14° CONGRESSO NAZIONALE SINut

SINut Società Italiana di Nutraceutica

12-14 settembre 2024

Bologna

Dal «waste» al nutraceutico di qualità: un approccio ecologico

Gianni Sagratini

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Scuola di Scienze del Farmaco e dei Prodotti della Salute

Il sottoscritto Gianni Sagratini
ai sensi dell'art. 3.3 sul Conflitto di Interessi, pag. 17 del Reg. Applicativo dell'Accordo Stato-Regione del 5 novembre 2009,

dichiara

X che negli ultimi due anni NON ha avuto rapporti diretti di finanziamento con soggetti portatori di interessi commerciali in campo sanitario

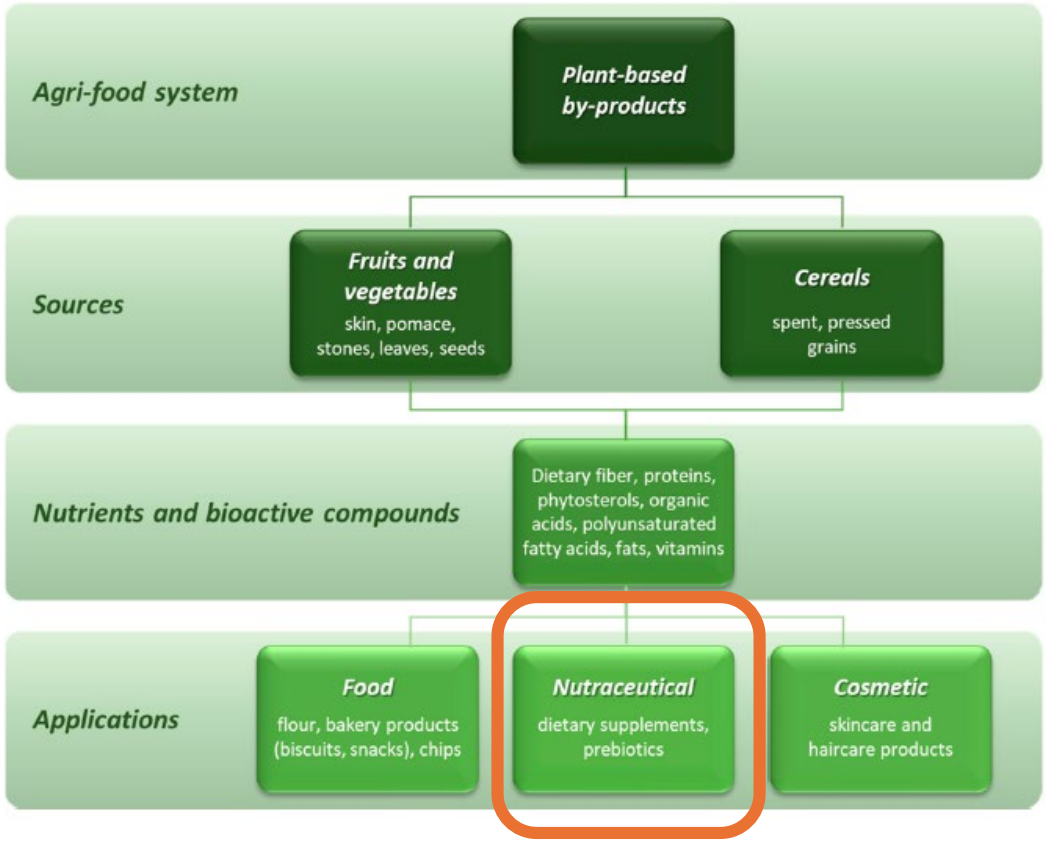
che negli ultimi due anni ha avuto rapporti diretti di finanziamento con i seguenti soggetti portatori di interessi commerciali in campo sanitario:

According to the United Nations Environment Programme's (UNEP) Food Waste Index Report 2021, **931 million tons of food waste** were produced across all food chain and **nearly 17 %** of the annual food production is wasted, **45–60 %** of which occurs because of industrial processing and postharvest operations (UNEP, 2021)

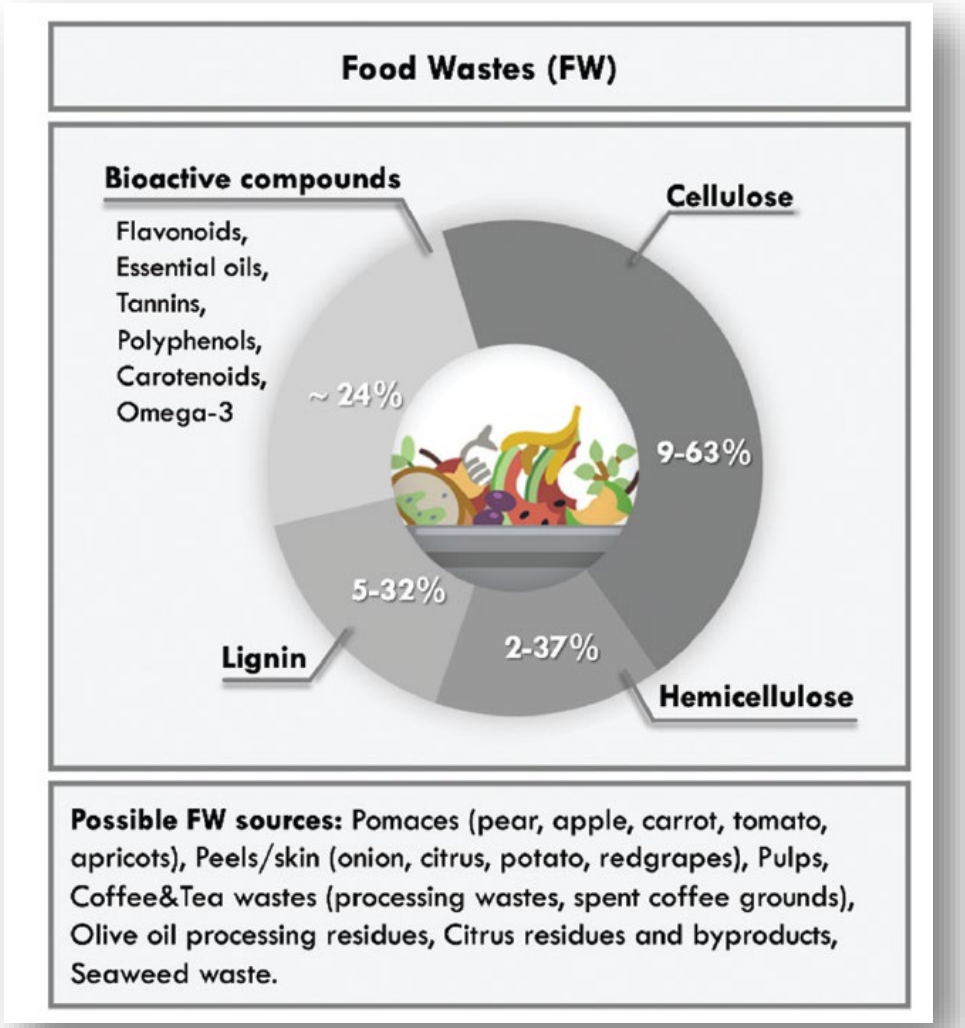
Gurleen Kaur Sodhi et al., Process Safety and Environmental Protection 188 (2024) 1464–1478

