Valuable products from food by-products

Fahrettin GÖĞÜŞ
Gaziantep University Food Engineering Department
Gaziantep, Turkey

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Outline

- Gaziantep University
- Studies on Food Waste Valorisation
    - Extruded Food Products
    - Olive Pomace
    - Pomegranate Pomace
    - Grapefruit Peels
    - Pistachio by-products

Gaziantep/Turkey

Gaziantep and University

Gaziantep University

An industrially developed and authentic city

GAZİANTEP

Gaziantep University/Department of Food Engineering

- Professors 11
- Associated Professor 5
- Assist.Professor 1
- Res.Assists 12
- PhD students 24
- MSc Students 56
- BSc Students 850

Examples on Food Waste Valorisation Studies

- Production of nutritionally balanced or enriched foods
- Olive pomace utilization
  - Cocoa butter equivalent
  - Production of 2-monoacylglycerol
- Pomegranate juice waste
  - Extraction of seed oil
- Grapefruit peels
  - Extraction of pectin and limonene
  - Hydrochar production
- Valorization of pistachio (*Pistacia vera* L.) hull and shell
  - Phenolics from hull
  - Oligosaccharides from shell

Production of nutritionally balanced or enriched foods

Rice grits (67%)

Durum clear flour

Partially defatted hazelnut flour

Fruit waste blend

extrusion

Grape seed: rich source of polyphenolics with potential antioxidant activity

Citrus by-products: nondigestible carbohydrates (dietary fiber) and bioactive compounds

Tomato pomace: high antioxidant activity, digestible amino acids

Durum clear flour: high in protein (14.16%), ash (1.52%), starch (about 65%) and phenolics

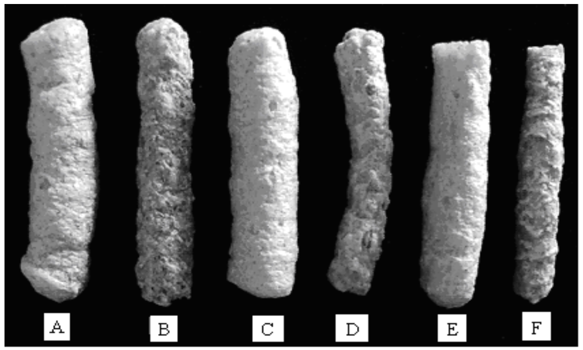
Defatted hazelnut flour: high in protein (3541%), fiber (10%) and phenolic compounds

Responses

- **Total phenolic content** increased three fold
- **Antioxidant activity** increased significantly
- **Starch digestibility** of the extrudates increased when compared to the unextruded raw materials

- Acceptable **sensory properties** were obtained at low PDHF content

Food processing wastes were used as a natural source of antioxidants in enrichment of extrudates produced from rice grits.



