Valorization of peach (*Prunus persica* L.) by-products using green methods

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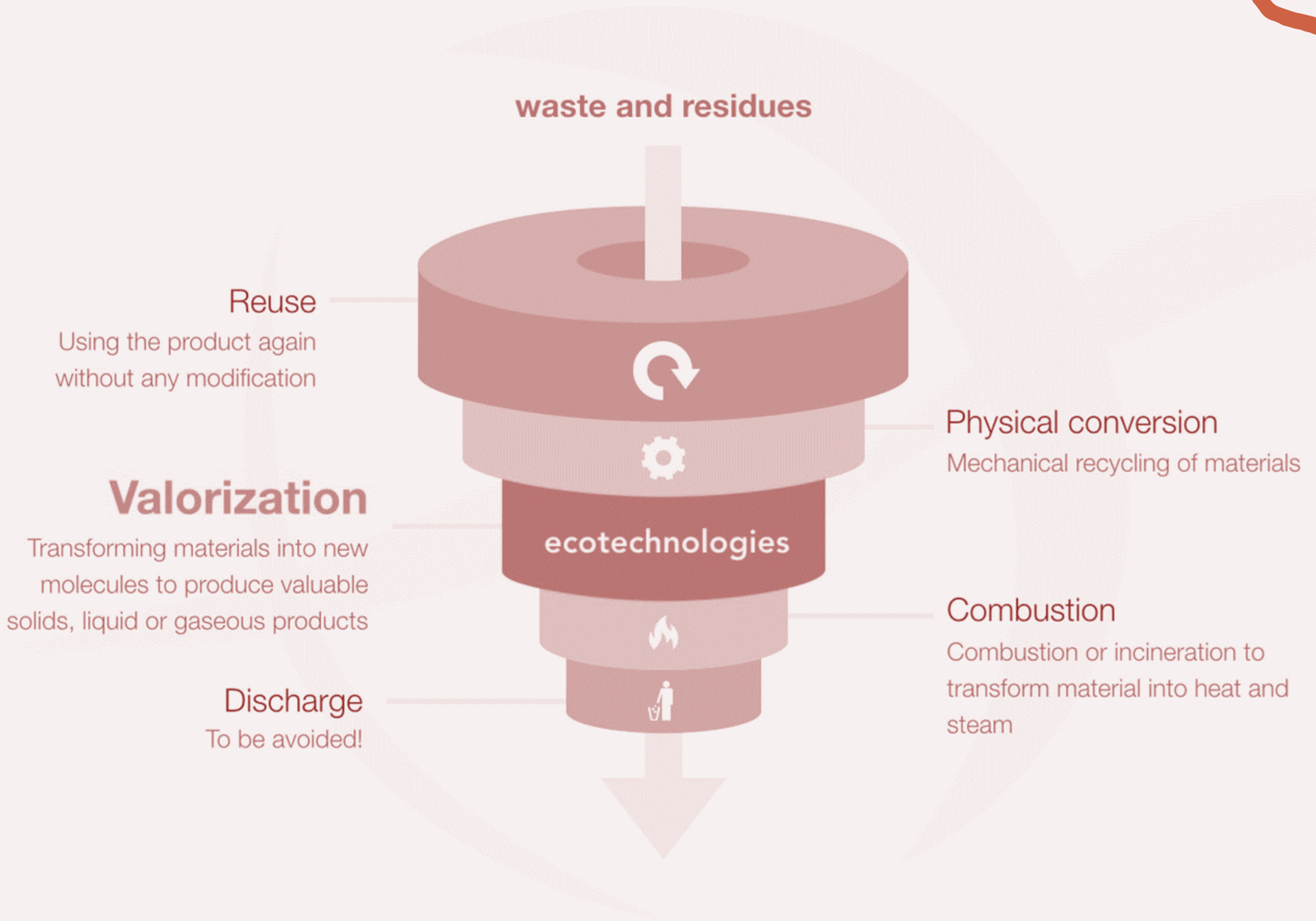
Food Technology Trends 2023

1) Alternative Proteins
2) Nutraceuticals
3) E-commerce
4) Food Safety & Transparency
5) Personalized Nutrition
6) Restaurant Digitization
7) Digital Food Management
8) Food Waste Reduction
9) Robotics
10) 3D Food Printers



Peach

Peach (*Prunus persica* L.) - Rosaceae family (similar to apricot, cherry and plum)

- Large global agricultural production (1.5 million hectares)
- China: 61% of global production (2020)
- Greece: 3rd in peach production after Spain and Italy (Europe)

Clingstone
(flesh attached to the pit)

