbella’ Extra-Virgin Olive Oil

Anallely López-Yerena [1,†], Antonia Ninot [2,†], Núria Jiménez-Ruiz [1], Julián Lozano-Castellón [1,3], Maria Pérez [1,4], Elvira Escribano-Ferrer [3,5], Agustí Romero-Aroca [2], Rosa M. Lamuela-Raventós [1,3] and Anna Vallverdú-Queralt [1,3,*]

Technological factors

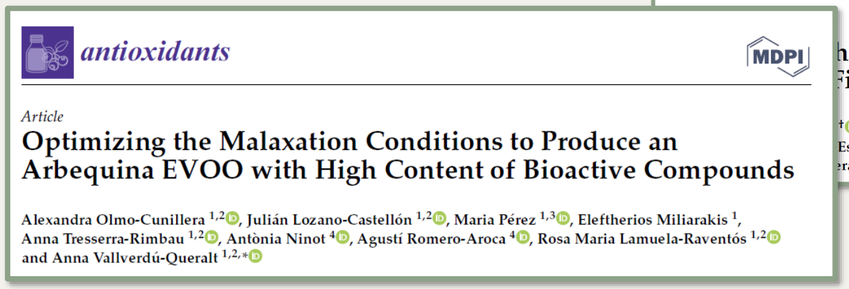


EVOO with high content of oleocanthal and oleacein

45 min at 25 ºC

Overall results suggested as the best conditions

30 min at 20 ºC

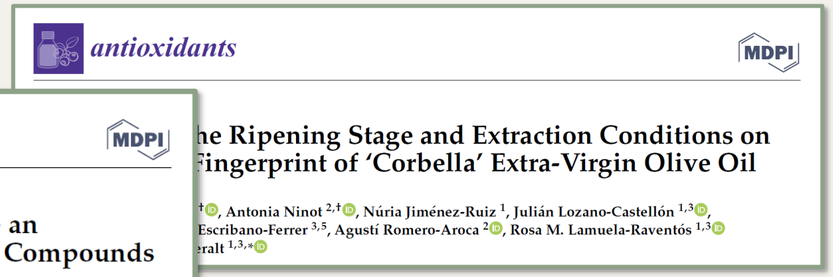

antioxidants

MDPI

Article

Optimizing the Malaxation Conditions to Produce an Arbequina EVOO with High Content of Bioactive Compounds

Alexandra Olmo-Cunillera [1,2], Julián Lozano-Castellón [1,2], Maria Pérez [1,3], Eleftherios Miliarakis [1], Anna Tresserra-Rimbau [1,2], Antònia Ninot [4], Agustí Romero-Aroca [4], Rosa Maria Lamuela-Raventós [1,2] and Anna Vallverdú-Queralt [1,2,*]

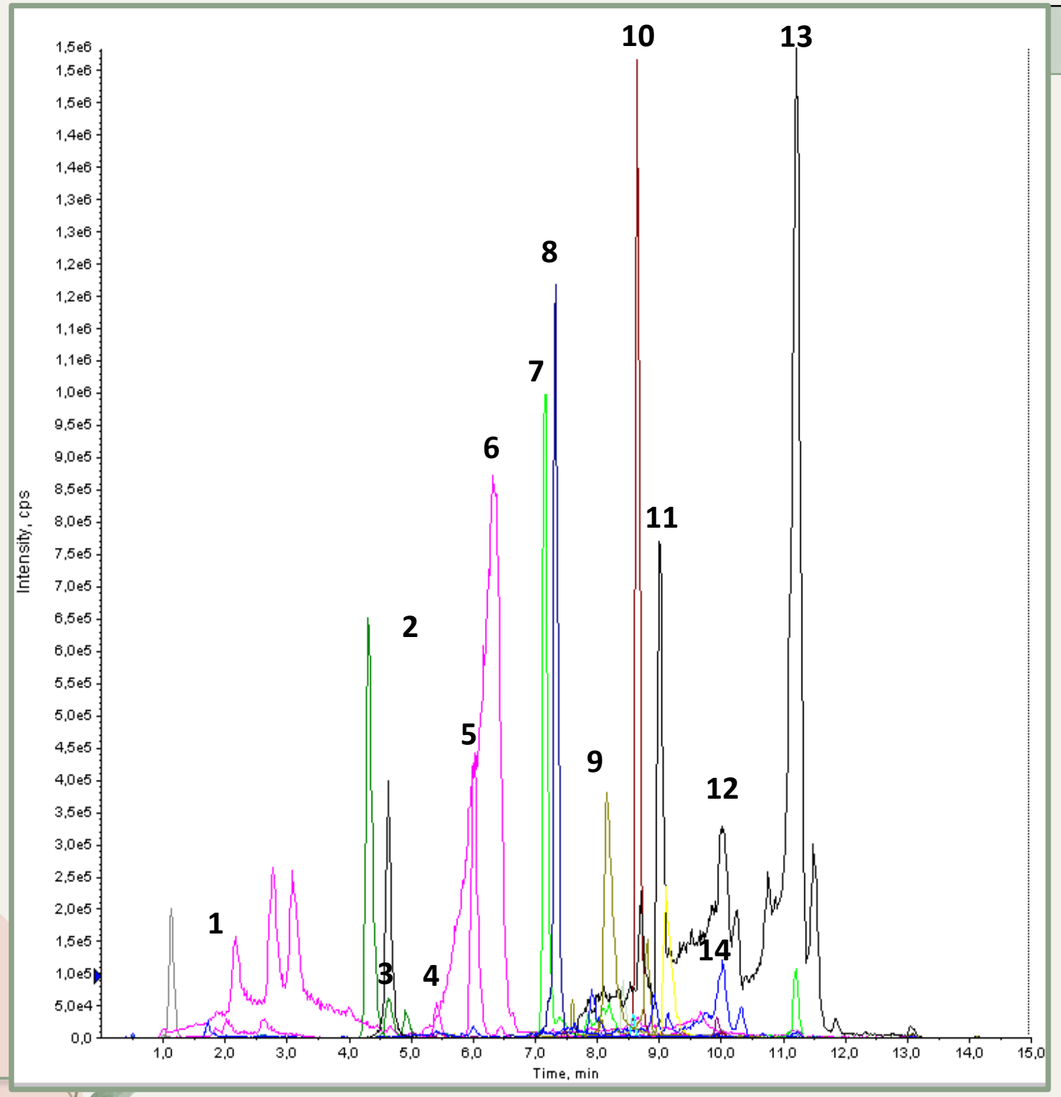

antioxidants

MDPI

he Ripening Stage and Extraction Conditions on Fingerprint of 'Corbella' Extra-Virgin Olive Oil

, Antonia Ninot [2,†], Núria Jiménez-Ruiz [1], Julián Lozano-Castellón [1,3], Escribano-Ferrer [3,5], Agustí Romero-Aroca [2], Rosa M. Lamuela-Raventós [1,3] eralt [1,3,*]

Polyphenol complexity of virgin olive oil

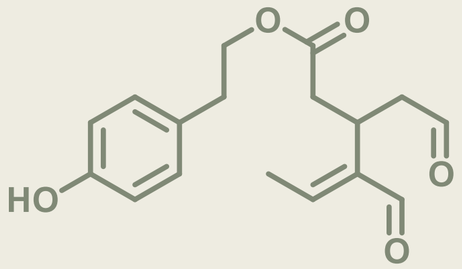


Num.	Compound
1	Hydroxytyrosol
2	*p*-coumaric
3	*m*-coumaric
4	Hydroxytyrosol acetate (3,4-DHPEA-AC)
5	Hydroxyelenolic acid
6	Elenolic acid
7	Lactone (ester with hydroxytirosol)
8	Hydroxydecarboxymethyl oleuropein aglycone
9	Luteolin
10	Decarboxyl methyl oleuropein aglycone (3,4-DHPEA-EDA) o Oleacein
11	Ligstroide aglycon I
12	Ligstroide aglycon II
13	Ligstroide aglycon III
14	Oleuropein aglycone (3,4-DHPEA-EA)

Organoleptic properties of EVOO

Organoleptic properties

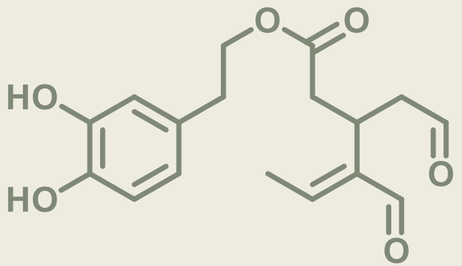
Oleocanthal (OLC)