Beverage industry

Coffee
Tea
Beer
Wine



Yassine Jaouhari et al., Foods 2023, 12, 2183.

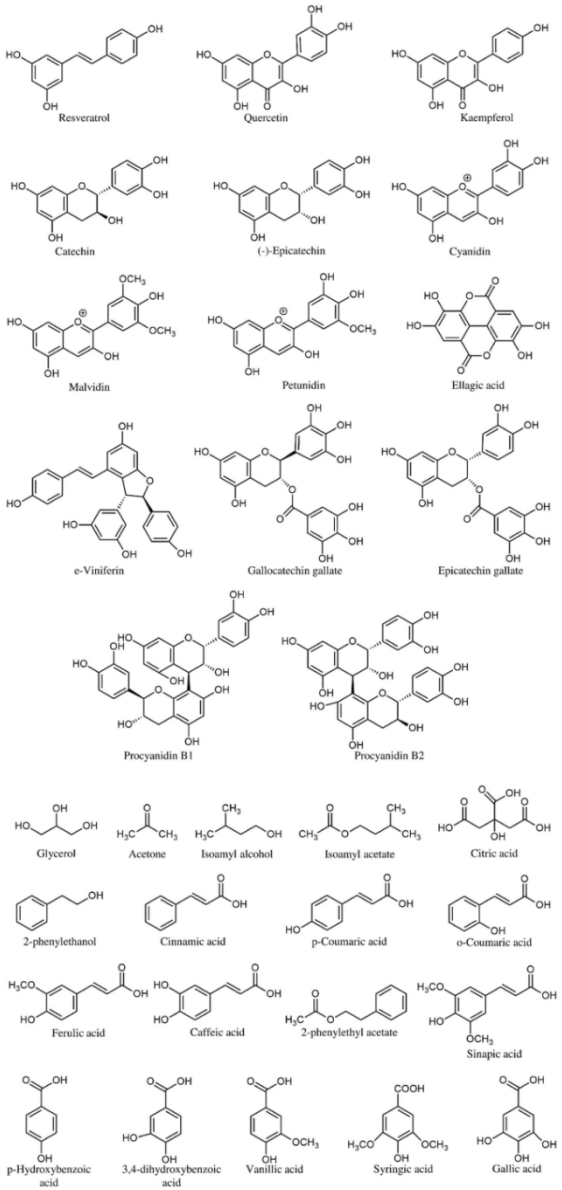


TYPE OF EXTRACTION	CONVENTIONAL (soxhlet, distillation, maceration)	MICROWAVE	ULTRASOUND	MECHANOCHEMICAL	ENZYMATIC
Advantages	High simplicity Easy scalable	Improved selectivity High yields Short extraction times	High energy-efficiency High yield Short extraction times Cost-effectiveness	Reduced use of solvents and reagents Short extraction times Simplicity	Use of water as main solvent High extraction selectivity and yield
Limitations	Long time/energy demanding procedures Poor selectivity Large volumes of solvents	Low yields towards the extraction of nonpolar compounds Unfit for heat-labile biomolecules	Need of optimization of the system (geometry, frequency, power and cycle propagation)	Lower recovery yields of phenolics	High cost of enzymes Low operational and storage stability of enzymes, hindering scalability
Extracted compounds	Phenolics, lipids/fat, oils	Phenolics	Phenolics, chlorophyll, carotenoids and lipids	Phenolics	Phytochemicals