Freestone
(flesh falls right off the pit)

Nutritional value per 100 g (3.5 oz)	
Energy	165 kJ (39 kcal)
Carbohydrates	9.54 g
of which sugars	8.39 g
Dietary fiber	1.5 g
Fat	0.25 g
Protein	0.91 g

(USDA, 2019)

Peach by-products

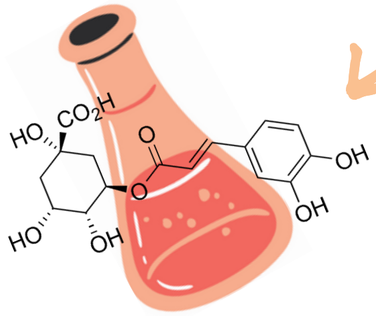
Large annual production of peaches & seasonality

Most fresh peaches are being processed

Can be used as animal feed

Significant amounts of by-products (e.g., peels)

Mainly discarded, increasing the volume of food waste



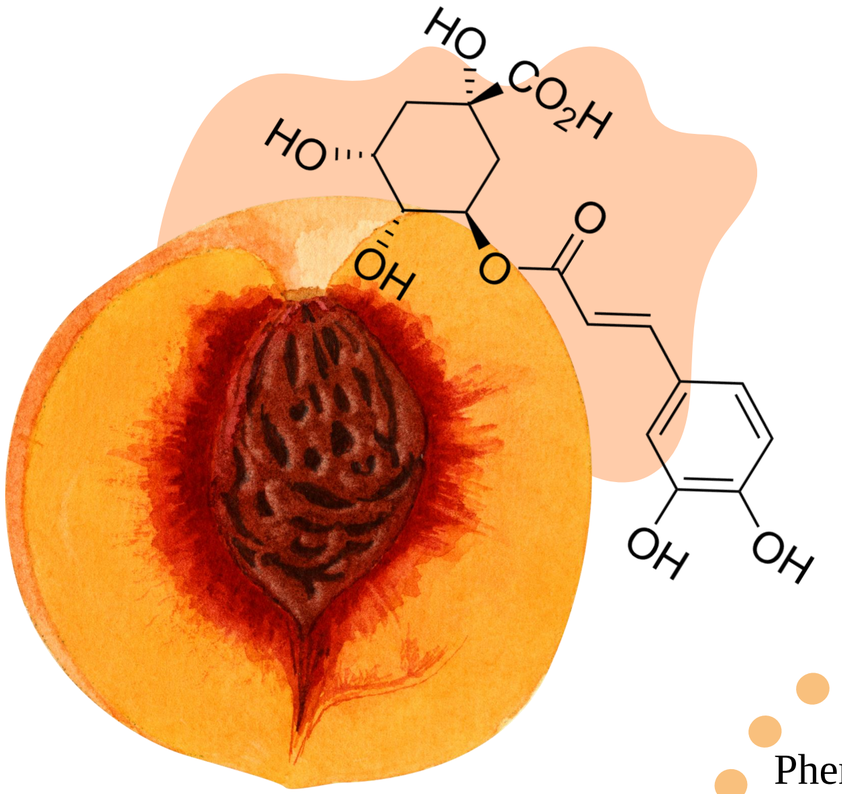
Resource of bioactive compounds with low processing costs

Industrialization into products with high added value containing natural compounds

(Munekata et al., 2022)

Peach peels

Higher concentrations of bioactive components compared to mesocarp (flesh)



Main phenolic acids: chlorogenic, neo-chlorogenic acid

Main flavonoids: catechin, epicatechin, quercetin glucosides

2-2.5 times higher concentrations of phenolic compounds & carotenoids (outer skin layer)

Phenolic compounds contribute to the protection from environmental stresses & microbial threats

(Campbell & Padilla-Zakour, 2013; Liu et al., 2015; Munekata et al., 2022; Kurtulbaş & Şahin, 2022)

Peach kernels

Pit or endocarp: 3 - 8% of the total fresh fruit mass

Mainly composed of unsaturated fatty acids (40-50%), proteins (15-45%), and fibers (4-8%)

components for food and cosmetic industries

Oil & lipophilic compounds content *(almond)*	**Reference**
Total oil content: 42.2 – 54.5 g/100 g	*Chamli et al., 2017*
UFA: 92.0 – 92.5 g/100 g oil Oleic acid content: 69.3 – 73.6 g/ 100 g oil Linoleic acid content: 16.0 – 20.5 g/100 g oil	
Total oil content: 48 g/100 g	*Maikhuri et al., 2021*
UFA: 92 g/100 g oil MUFA: 59.6 g/100 g oil PUFA: 32.4 g/100 g oil Oleic acid content: 58.0 g/100 g oil Linoleic acid content: 30.8 g/100 g oil	