Pungent

Bitter

Oleacein (OLEA)



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https://doi.org/10.1080/10408398.2019.1650715

Taylor & Francis
Taylor & Francis Group

REVIEW

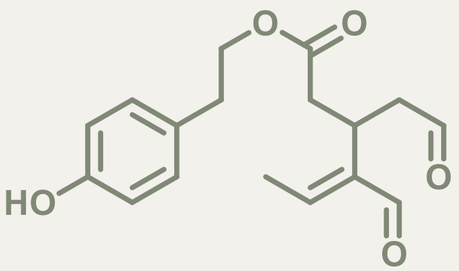
Check for updates

Health-promoting properties of oleocanthal and oleacein: Two secoiridoids from extra-virgin olive oil

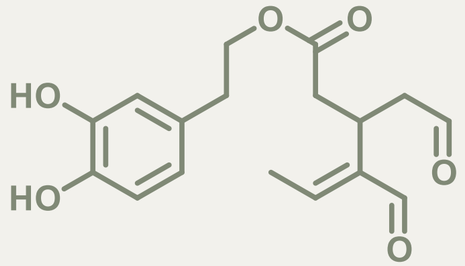
Julián Lozano-Castellón[a,b]*, Anallely López-Yerena[a]*, José Fernando Rinaldi de Alvarenga[a], Jaume Romero del Castillo-Alba[a], Anna Vallverdú-Queralt[a,b], Elvira Escribano-Ferrer[b,c], and Rosa M. Lamuela-Raventós[a,b]

Health-promoting properties of EVOO

Oleocanthal (OLC)



Oleacein (OLEA)



- Neuro-protective effects
- Anti-inflammatory effects
- Anticancer properties
- Antimicrobial properties
- Protection against cardiovascular diseases

Health-promoting properties

30 YEARS POLYPHENOL RESEARCH

Virgin Olive oil and its phenols

Effects of cooking and processing

Take home message

Polyphenol Research Group

Virgin Olive oil and its phenols

Effects of cooking and processing

EVOO

Tomato sauce with EVOO

Sofrito with EVOO

Cooking is a complex process, due to the diversity of food matrices, cooking techniques, and the reactions taking place, which are affected by temperature, oxygen, pH, and other factors

Cooking with EVOO

- EVOO serves as heat transfer medium
- EVOO is transformed due to temperature and oxygen
- Both major and minor fraction change

- Rich in monounsaturated fatty acids
- Poor in polyunsaturated fatty acids
- Antioxidant compounds

Less susceptible to oxidation

Protective effect against degradation

EVOO is now described as the best oil for frying
(Santos, C. S. P. et all. *Food Chemistry,* **2018**, *243*, 192–201)

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journal homepage: www.elsevier.com/locate/tifs

Cooking with extra-virgin olive oil: A mixture of food components to prevent oxidation and degradation

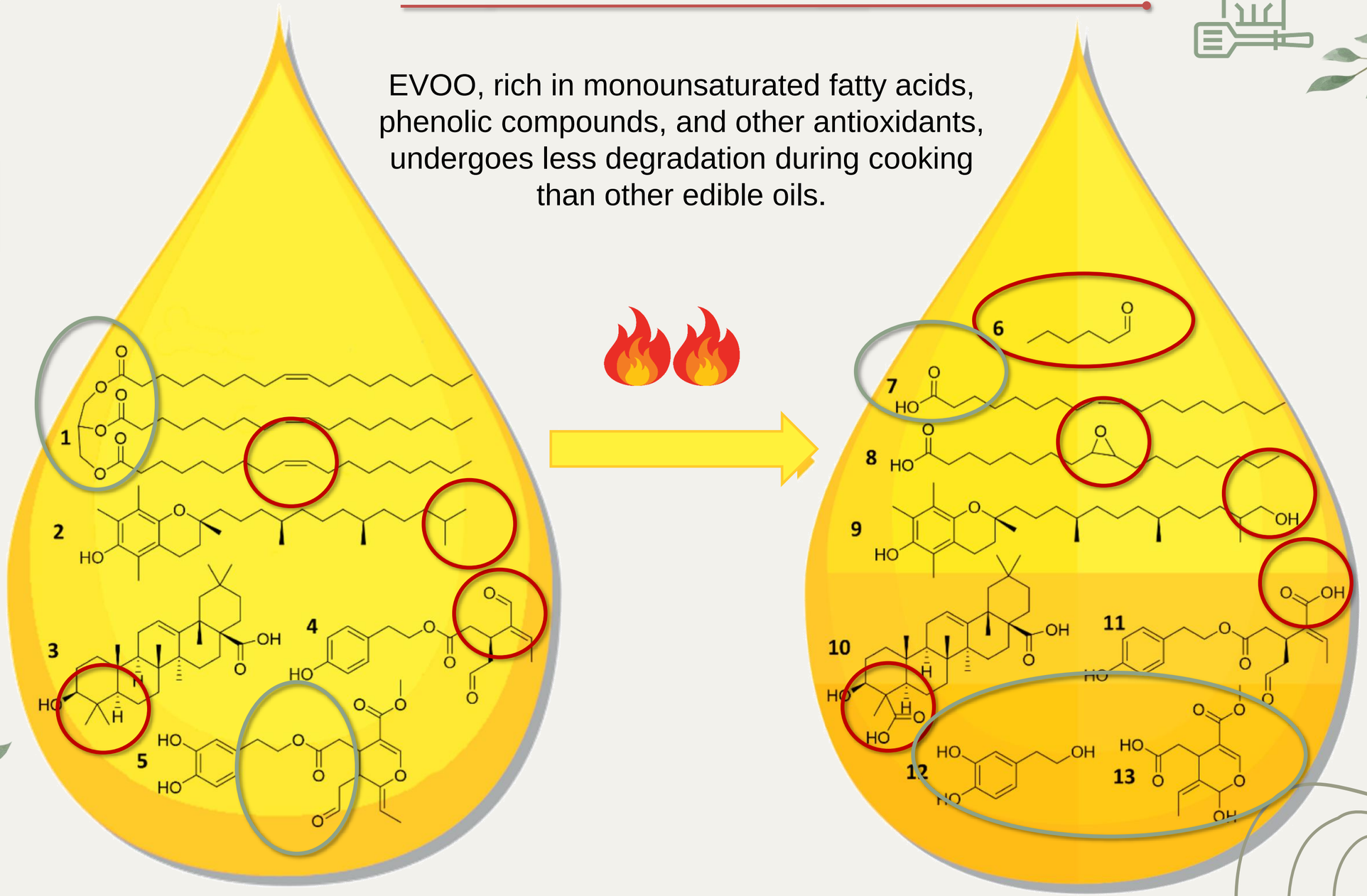
Julián Lozano-Castellón [a,b], José Fernando Rinaldi de Alvarenga [c], Anna Vallverdú-Queralt [a,b], Rosa M. Lamuela-Raventós [a,b,*]

General transformations during cooking with EVOO

EVOO, rich in monounsaturated fatty acids, phenolic compounds, and other antioxidants, undergoes less degradation during cooking than other edible oils.

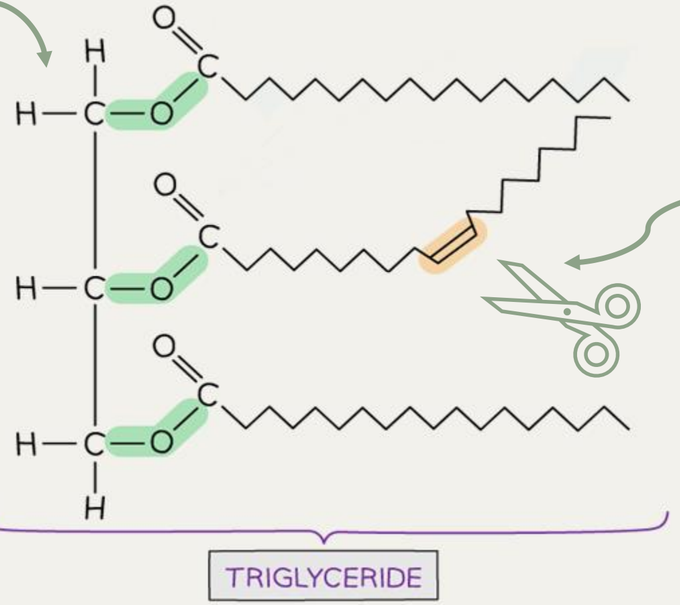
Hydrolysis

Oxidation

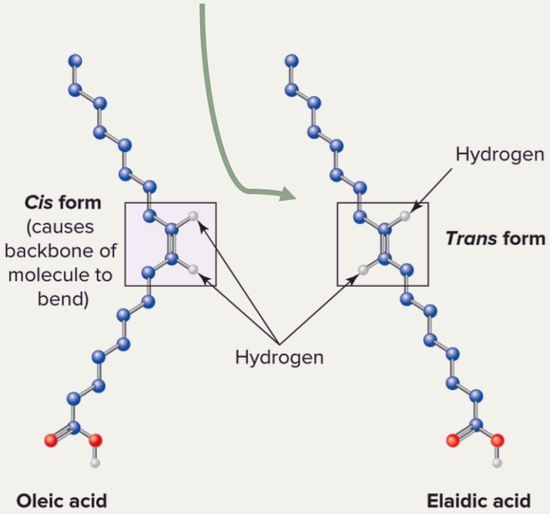


Triglyceride changes during cooking with EVOO

- The **hydrolysis** products, mainly free fatty acids, have been proposed as a marker of cooked oil.