Claudia Espro et al., *Chem. Soc. Rev.*, 2021, 50, 11191–11207

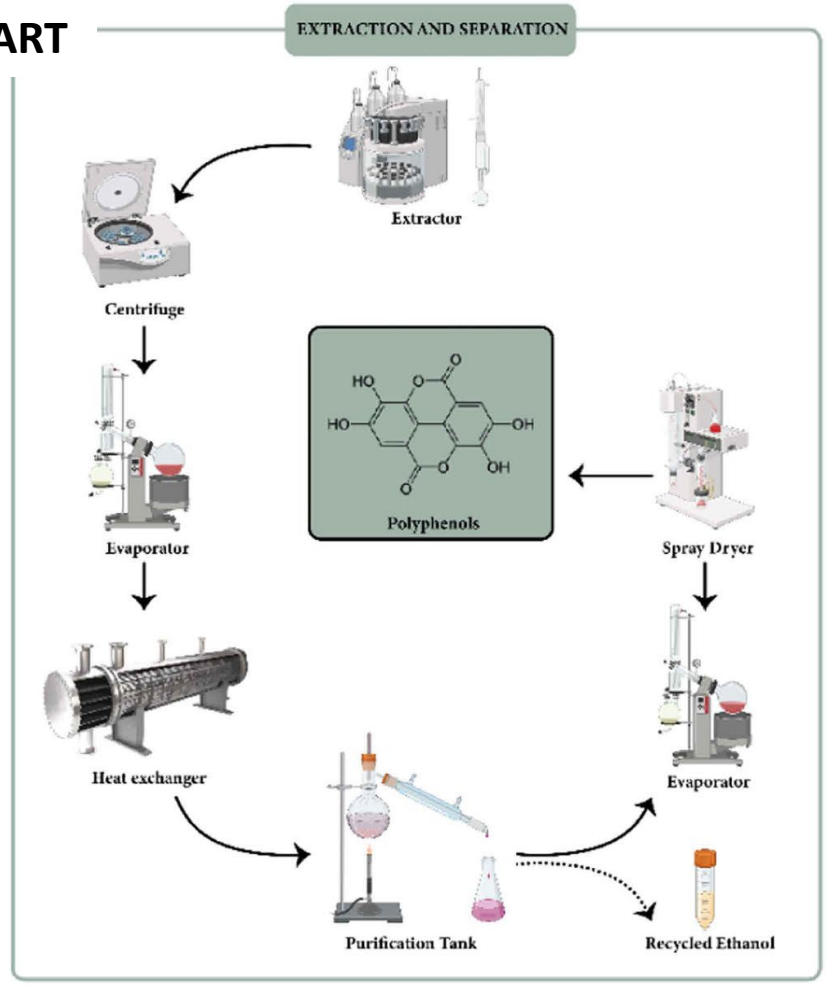
APPLICATIONS

Grape pomace is a significant by-product of wine industry



FLOWCHART

- 20-30% waste
- 13 million tons of grape pomace each year wine industry worldwide



Gurleen Kaur Sodhi et al., Process Safety and Environmental Protection 188 (2024) 1464–1478

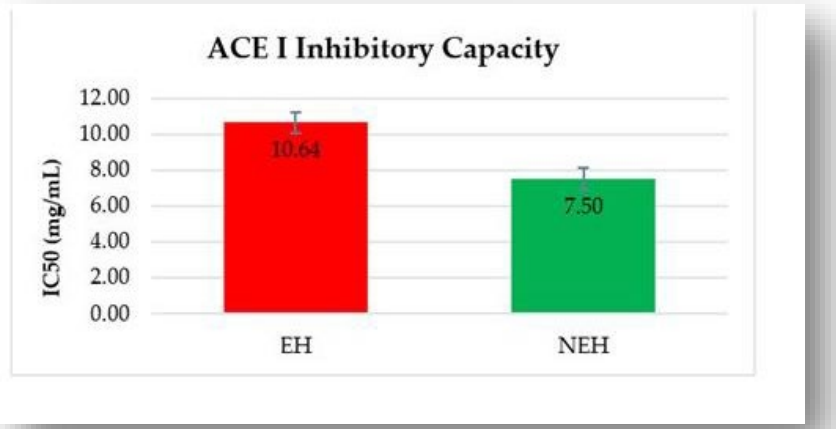
Marine Hydrolysates Isolated from Tuna

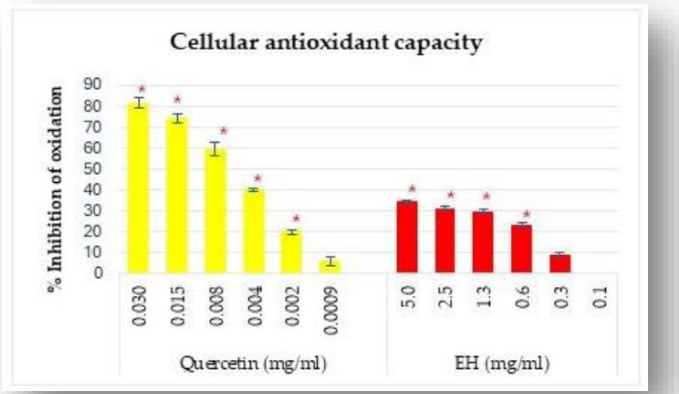
Figure 1. Cooked tuna side streams before (TFB) and after (TFP) the mild dehydration process.

Figure 2. Tuna protein hydrolysates: EH (Enzymatic Hydrolysates) and NEH (Non-Enzymatic Hydrolysates).

Bioactive peptides

EH vs. NEH





Federica Grasso et al., Antioxidants **2024**, 13, 1011 https://doi.org/10.3390/antiox13081011

PRIN 2022 Vita*D*waste

Innovative and sustainable processes for the development of Vitamin D nutraceutical from fish waste: extraction, formulation and clinical study for the evaluation of its bioavailability and clinical equivalence