Ultrasound-assisted extraction (UAE)

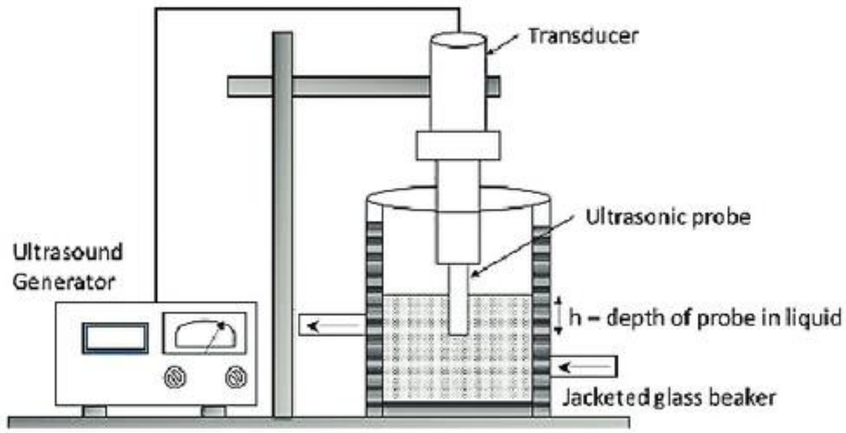
Mechanism/principle: acoustic cavitation

Advantages

- ✓ Reduced extraction time compared to conventional techniques
- ✓ Lower energy consumption
- ✓ Simplicity of use
- ✓ Small volumes of solvent required

Disadvantages

High temperatures may degrade the bioactive compounds



«Green» extraction technique

(Gil-Martin et al., 2022)

Aim of the study

Valorization of by-products from the peach industries of Northern Greece (e.g., peels, kernels)
Recovery of bioactive compounds (e.g., phenolics)

Goals to be achieved

- ✓ sustainability – circular economy – agricultural/food waste reduction
- ✓ exploitation of natural compounds as additives – nutraceuticals
- ✓ food safety

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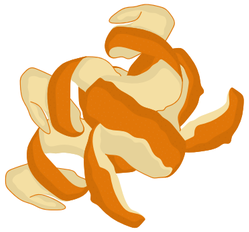
Peach peels (phenolics extraction)



Peach peels

Clingstone peach variety: *Catherina*

Lyophilization & milling
(d: 0,10 – 0,17 mm)

Response surface methodology –
model development (31 experiments)

Extraction duration: 1 – 31 min

Ethanol concentration in solvent: 0 – 80% v/v

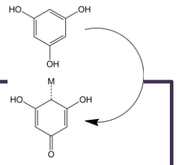
Solvent: solid ratio: 10:1 – 70:1 v/w

Pulse duration on – off: 0.1 – 0.9 (per 1 cycle)

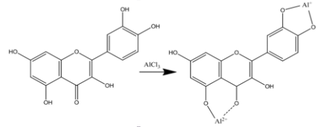
Ultrasound-assisted
extraction
(50% amplitude, < 35°C)

Extracts analysis

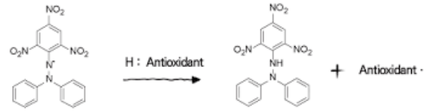
Total phenolic content (Folin-Ciocalteu assay)



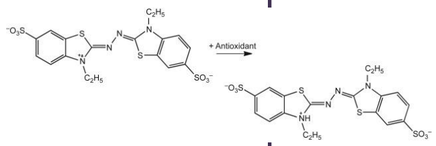
Total flavonoid content (aluminum chloride assay)



DPPH radical scavenging activity



ABTS radical scavenging activity



Chlorogenic acid concentration (HPLC-DAD)

Methodology

Peach peels (phenolics extraction)

Peach

Lyophilization & milling
(d: 0,10 – 0,17 mm)

Enzyme pre-treatment optimization (50°C)

Duration: 60-240 min
Enzyme type (cellulase: pectinase): 0-100% pectinase
Enzyme concentration: 2-4% w/w
Solvent/solid waste ratio: 2:1 to 6:1 v/w