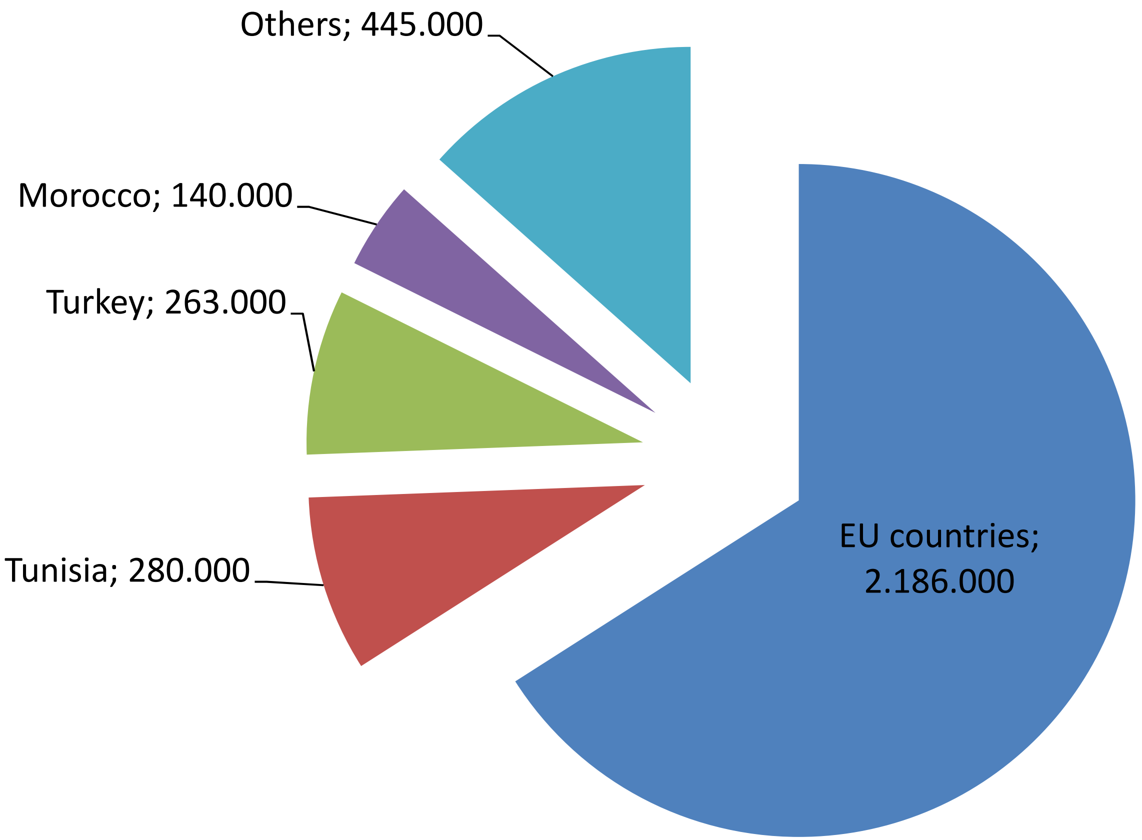
Utilization of olive pomace

Olive pomace is a natural agricultural by-product of olive oil production

Why olive pomace?

- High abundance in the world
- Most of usages do not have great economical value
- The same fatty acid composition with olive oil
- Olive oil producers seek alternative uses for olive pomace

Olive oil production in the world



(tonnes), IOOC, 2017/18 crop year

Olive pomace oil production process

Olive (1 tonne)
↓
Washing
↓
Crushing
↓
Malaxation
↓
Decanter
↓
Washing
↓
Olive oil (200 kg)

Waste →

Crude olive pomace (800 kg)
↓
Drying → Waste water (500 kg)
↓
Solvent (hexane) extraction → Pomace dry residues (276 kg)
↓
Distillation
↓
Olive pomace oil (24 kg)
↓
Refining
↓
Refined olive pomace oil

Olive pomace cocoa butter equivalent

High cost and fluctuations in the supply

&

Demand of cocoa butter

The oils and fat industry investigates the possibility of using other fat and oil sources as an alternative to cocoa butter

Olive pomace cocoa butter equivalent

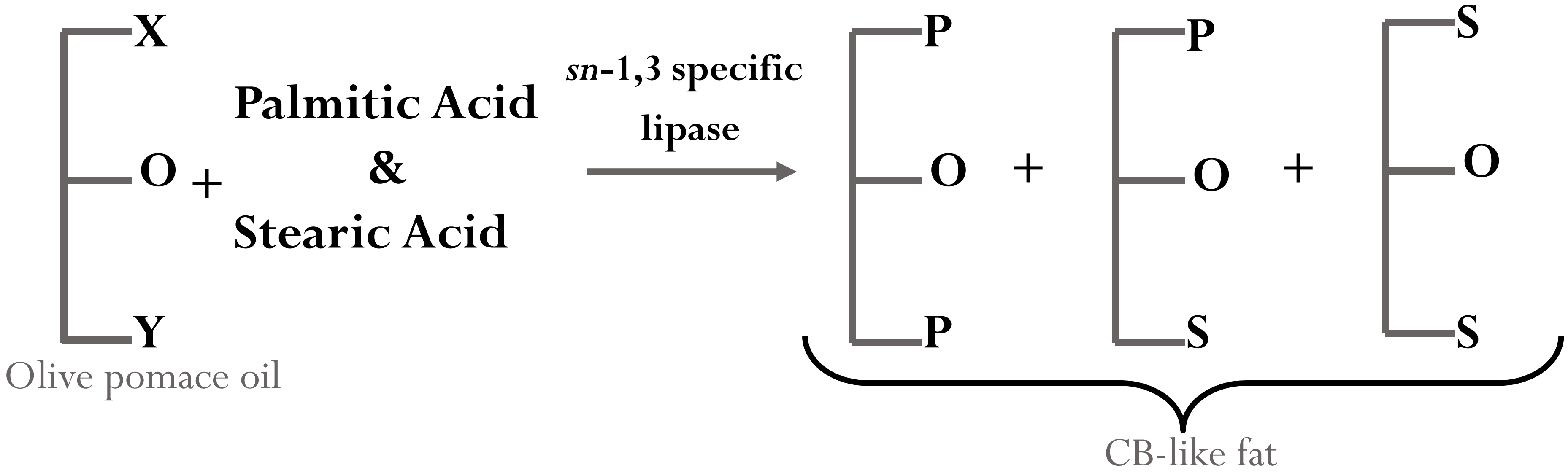
- Enzymatic synthesis of cocoa butter equivalents from cheap oils and fats using *sn*-1,3 specific lipases is an alternative method.