UNICAM Università di Camerino 1336

UPO Università del Piemonte Orientale

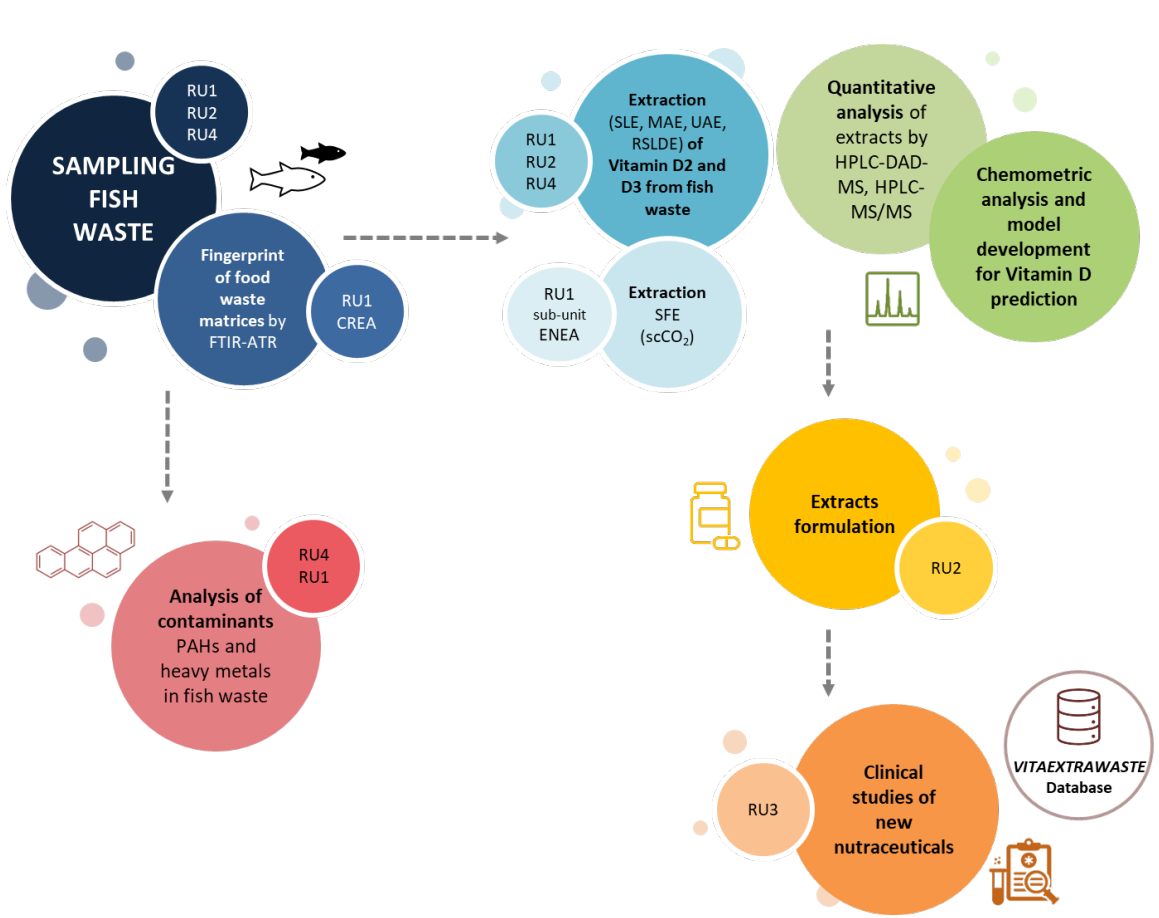
Alma Mater Studiorum A.D. 1088

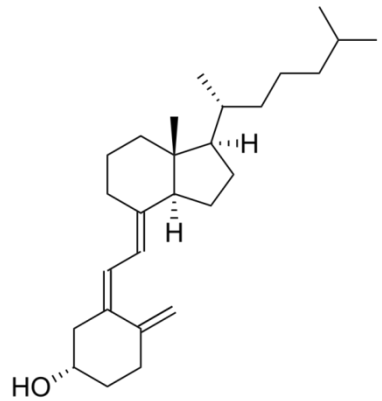
CNR IRBIM Istituto per le Risorse Biologiche e le Biotecnologie Marine

ENEA

crea Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria

Project Workflow





FISH WASTE SAMPLING AND ANALYSIS OF CONTAMINANTS

SGOMBRO Atlantic mackerel

Scomber scombrus

MERLUZZO European hake

Merluccius merluccius

SARDINA Sardine

Sardina pilchardus

ALICE o ACCIUGA Anchovy

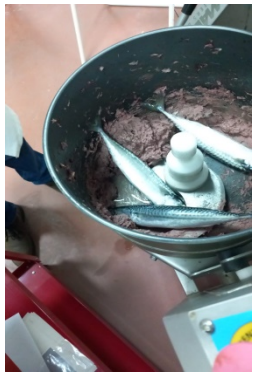
Engraulis encrasicolus

TRIGLIA Red mullet

Mullus barbatus

CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

Grinding biomass

(Cutter Malavasi P2502N da 26 litri)

Freeze drying biomass

(Lio Virtis ULTRA Genesis 35ES)

Sardine (a_w=0,31±0,02)

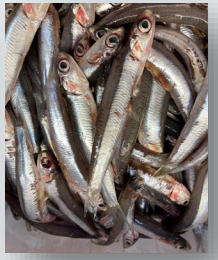
vassoio	1A	2	3A	4	5
Campione fresco, C (g)	1284,0	1197,4	1344,0	1453,0	1220,3
				Totale sardine fresche (g)	**6498,7**
Campione liofilizzato, CL (g)	311,2	289,3	325,6	353,7	174,5
				Totale sardine liofilizzate (g)	**1454,3**
Acqua sublimata, H2O (g)				**Totale (g)**	**5044,4**
				(%)	**(77,6%)**

Sgombri (a_w=0,34±0,03)

vassoio	6A	6B	6C	6D	6E
Campione fresco, C (g)	1513,2	979,6	1434,2	1405,3	1319,4
				Totale sgombri freschi (g)	**6651,7**
Campione liofilizzato, CL (g)	479,3	310,2	453,8	444,8	418,3
				Totale sgombri liofilizzati (g)	**2106,4**
Acqua sublimata, H2O (g)				**Totale (g)**	**4545,3**
				(%)	**(68,3%)**

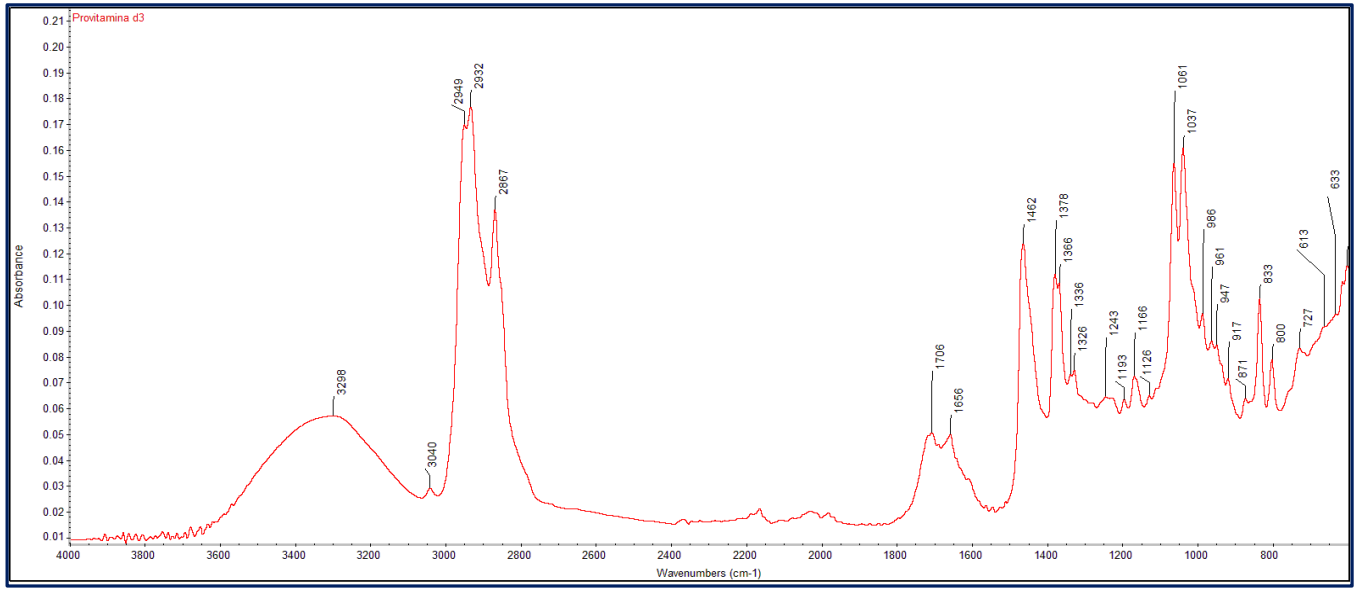
(Estrattore SPE-ED SFE 2)