- Heat induced **isomerization** increases the content of *trans*-fatty acids



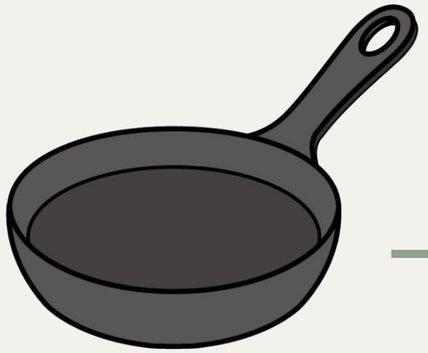
- Fatty acid **oxidation** occurs through an autocatalytic free radical reaction, generating off-flavor compounds: ketones, hydrocarbons, alcohols, carboxylic acids and aldehydes, such as the carcinogenic acrolein

EVOO vs other oils:

- High component of monounsaturated fatty acids, reduce the risk of oxidation
- Antioxidants such as α-tocopherol, carotenoids and phenolic compounds will partially inhibit oxidation

Effect of cooking in EVOO phenolic content

30 min
60 min
120 ºC
170 ºC
15 min
30 min



liquid-liquid extraction

UPLC-ESI-QqQ-MS/MS

antioxidants

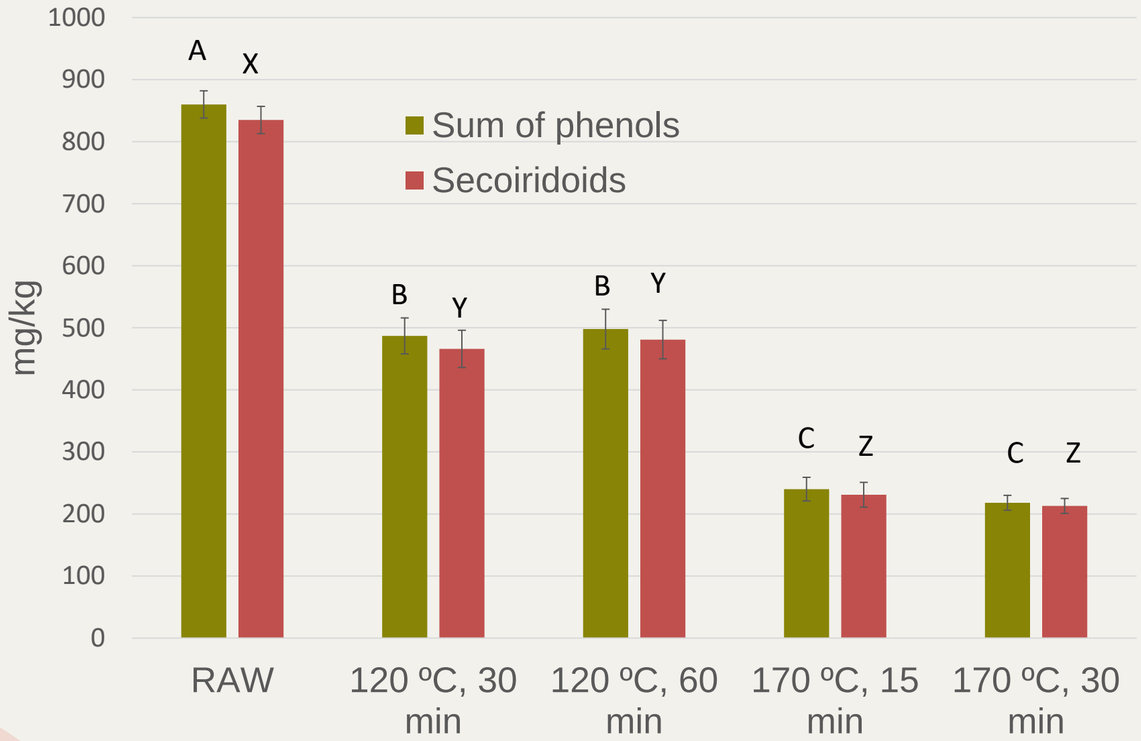
MDPI

Article

Domestic Sautéing with EVOO: Change in the Phenolic Profile

Julián Lozano-Castellón [1,2], Anna Vallverdú-Queralt [1,2], José Fernando Rinaldi de Alvarenga [3], Montserrat Illán [1], Xavier Torrado-Prat [1] and Rosa Maria Lamuela-Raventós [1,2,*]

Changes in the phenolic content



During the cooking process, the content of polyphenols decreases by 40% at 120ºC and by 75% at 170ºC, compared to the levels of antioxidants in raw oil (860 mg/Kg).

Nevertheless, the levels of antioxidants keep fulfilling the parameters stated as healthy by the European Union.

Changes in the phenolic content

'Olive oil polyphenols contribute to the protection of blood lipids from oxidative stress'

During the cooking process, the content of polyphenols decreases by 40% at 120ºC and by 75% at 170ºC, compared to the levels of antioxidants in raw oil (860 mg/Kg).

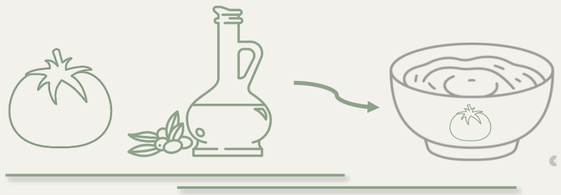
20 g olive oil intake every day... when it contains at least 5 mg of hydroxytyrosol

Nevertheless, the levels of antioxidants keep fulfilling the parameters stated as healthy by the European Union.

> 250 mg/kg of hydroxytyrosol and its derivatives (e.g. oleuropein complex and tyrosol)

Virgin Olive oil and its phenols

Effects of cooking and processing

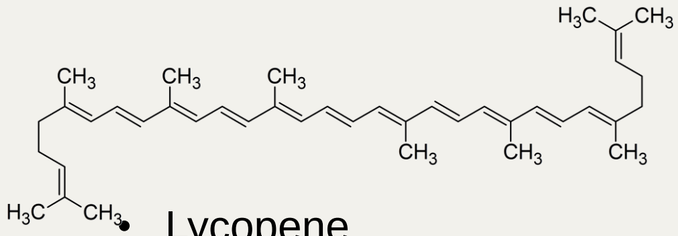


Tomato sauce with EVOO

Tomato sauce with EVOO

- 90-95% water
- 3% carbohydrates
- 2% fiber
- Source of vitamin C and E
- Source of minerals (K, Mg)
- Source of phytochemicals: carotenoids, glycoalkaloids and polyphenols

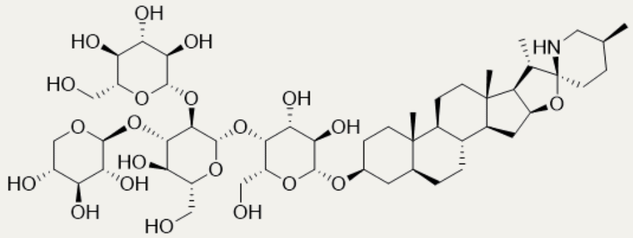
Carotenoids



- Lycopene
- α-carotene
- β-carotene
- Neurosporene

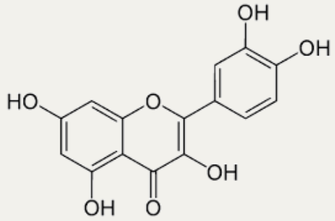
(...)