Refined olive pomace oil:
a good potential cheap source of oil for CB-like fat production

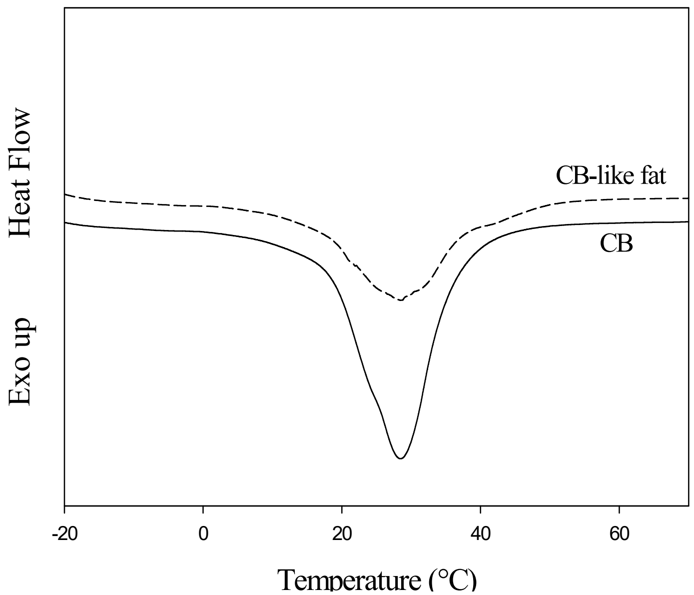
↓

high sn-2 oleic acid content

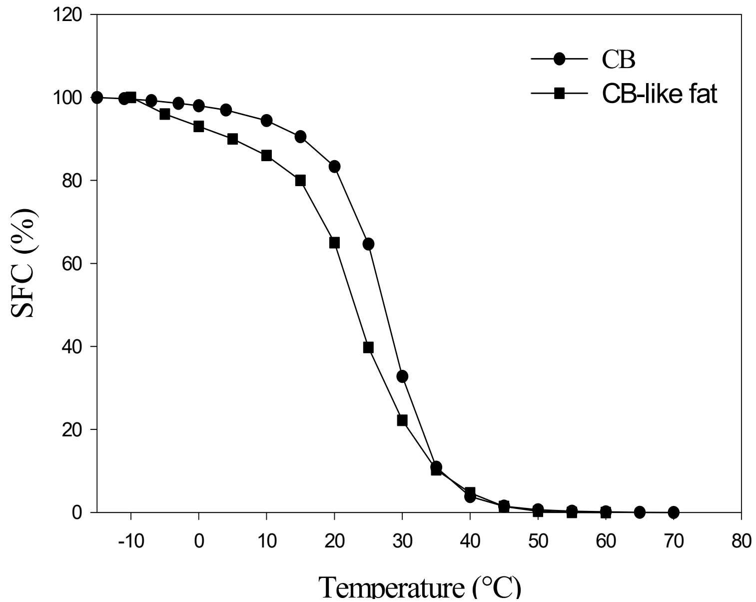
Olive Pomace Oil to Cocoa Butter Equivalent



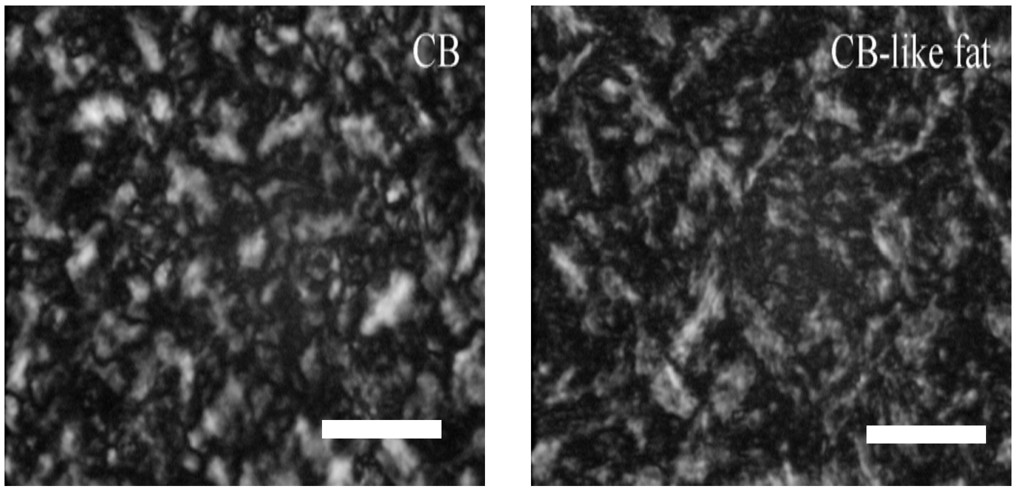
Packed bed reactor with lipase from *Mucor miehei*
olive pomace oil: PA: SA: 1:2:6
Temperature: 45°C
Time: 3 h
Solvent: hexane