Classification system and description

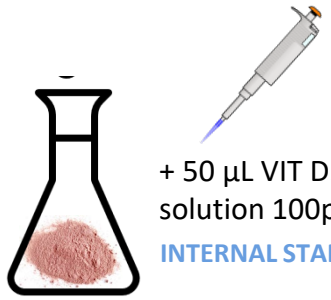
ANCHOVIES (*Engraulis encrasicolus*)	
DESCRIPTION OF THE WASTE	Whole uneviscerated sample
FISHING ZONE	*GSA 17 - North Central Adriatic*
FISHING TYPOLOGY	*Flying*
CODE LANGUAL™ CODE FOODEX2 	[A0267]; [A0717]; [A0727]; [A0801]; [B3837]; [C0275]; [E0150]; [R0138]; [R0264]; [Z0216] A02DD#F20.A07QN$F20.A07QQ

Predictive model Vitamin D3, FTIR –ATR

Application SPECTRA FEATURES SEARCH



Ultrasound Assisted Extraction (UAE)



5g of fish powder

+ 50 µL VIT D2 solution 100ppm

INTERNAL STANDARD

Saponification

UAE Extraction with hexane

30 min 60Hz

Lipophylic phase recovery

N_2 drying

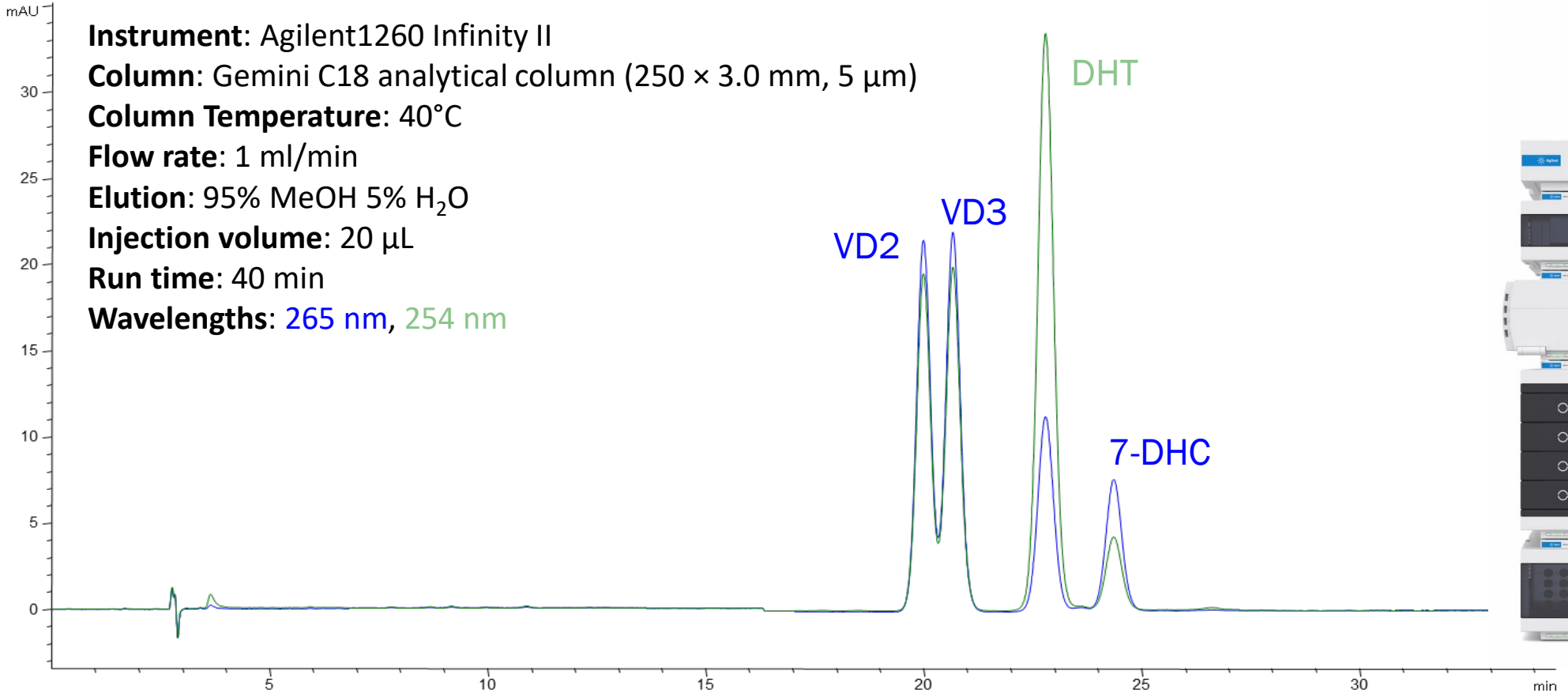
Reconstitution in 1ml of HPLC-grade MeOH