Glycoalkaloids



- Tomatina
- Esculeoside A
- Lycoperoside H

Polyphenols



- Flavonoids (Quercetin, kaempferol, Naringenin)
- Phenolic acids (Caffeic acid, *p*-Coumaric acid, Ferulic acid)
- Stilbenes (resveratrol)

(...)

Tomato sauce with EVOO

The bioavailability of some flavonoids is impaired by their low water solubility, low absorption, rapid excretion, and/or extensive metabolism by enzymes and gut microbiota.

40
healthy

PROSPECTIVE
RANDOMIZED
CROSS-OVER
OPEN
CONTROLLED

500 g TOMATO

250 g
TOMATO SAUCE

250 g
TOMATO SAUCE
+ OLIVE OIL

10 POLYPHENOLS

93 POLYPHENOLS

1578 DOI 10.1002/mnfr.201500820 *Mol. Nutr. Food Res.* 2016, *60*, 1578–1589

RESEARCH ARTICLE

Bioavailability of tomato polyphenols is enhanced by processing and fat addition: Evidence from a randomized feeding trial

Miriam Martínez-Huélamo[1,2], Anna Vallverdú-Queralt[2,3], Giuseppe Di Lecce[1], Palmira Valderas-Martínez[2,4], Sara Tulipani[5], Olga Jáuregui[6], Elvira Escribano-Ferrer[2,7], Ramón Estruch[2,4], Montse Illan[1] and Rosa M. Lamuela-Raventós[1,2]

Foods without phenolics

Tomato sauce elaboration

TOMATO LISO ROJO RAMA

WASHING

BREAKING

COOKING (99°C)

Campus de l'Alimentació
Universitat de Barcelona

HEAT REFINED OLIVE OIL (5%)

60 MIN

WATER (5%)

TOMATO SAUCE + REFINED OIL

TOMATO SAUCE

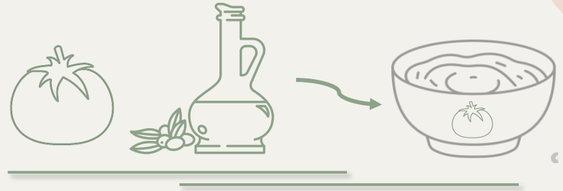
WEIGHTING AND PACKAGING

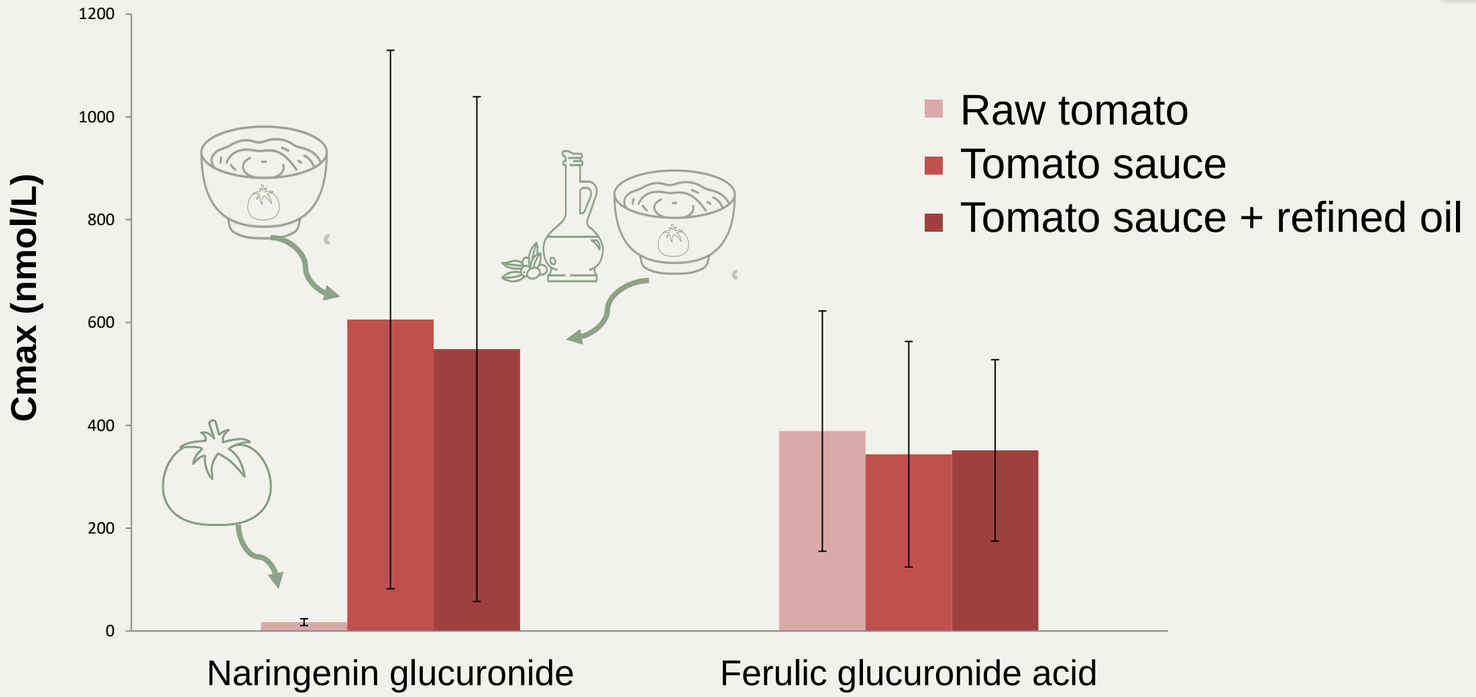
COLD STORAGE

Phenolic Composition Tomato and Sauces

Compound	RAW TOMATO ng/g FW	TOMATO SAUCE ng/g FW	TS+OIL ng/g FW
Coumaric hexose 1	35,2 ± 0,6	29,7 ± 2,5	20,2 ± 2,1
Protocatechuic	23,9 ± 3,0	137,4 ± 9,3	77,4 ± 8,5
Caffeic hexose 1	**1641,0 ± 108,8**	**1545,5 ± 175,5**	**1088,4 ± 55,0**
Coumaric hexose 2	235,3 ± 4,8	51,7 ± 4,1	53,6 ± 6,7
3-Caffeoylquinic acid	135,7 ± 1,0	189,5 ± 12,2	298,2 ± 14,8
Ferulic hexose	**1437,2 ± 54,2**	**822,3 ± 12,1**	**832,6 ± 8,0**
Caffeic hexose 2	**647,8 ± 20,9**	**722,5 ± 49,8**	**675,8 ± 19,8**
Homovanillic hexose 1	**4525,1 ± 361,6**	**6985,3 ± 445,0**	**8312,9 ± 524,1**
Homovanillic hexose 2	**636,6 ± 54,5**	**738,7 ± 43,0**	**923,6 ± 55,3**
5-Caffeoylquinic acid	**385,5 ± 10,6**	**899,1 ± 39,9**	**704,6 ± 78,9**
Coumaric hexose 3	201,4 ± 1,8	374,2 ± 6,6	380,3 ± 8,6
Caffeic acid	379,5 ± 18,1	498,6 ± 18,7	527,7 ± 16,9
4-Caffeoylquinic acid	832,5 ± 7,1	533,8 ± 38,6	542,7 ± 12,4
3-Hydroxybenzoic acid	40,8 ± 3,6	13,3 ± 1,0	1,6 ± 0,2
Rutin	**1889,4 ± 9,1**	**3849,9 ± 74,7**	**3628,5 ± 63,9**
Naringenin chalcone	185,7 ± 2,6	207,5 ± 14,0	223,5 ± 1,1
Ferulic acid	48,2 ± 4,9	n.d.	n.d.
Dicaffeoylquinic acid	57,8 ± 0,3	48,0 ± 0,3	50,0 ± 0,5
Apigenin glucoside	77,0 ± 2,4	97,9 ± 2,3	88,7 ± 11,0
Naringenin hexoside	62,5 ± 4,1	60,0 ± 9,0	71,0 ± 6,6
Tricaffeoylquinic acid	116,3 ± 3,8	65,3 ± 5,7	63,1 ± 1,7
p-Coumaric acid	21,0 ± 1,8	26,8 ± 3,0	12,4 ± 1,6
Naringenin	**3499,9 ± 379,2**	**3349,3 ± 38,7**	**3746,8 ± 102,2**