Response surface methodology – model development

Extraction duration: 1 – 31 min

Ethanol concentration: 0 – 80% v/v in water

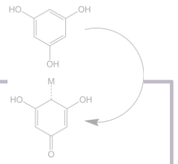
Solvent: solid ratio: 10 – 70 v/w

Pulse duration on – off: 0.1 – 0.9

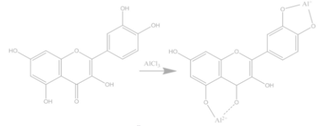
Ultrasound-assisted extraction

Extracts analysis

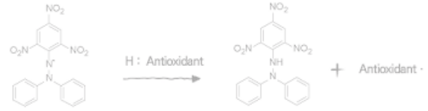
Total phenolic content (Folin-Ciocalteu assay)



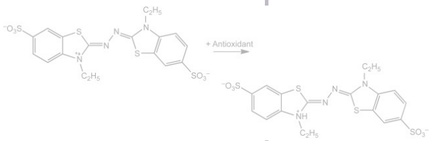
Total flavonoid content (aluminum chloride assay)



DPPH radical scavenging activity



ABTS radical scavenging activity



Chlorogenic acid concentration (HPLC-DAD)

Methodology

Peach kernels (oil extraction)

Peach kernels

Drying (40° C, 24 h)
& milling

Response surface methodology – model development

Optimization of ultrasound-assisted extraction

Clingstone peach variety: *Catherina*

Extraction temperature: 20-65 °C

Amplitude level: 30-60%

Solvent/solid waste ratio: 8:1 to 24:1 v/w

Dependent factor:
oil yield
(g oil/g kernel powder)

Extraction time: 35 min
Solvent: hexane

Methodology

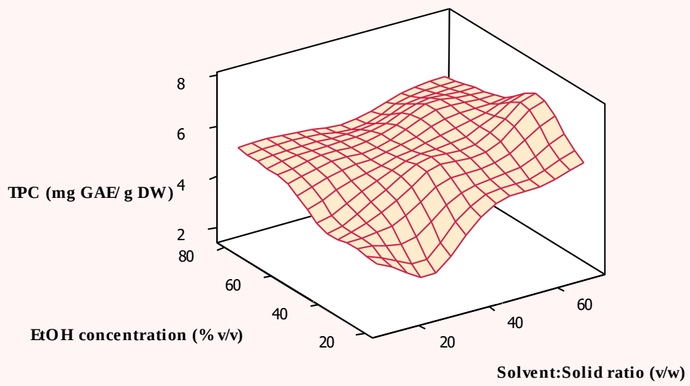
Results

Total phenolic content (TPC)

- ✓ TPC values ranged from 1.75 – 7.58 mg gallic acid equivalents (GAE)/ g dry weight of peach peels (DW)
- ✓ 40% - 60% v/v of EtOH – highest TPC
- ✓ 70:1 v/w solvent: solid ratio – highest TPC
- ✓ Duration and pulse on-off: non-significant factors for TPC

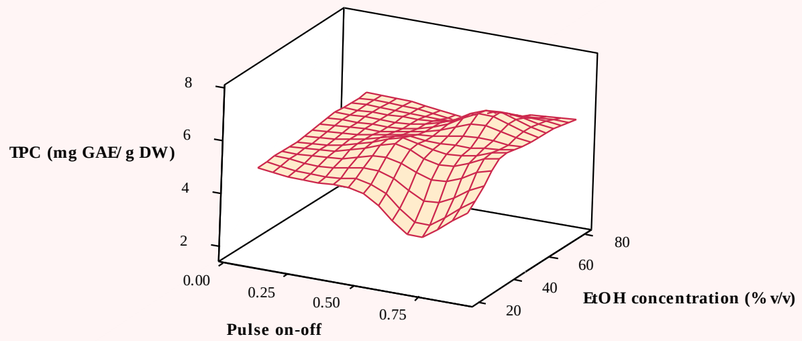
R^2 (%)	96,57
R^2_{adj} (%)	93,37
	p-values
Regression	0,000
Lack of fit	0,074
Duration (X_1)	0,907
Ethanol concentration (X_2)	0,000
Solvent: solid ratio (X_3)	0,000
On-off (X_4)	0,539

Surface Plot of TPC vs EtOH concentration (% v/v), Solvent:Solid ratio (v/w)