0.45µm Filtration

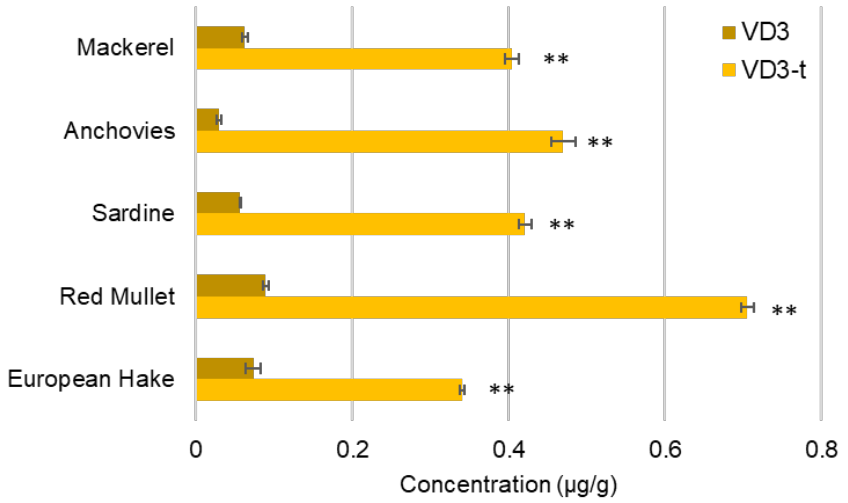
HPLC-DAD injection

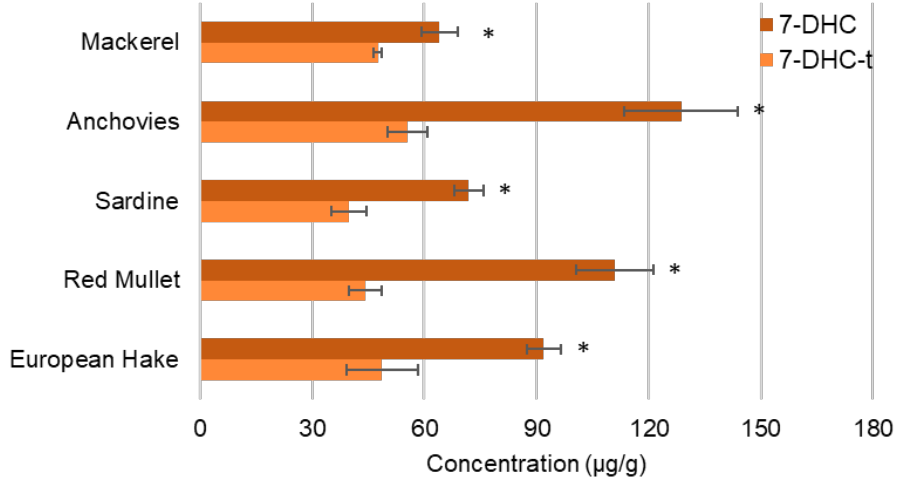
HPLC-DAD quantification method

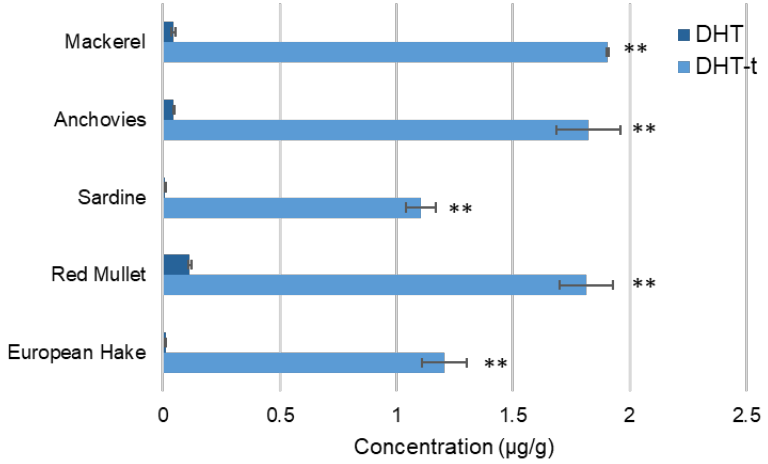
Instrument: Agilent1260 Infinity II
Column: Gemini C18 analytical column (250 × 3.0 mm, 5 µm)
Column Temperature: 40°C
Flow rate: 1 ml/min
Elution: 95% MeOH 5% H_2O
Injection volume: 20 µL
Run time: 40 min
Wavelengths: 265 nm, 254 nm



Real fish samples application







Sun Y. , Alessandroni L., Angeloni S., Del Bianco E., Sagratini G. From 7-dehydrocholesterol to vitamin D3: optimization of UV conversion procedures toward the valorization of fish waste matrices. *Food Chemistry:X, Volume 22, 30 June 2024, 101373*

VIT D3 ADDITION: RESULTS

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SINut Società Italiana di Nutraceutica
12-14 settembre 2024
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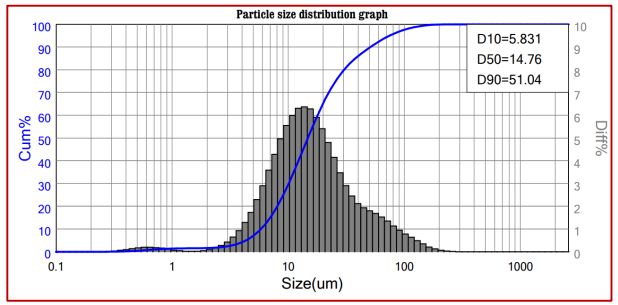
E5-D SPRAY-DRYING

Parameters	Test4
Tin (°C)	160
Tout (°C)	**94**
Aspiration (%)	100
Gas atomization (bar)	1.75
Pump (%)	26
Feeding rate (g/min)	8.75

Increase of Tout: probably caused by the spray dryer **covering**, which limited the heat dispersion

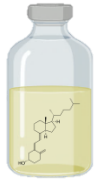
E5-D CHARACTERIZATION

Characteristics	E5-D
Process yield (%)	**72.85**
Oil recovery (%)	**85.69 ± 3.91**
Flowability	**PASSABLE**
D90 (µm)	**51.04**



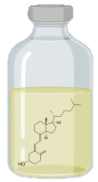
The characteristics were acceptable but **improvable**