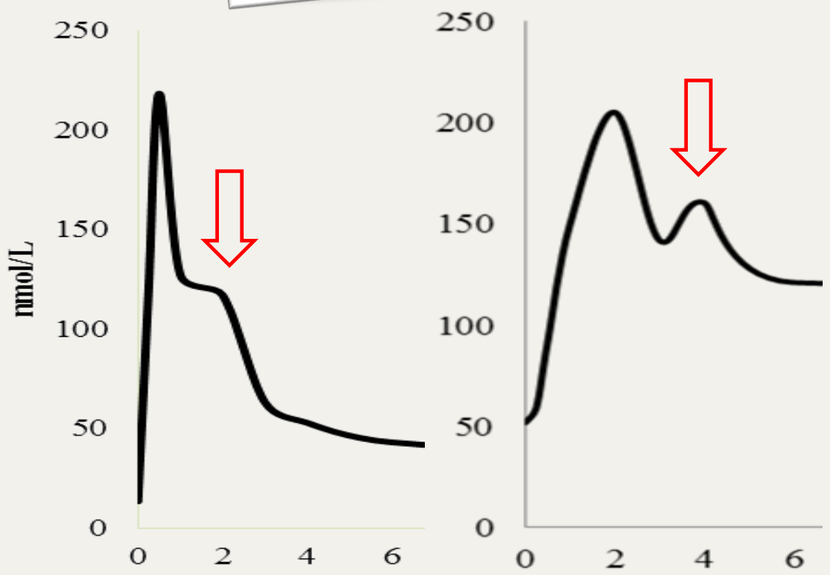
Processing and matrix effect





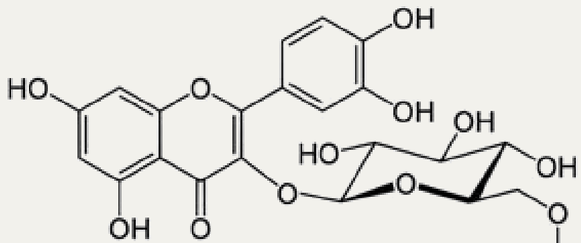
Enterohepatic circulation

OIL → ENTEROHEPATIC CIRCULATION

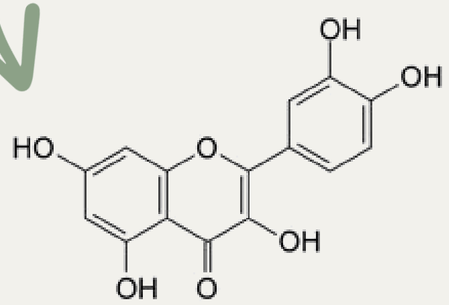


NARINGENIN GLUCURONIDE

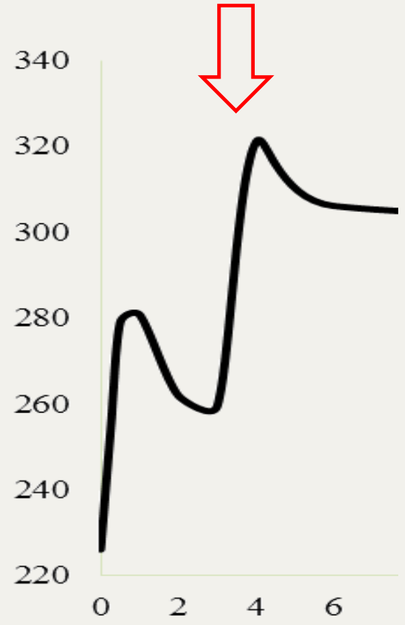
FERULIC ACID GLUCURONIDE



Rutin

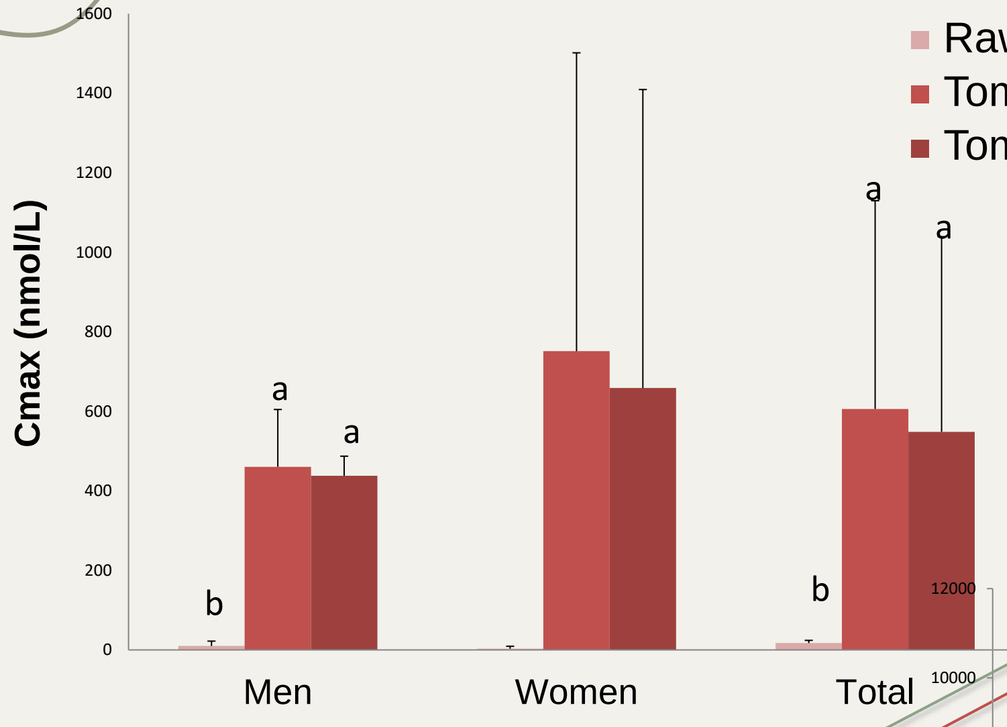


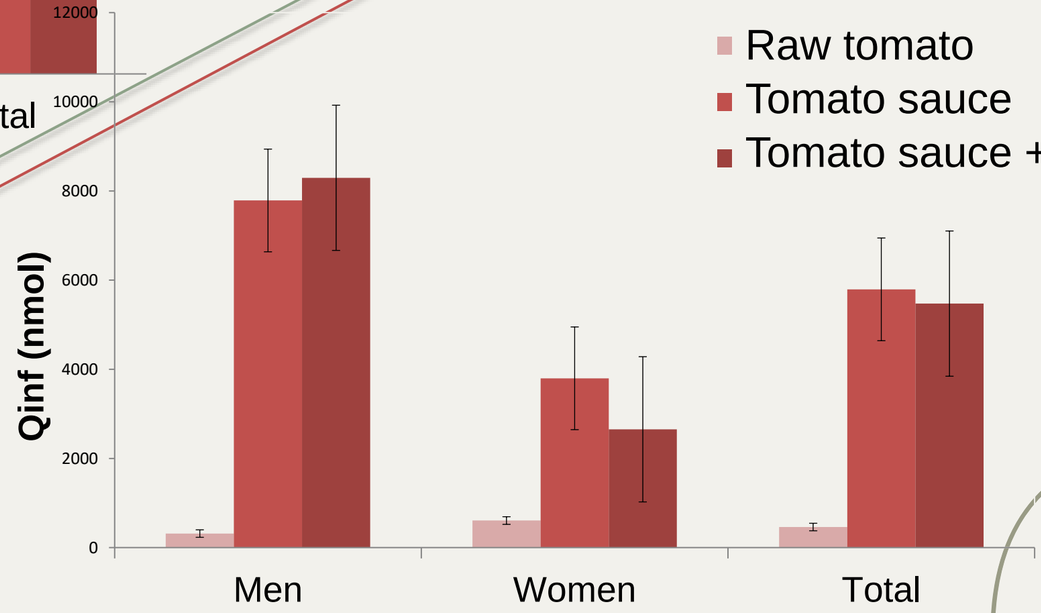
Quercetin



QUERCETIN

Naringenin glucuronide results





Virgin Olive oil and its phenols

Effects of cooking and processing

Sofrito with EVOO

More complex food?

Sofrito

A Mediterranean sauce

The sofrito is a typical technique of lightly frying onion and garlic in EVOO.

The tomato sofrito sauce has been reported to contain 40 different phenolic compounds and a high content of carotenoids.

Bioactive compounds in the sofrito

Table 1
Sample information reported on the labels.