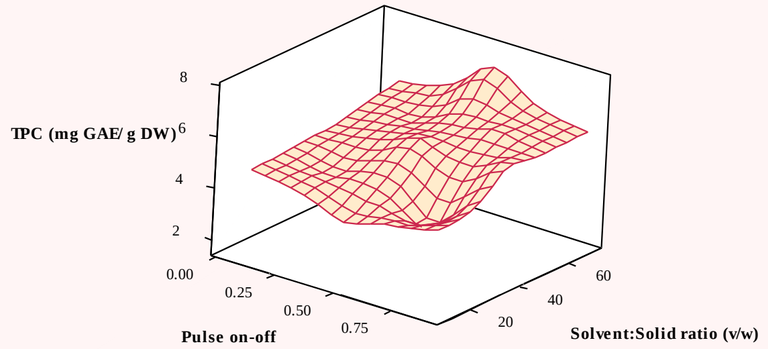
p-value = 0,001
↑TPC: 40% v/v EtOH & 70:1 v/w solvent: solid ratio

Surface Plot of TPC vs EtOH concentration (% v/v), On-Off



p-value = 0,000
↑TPC: 60% v/v EtOH & 0.7: 0.3 on-off per 1 cycle

Surface Plot of TPC vs Solvent:Solid ratio (v/w), On-Off

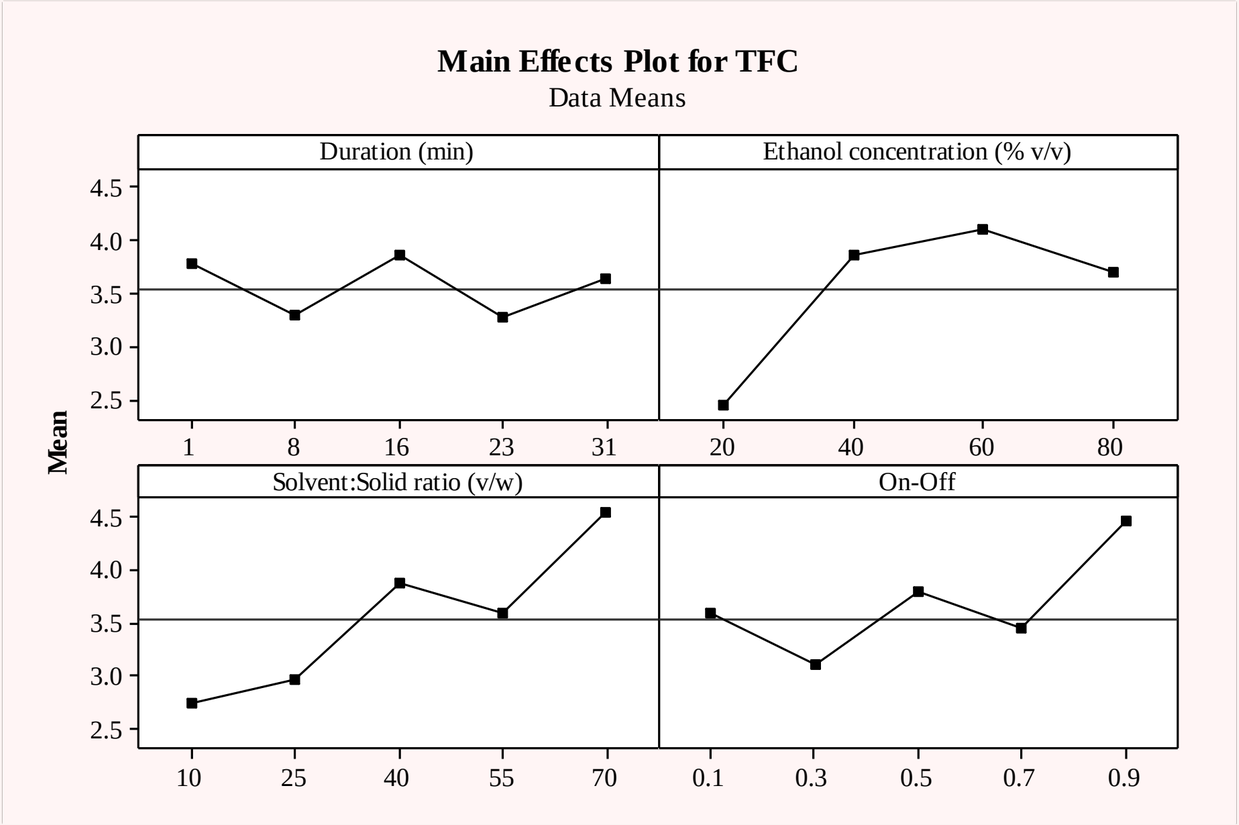


p-value = 0,000
↑TPC: 70:1 v/w solvent: solid ratio & 0.5: 0.5 on-off per 1 cycle

Total flavonoid content (TFC)