VIT-D3 RECOVERY



70.48 ± 6.21%

ENCAPSULATED



55.49 ± 1.61%

NON-ENCAPSULATED

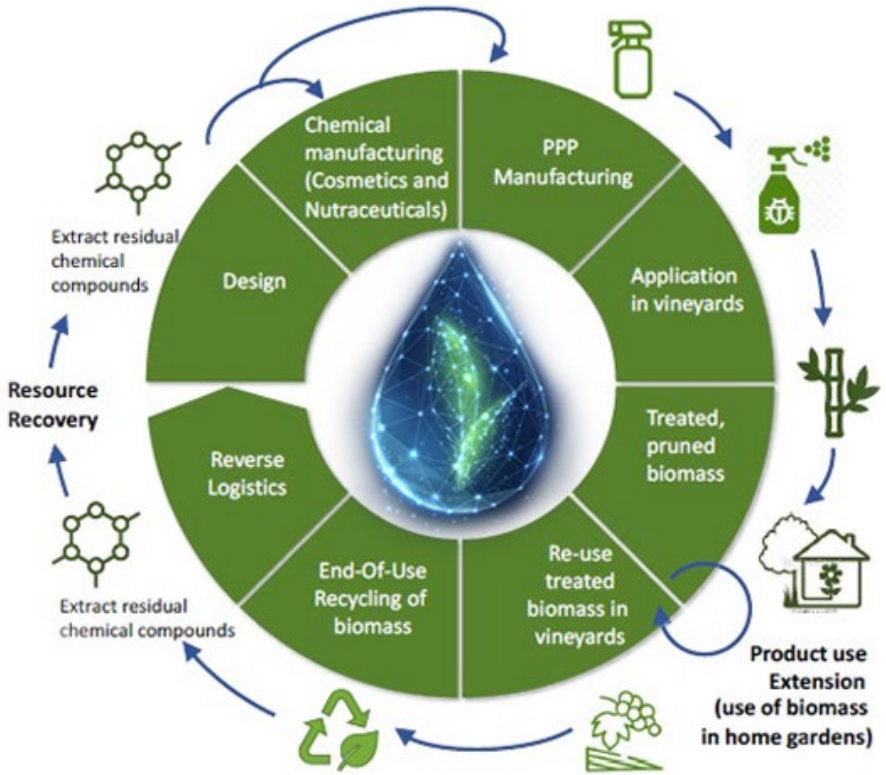
Vit. D3 was **preserved if encapsulated** into polynucleate microcapsules obtained from the combination of emulsification and spray drying

Clinical study by UniBo

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA A.D. 1088

Life NaturalAgro

https://www.lifenaturalagro.eu/



NATURAL DEVELOPMENT GROUP®

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UNIVERSITÉ DE REIMS CHAMPAGNE-ARDENNE

Entopan INNOVATION

VINIDEA

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA

iniav

vitepiú

CQY CERTIQUALITY

Circular Economy concept validation

DEVELOPMENT of NEW EXTRACTION and QUANTIFICATION method to be applied to grapevine shoots with and without treatment to understand the impact of the formulation on bioactive substances synthesis

STARTING POINT – STATE OF ART

SCIENTIFIC LITERATURE REVIEW to select principal bioactive compounds in grapevine canes and their possible application