Sample code	Ingredients	Packaging
Sofrito A	Tomato, sunflower oil, fresh onion, fresh garlic, corn flour, natural flavours	Tetra pak
Sofrito B	Tomato and tomato concentrate, sunflower oil, sugar, corn flour, salt, onion, garlic, white pepper, natural flavours	Clear glass bottle
Sofrito C	Tomato, water, onion, oil, sugar, garlic, salt, almond	Clear glass bottle
Sofrito D	Tomato, onion, sunflower oil, corn flour, sugar, garlic, salt	Tetra pak
Sofrito E	Tomato concentrate, extra-virgin olive oil, sugar, corn flour, onion, garlic, salt	Clear glass bottle
Sofrito F	Tomato concentrate, sunflower oil, corn flour modify, onion, garlic, sugar, salt, citric acid	Tetra pak
Sofrito G	Tomato, onion, sugar, sunflower oil, salt, corn flour, citric acid, spice	Clear glass bottle
Sofrito H	Tomato concentrate, sugar, sunflower oil, salt, corn flour, onion	Clear glass bottle
Sofrito I	Tomato, onion, sunflower oil, salt, corn flour, salt	Clear glass bottle
Sofrito J	Tomato, onion, olive oil, sugar, salt, corn flour	Clear glass bottle

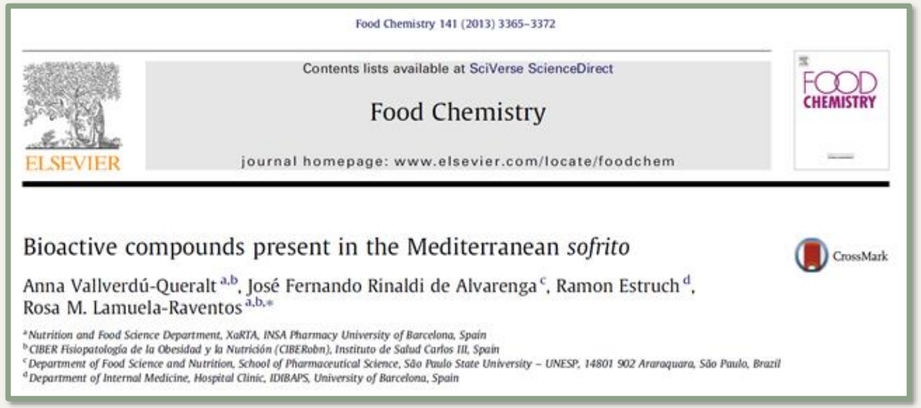
Influenced by ingredients such as:

↑ EVOO and/or Onion

↓ Sunflower oil

Sofrito with higher levels of lycopene was that contains extra virgin olive oil

(Sofrito E)



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Contents lists available at SciVerse ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Bioactive compounds present in the Mediterranean *sofrito*

Anna Vallverdú-Queralt [a,b], José Fernando Rinaldi de Alvarenga [c], Ramon Estruch [d], Rosa M. Lamuela-Raventos [a,b,*]

[a] Nutrition and Food Science Department, XaRTA, INSA Pharmacy University of Barcelona, Spain
[b] CIBER Fisiopatología de la Obesidad y la Nutrición (CIBERobn), Instituto de Salud Carlos III, Spain
[c] Department of Food Science and Nutrition, School of Pharmaceutical Science, São Paulo State University – UNESP, 14801 902 Araraquara, São Paulo, Brazil
[d] Department of Internal Medicine, Hospital Clinic, IDIBAPS, University of Barcelona, Spain

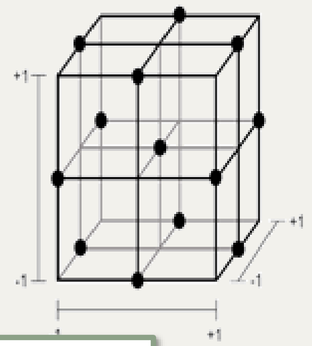
Home cooking sofritos

Factorial design

Treatment	Olive Oil	Onion	Garlic	Time
1	5 %	20 %	2 %	30 min
2	10 %	20 %	2 %	30 min
3	5 %	40 %	2 %	30 min
4	10 %	40 %	2 %	30 min
5	5 %	20 %	4 %	30 min
6	10 %	20 %	4 %	30 min
7	5 %	40 %	4 %	30 min
8	10 %	40 %	4 %	30 min
9	5 %	20 %	2 %	60 min
10	10 %	20 %	2 %	60 min
11	5 %	40 %	2 %	60 min
12	10 %	40 %	2 %	60 min
13	5 %	20 %	4 %	60 min
14	10 %	20 %	4 %	60 min
15	5 %	40 %	4 %	60 min
16	10 %	40 %	4 %	60 min

Table 1. Experimental level of the factors used in the Full Factorial Design (FDD).

- ✓ Full factorial design 2^4
- ✓ Performed independently
- ✓ Triplicate
- ✓ Randomized
- ✓ 48 experiments
- ✓ Better reproducibility



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Food Research International

journal homepage: www.elsevier.com/locate/foodres

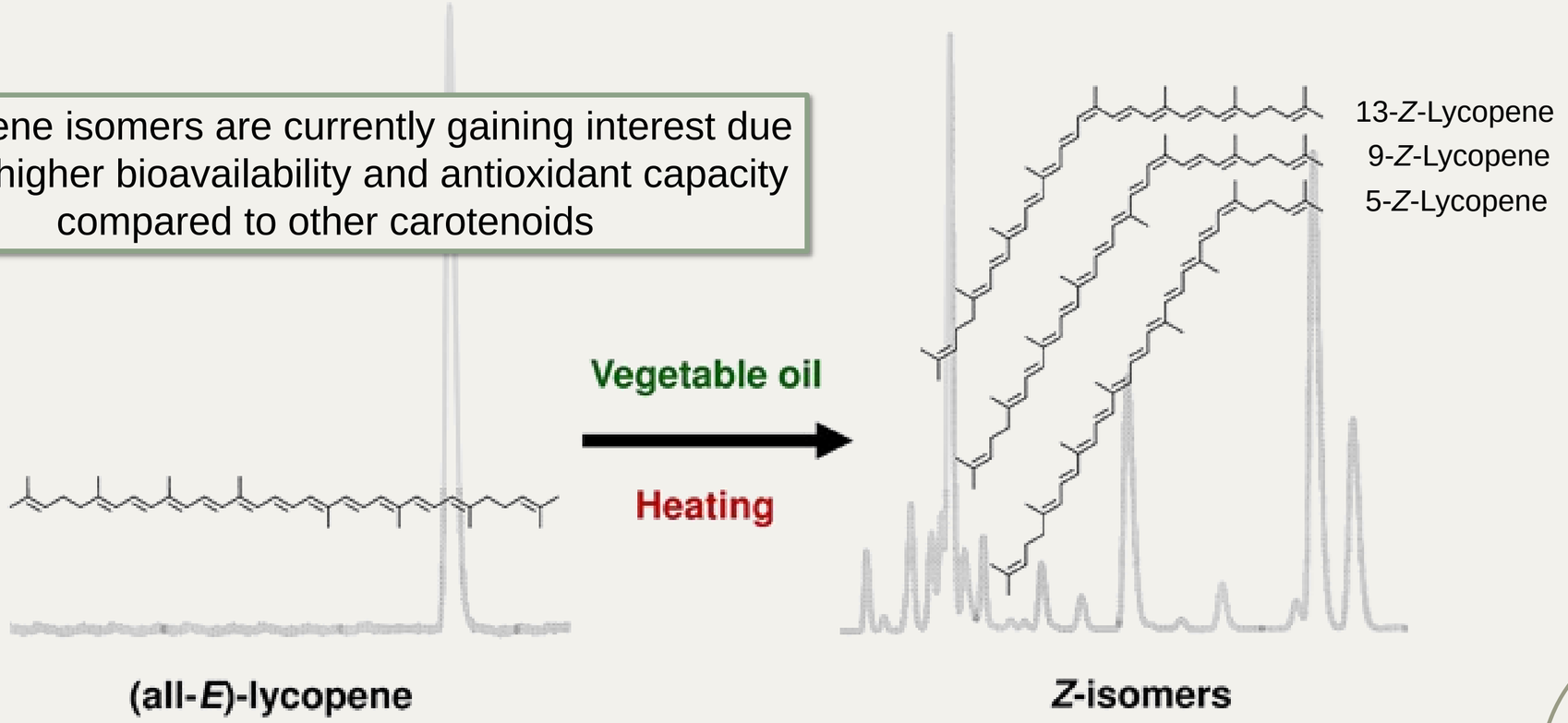
Home cooking and ingredient synergism improve lycopene isomer production in *Sofrito*