- ✓ TFC values ranged from 2.02 – 5.02 mg catechin equivalents (CAT)/ g dry weight of peach peels (DW)
- ✓ 60% v/v of EtOH – highest TFC
- ✓ 70:1 v/w solvent: solid ratio – highest TFC
- ✓ 0.9: 0.1 pulse on-off (per 1 cycle) – highest TFC
- ✓ Duration: non-significant factor for TFC

R^2 (%)	95,31
R^2_{adj} (%)	90,93
	p-values
Regression	0,000
Lack of fit	0,973
Duration (X_1)	0,707
Ethanol concentration (X_2)	0,000
Solvent: solid ratio (X_3)	0,000
On-off (X_4)	0,002

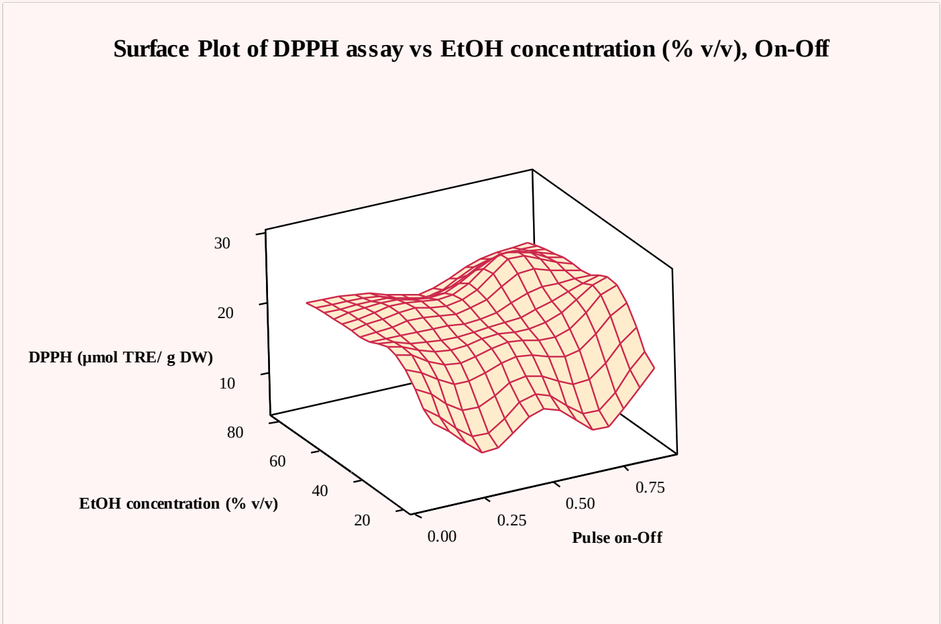


Interactions among factors were non-significant for this response

DPPH & ABTS radical scavenging activity

- ✓ DPPH radical scavenging activity values ranged from 4.48 – 28.86 μmol Trolox equivalents (TRE)/ g dry weight of peach peels (DW)
- ✓ 60% v/v of EtOH
- ✓ 70:1 v/w solvent: solid ratio
- ✓ 0.9: 0.1 pulse on-off (per 1 cycle)
- ✓ Duration: non-significant factor

ABTS: Lack-of-fit < 0.05



p-value = 0,011
↑Antioxidant activity: 60% v/v EtOH & 0.7: 0.3 on-off per 1 cycle