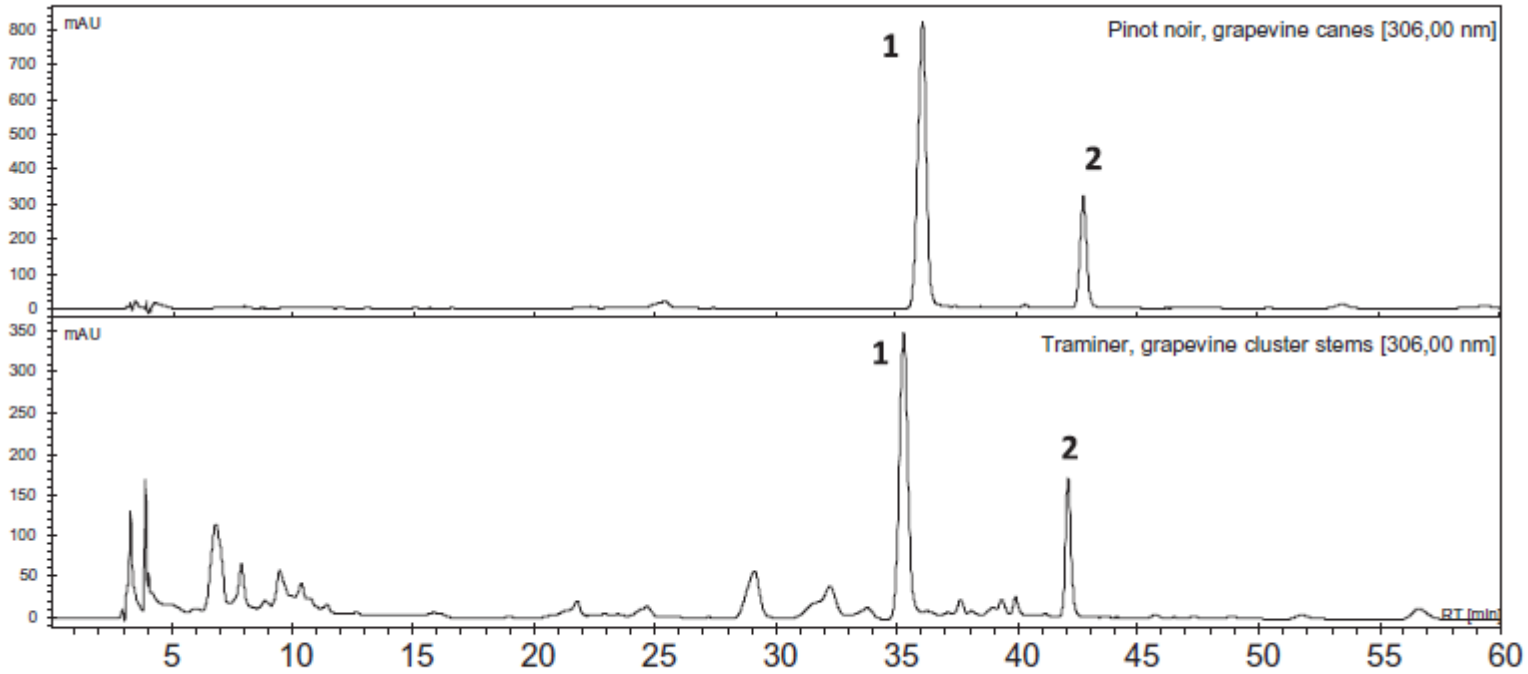


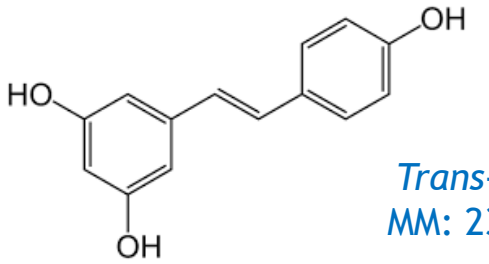
Fig. 1. HPLC-DAD chromatograms of a "Pinot noir" grape cane (upper) and a "Traminer" grape cluster stem extract recorded at 306 nm. 1, *trans*- resveratrol; 2, *trans*-ε-viniferin.

Table 3
Stilbene content of grape canes from viticultural region Palatinate in Germany, 2013.

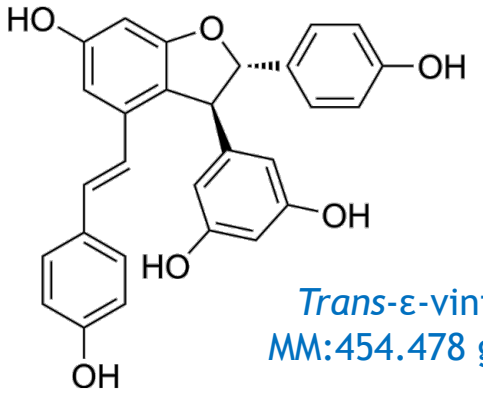
Cultivar	*trans*-Resveratrol [mg/kg DW]	*trans*-ε-Viniferin [mg/kg DW]
Cabernet sauvignon	1639 ± 15	2203 ± 29
Merlot	2409 ± 103	1656 ± 355
Regent	753 ± 27	1218 ± 40
Riesling	1994 ± 34	1928 ± 96
Pinot gris	1941 ± 32	3297 ± 70
Sauvignon blanc	2010 ± 124	3329 ± 296
Pinot noir	1908 ± 124	2790 ± 123
Pinot blanc	3199 ± 95	2125 ± 155

The contents in canes ranged **from 441 to 7532 and 1218 to 5341 mg/kg DW for trans-resveratrol and trans-ε-viniferin**, respectively, depending on variety, vintage and storage time. Within **storage of 6 months** the content in canes increased **by up to a factor of fourteen.**

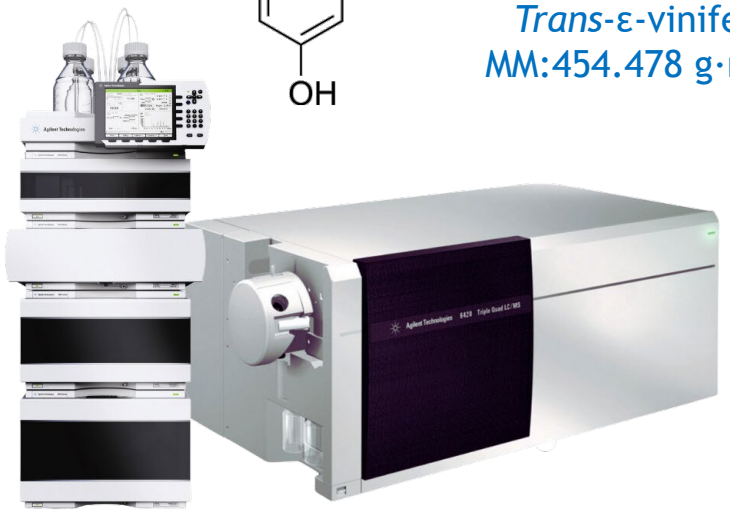
Philipp Ewald et el., Food Research International 100 (2017) 326–331



Trans-resveratrol
MM: 232.2 g·mol^{-1}



Trans-ε-viniferin
MM:454.478 g·mol^{-1}



Bioactives from waste wood extracts

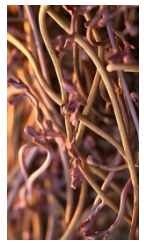
QUANTIFICATION

Instrument: UHPLC-ESI-MS/MS

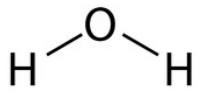
Column: Synergi C18 Hydro-RP 80 Å (250 × 4.6 mm, 4 µm)

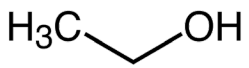
Mobile phases: 60% H_2O 0.1% HCOOH and 40% CH_3OH
Flow rate: 0.7 ml min^{-1}
Elution mode: isocratic
Injection volume: 4 µL

EXTRACTION

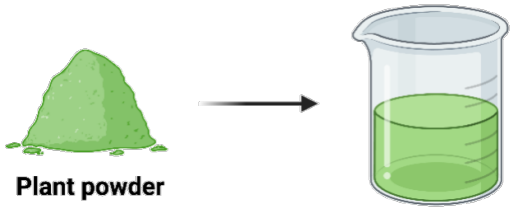


Matrix treatment: drying, freeze-drying, mincing





Solvents: EtOH/H_2O
Matrix/solvent ratio



SLE
(Solid-Liquid Extraction)

UAE
(Ultrasound Assisted Extraction)

Soxhlet extraction

Technologies

FUNDAMENTAL AND CRITICAL ISSUES

- Sustainability
- Extraction, purification, characterization
- Formulation
- Bioactivity and bioavailability
- Ethics committee

CONCLUSIONS

To favour the production of **nutraceuticals** from **food waste**, various scientific and technological challenges are needed:

1) The development of efficient and low energy-demanding separation and purification methods

2) The implementation of continuous processes that can operate at the industrial scale

3) The direct use of agro-industrial and domestic wastes as feedstocks

ACKNOWLEDGEMENTS

PRIN 2022 VITA *D* WASTE

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