José Fernando Rinaldi de Alvarenga [a], Camilla Tran [b], Sara Hurtado-Barroso [a,c], Miriam Martinez-Huélamo [a,c], Montserrat Illan [a], Rosa M. Lamuela-Raventos [a,c,*]

Z-Lycopene isomers from *E*-lycopene

Lycopene is the major carotenoid found in tomato and tomato products and has antioxidant capacity

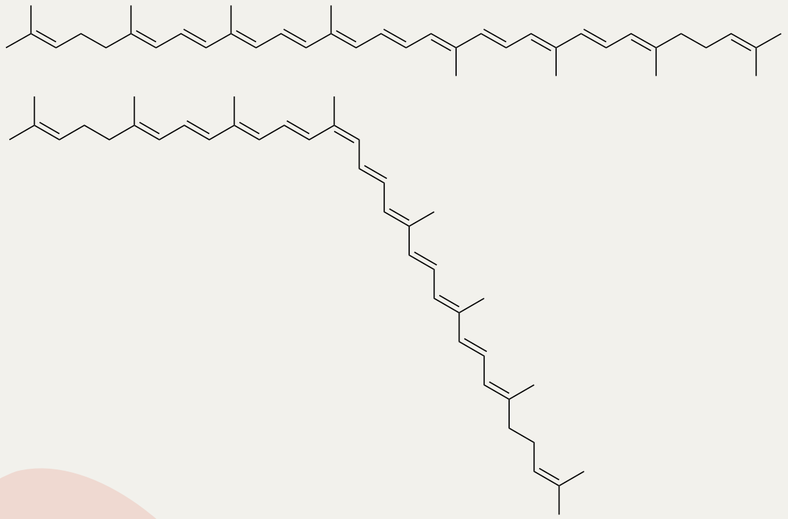
Z-lycopene isomers are currently gaining interest due to their higher bioavailability and antioxidant capacity compared to other carotenoids

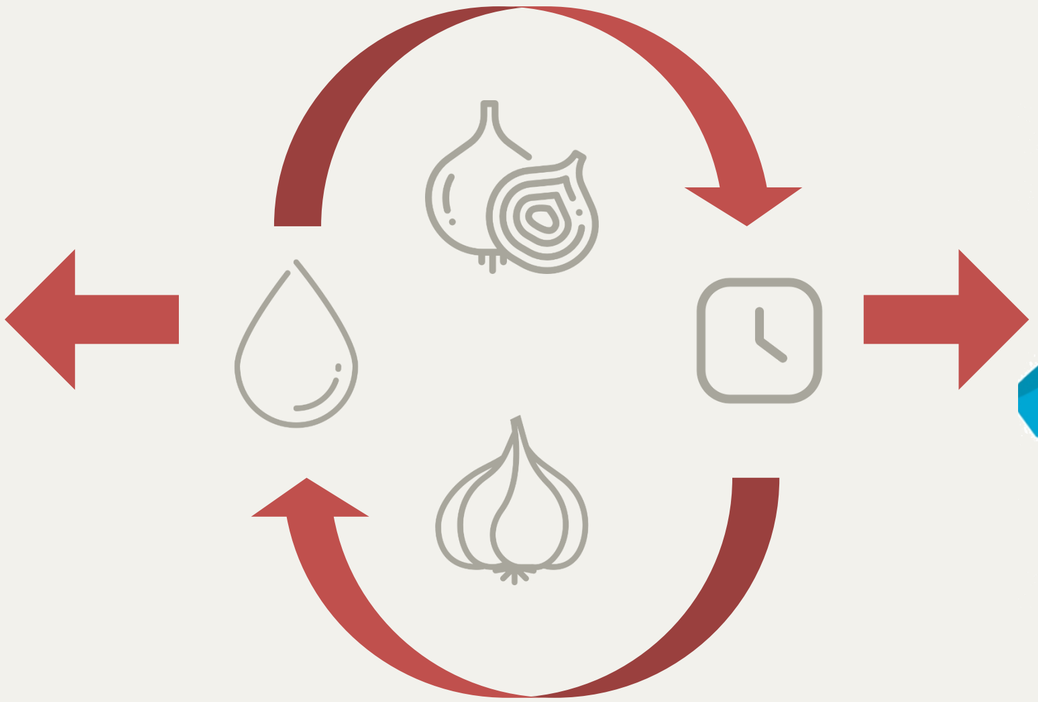


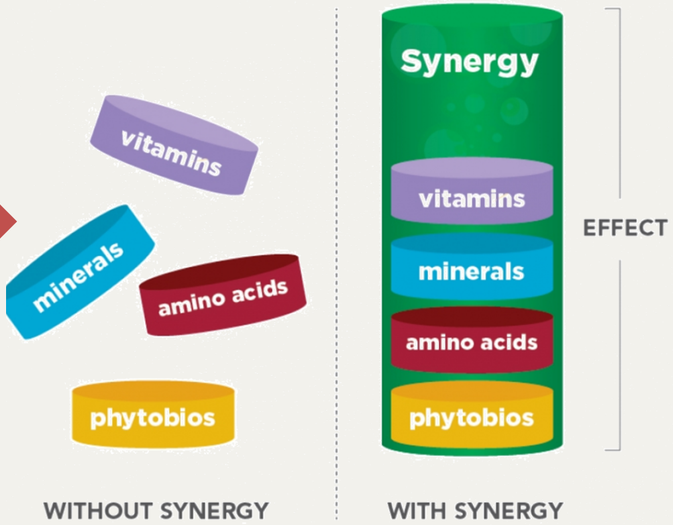
Synergism effect

Lycopene

Isomerization



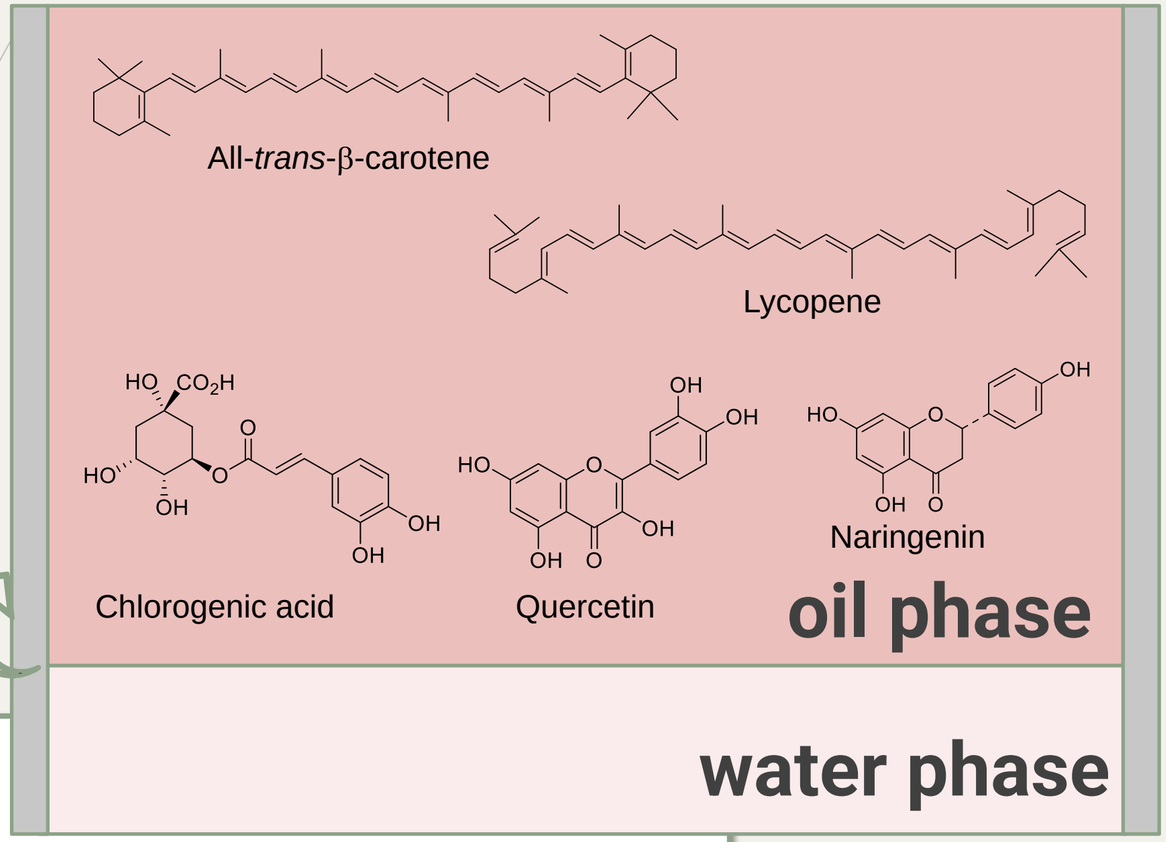




Synergism Effect

The use of onion combined with a long processing time of the sauce (60 minutes) can improve the bioavailability of lycopene in tomato products.