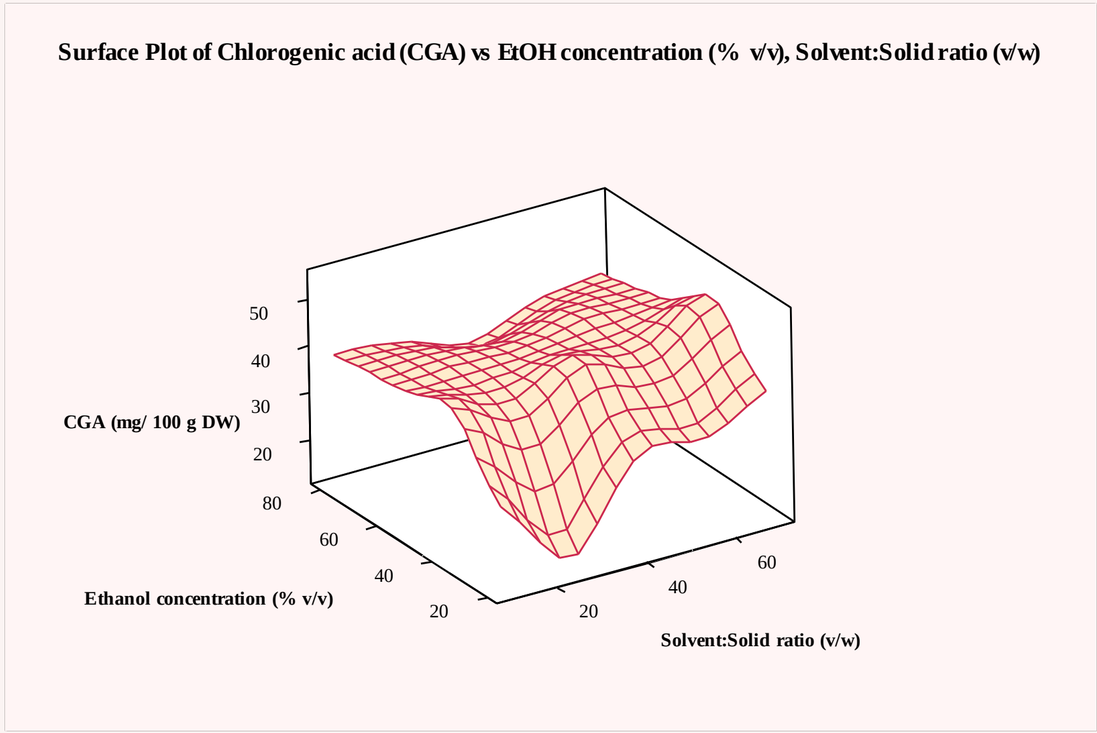
R^2 (%)	96,62
R^2_{adj} (%)	93,47
	p-values
Regression	0,000
Lack of fit	0,927
Duration (X_1)	0,201
Ethanol concentration (X_2)	0,000
Solvent: solid ratio (X_3)	0,000
On-off (X_4)	0,019

Chlorogenic acid (CGA)

- ✓ CGA concentration ranged from 3.74 – 53.81 mg/ 100 g dry weight of peach peels (DW)
- ✓ Responses followed the same trend as TPC
- ✓ 40% v/v of EtOH – highest chlorogenic acid content
- ✓ 70:1 v/w solvent: solid ratio – highest chlorogenic acid content
- ✓ Duration and pulse on-off: non-significant factors for CGA

Quantification based on a chlorogenic acid standard curve (10 – 200 ppm) – HPLC-DAD

R^2 (%)	85,94
R^2_{adj} (%)	72,81
	p-values
Regression	0,000
Lack of fit	0,061
Duration (X_1)	0,954
Ethanol concentration (X_2)	0,000
Solvent: solid ratio (X_3)	0,008
On-off (X_4)	0,157



p-value = 0,025

↑CGA concentration: 40% v/v EtOH & 70:1 v/w solvent: solid ratio

Optimum extraction conditions (peach peels & kernels)