Oil/water phase distribution



Cooking with olive oil

Can help the extraction of carotenoids and phenolic compounds from the food matrix…

Could contribute to its bioaccessibility, bioavailability, and health effects

molecules

Article

Using Extra Virgin Olive Oil to Cook Vegetables Enhances Polyphenol and Carotenoid Extractability: A Study Applying the *sofrito* Technique

José Fernando Rinaldi de Alvarenga [1], Paola Quifer-Rada [2], Fernanda Francetto Juliano [3], Sara Hurtado-Barroso [1,4], Montserrat Illan [1], Xavier Torrado-Prat [1] and Rosa Maria Lamuela-Raventós [1,4,*]

30 YEARS POLYPHENOL RESEARCH

Virgin Olive oil and its phenols

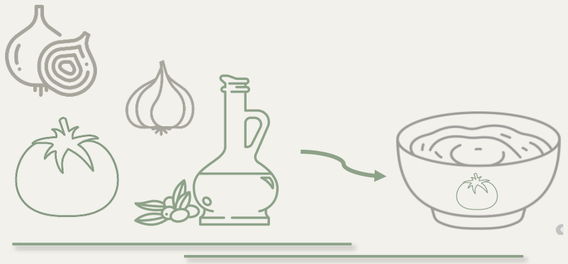
Effects of cooking and processing

Take home message

Polyphenol Research Group

Take home message

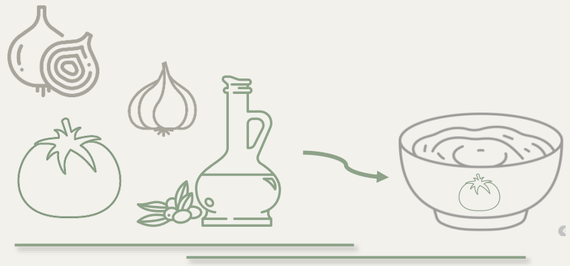
- Extra virgin olive oil is described as the best oil for frying because it is rich in monounsaturated fatty acids and low in polyunsaturated fatty acids, so it is less susceptible to oxidation, and because its antioxidant compounds exert a protective effect against degradation during cooking



- The presence of EVOO enhances the bioavailability of bioactive compounds in foods (tomato sauce, tomato sofrito sauce).

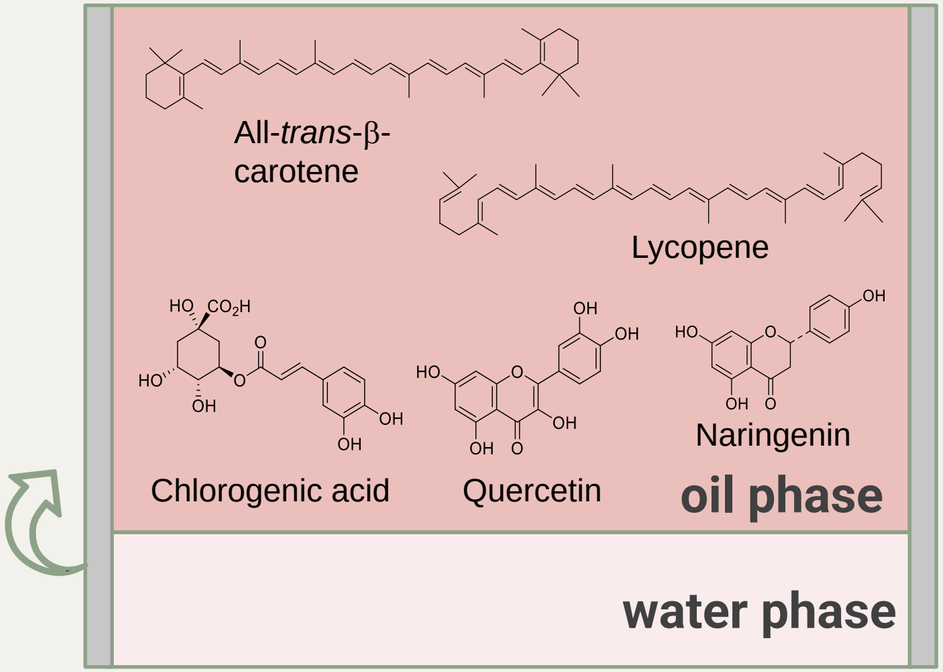
- The tomato sofrito sauce made with EVOO has shown the ability to improve the vascular function and weight in animal models, and to decrease inflammatory status in healthy individuals.

Take home message



- The use of EVOO and onion combined with a long processing time of the sauce (60 minutes) can improve the bioavailability of lycopene in tomato products.

- Phytochemicals migrate to EVOO, increasing its bioavailability and stability.



Phenolic compounds prevent formation of undesired compounds as acrylamide

30 YEARS POLYPHENOL RESEARCH

Virgin Olive oil and its phenols

Effects of cooking and processing

Take home message

Polyphenol Research Group

Acknowledgement to the key researchers

Alexandra Olmo Cunillera

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Anna Vallverdú Queralt

José Fernando Rinaldi de Alvarenga

Miriam Martínez Huelamo

Campus de l'Alimentació
Universitat de Barcelona

Montse Illan i Xavier Torrado

Polyphenol Research Group

The Natural Antioxidants group was founded 30 years ago

At the beginning, our studies were focused on the analysis of wine and cava.

Today we carry out different research projects both in food and in animals and humans.

Study of bioactive compounds in food

Cooking effect

Nutritional studies of bioactive compounds: clinical trials and epidemiological studies

Polyphenol Research Team

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Mohamed Mohamed Abuabib

David Murcia Lesmos

Ricardo López Solís

Rocío Gutiérrez Romero

Polina Galkina

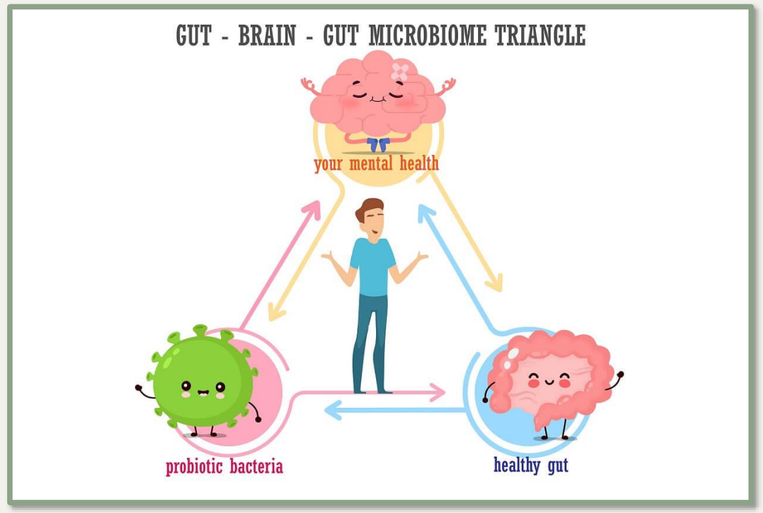
New Research Lines

TED2021-130783B-C21

In collaboration with Dr Romanyà

Use of organic and sustainable techniques in farming is expected to increase the quantity of functional compounds in food, which would affect the microbiota and human health.

PID2020-114022RB-I00

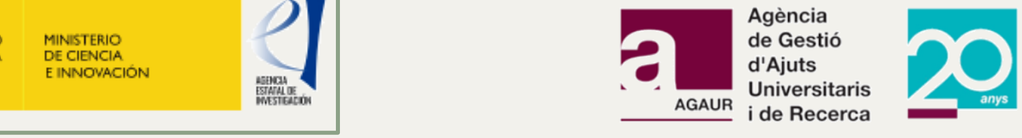


Novel biomarkers from the microbiome that may act through intestine-brain axis, having an effect on metabolic stress and brain cognitive performance. We are analyzing the postbiotic effects of bioactive compounds on human behavior.

30 YEARS POLYPHENOL RESEARCH

Follow us in social media

SGR-Cat 2021



ciberobn

Thank you!!

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