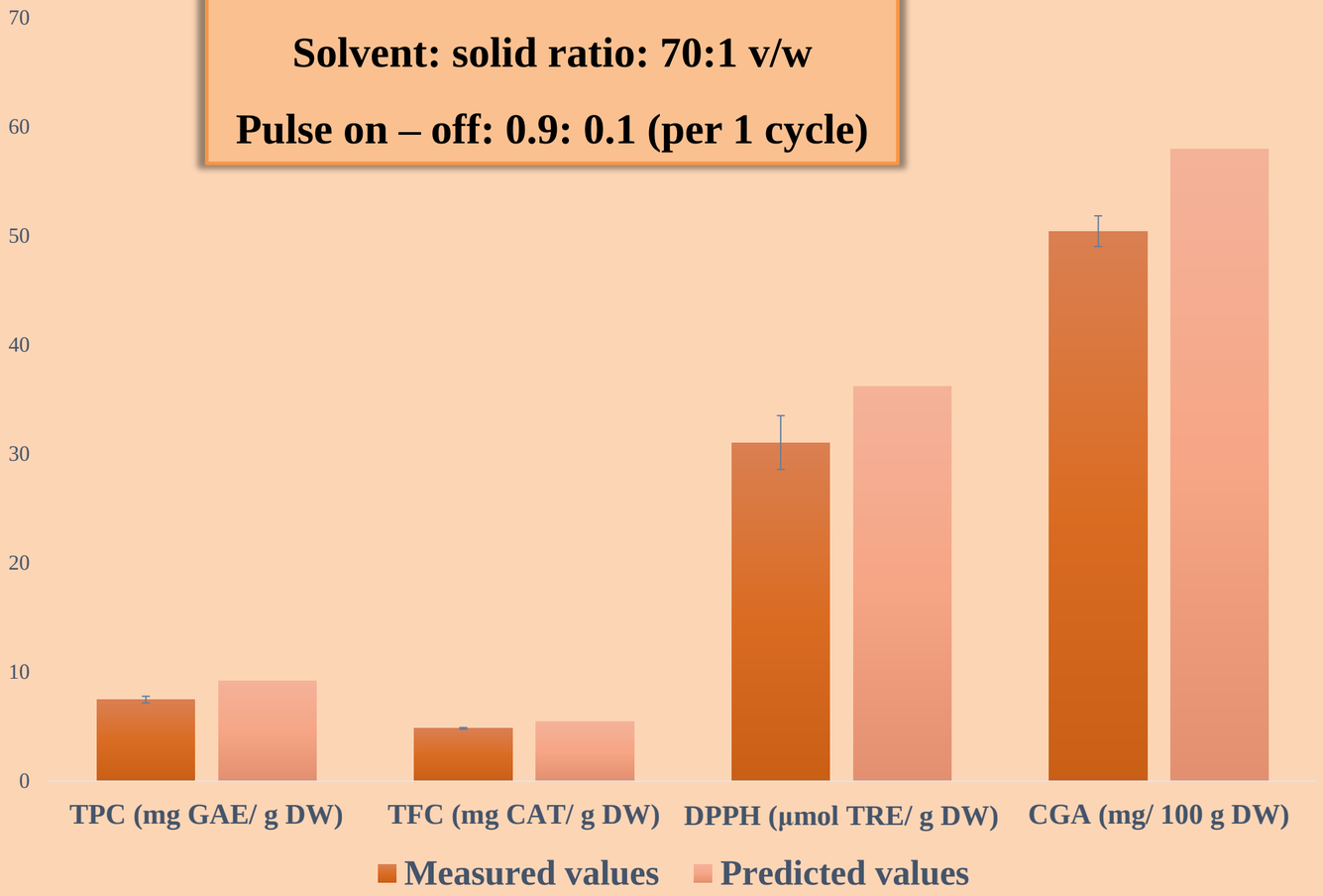
OPTIMUM CONDITIONS

Extraction duration: 17 min

EtOH concentration: 53% v/v

Solvent: solid ratio: 70:1 v/w

Pulse on – off: 0.9: 0.1 (per 1 cycle)

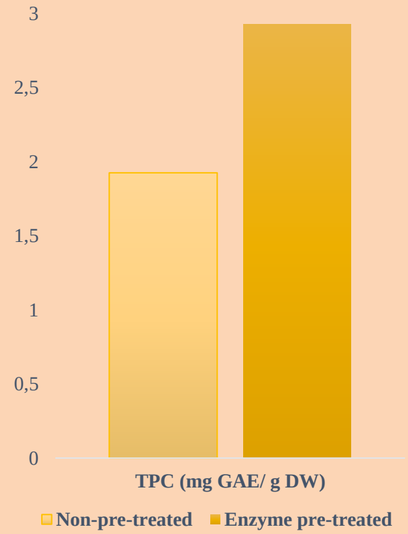


OPTIMUM CONDITIONS

(enzyme pre-treatment)

50% pectinase

3% w/w enzyme concentration



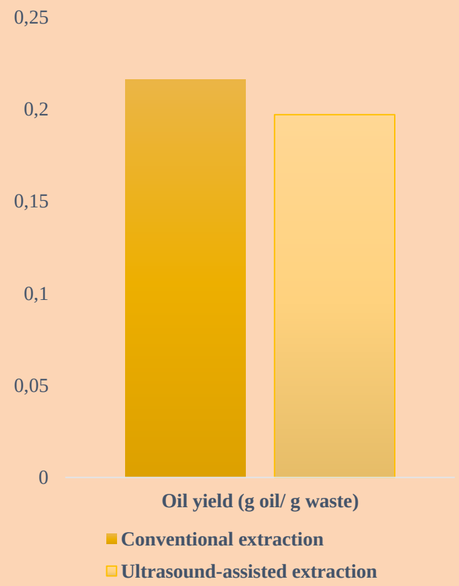
OPTIMUM CONDITIONS

(peach kernel oil)

Extraction temperature: 42.5 °C

Amplitude level: 45%

Solvent/solid waste ratio: 16:1 v/w



Conclusions

- ✓ Effective optimization of phenolics compounds extraction from peach peels with UAE
- ✓ Enzyme pre-treatment with cellulase/pectinase may enhance the total yield of phenolic compounds from peach peels
- ✓ UAE seems a promising method for peach kernel oil extraction
- ✓ Potential of peach by-products valorization
- ✓ Possible future applications as natural additives (e.g., antioxidants)
- ✓ Production of functional food products

Thank you for your attention!

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