DSC melting profiles of CB and CB-like fat

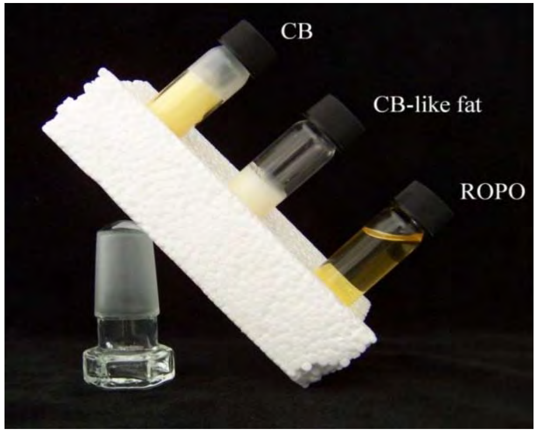


Change in SFC of CB and CB-like fat



PLM grayscaled images of CB and CB-like fat.
The horizontal length of the inset bar 50μm

Synthesis of Cocoa Butter Equivalent

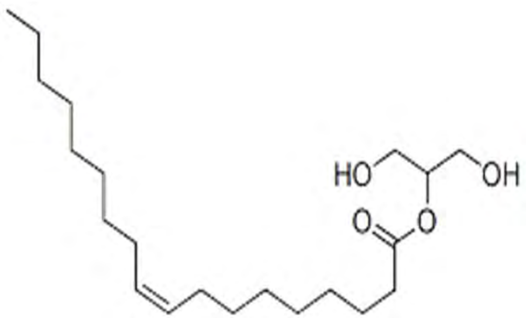


CB-like fat could replace CB without significantly changing the physical and chemical properties of the product.

- Çiftçi O.N., Fadıloğlu S., Göğüş F. and Güven A. (2008). Prediction of a model enzymatic acidolysis system using neural networks. Grasas y Aceites, 59, 375-382.
- Çiftçi O.N., Fadıloğlu S., Göğüş F., Kowalski B. (2008). Production of Triacylglycerols of Cocoa Butter in a Model Acidolysis System. Grasas y Aceites, 59, 316-320.
- Çiftçi O.N., Fadıloğlu S., Göğüş F., (2009). Conversion of Olive Pomace Oil to Cocoa butter-like Fat in a Packed-bed Enzyme Reactor,. Bioresource Technology, 100, 324-329.
- Çiftçi O.N., Fadıloğlu S., Göğüş F., (2009). Utilization of Olive-Pomace Oil for Enzymatic Production of Cocoa Butter-like Fat. Journal of American Oil Chemists Society, 86, 119-125.
- Çiftçi O.N., Kowalski B., Göğüş F., Fadıloğlu S. (2009) Effect of the Addition of a Cocoa Butter–Like Fat Enzymatically Produced from Olive Pomace Oil on the Oxidative Stability of Cocoa Butter, Journal of Food Science, 74, E184-190.
- Çiftçi O.N., Fadıloğlu S., Göğüş F. and Güven A. (2009) Genetic programming approach to predict a model acidolysis system, Engineering Applications of Artificial Intelligence, 22, 759-766.

Synthesis of 2-monoacylglycerol from olive pomace oil

- 2-monoacylglycerols (2-MAG) rich in oleic acid



2-monoolein

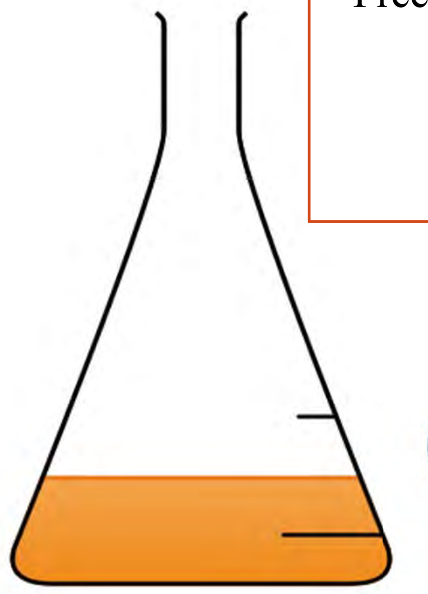
- **Come exclusively from plant origin**
- **Application in functional food/drink and pharmaceutical products**
- **Health benefits**
  - **Chlolesterol lowering agent**
  - **Reduce risk of cardiovascular disease and cancer**

Synthesis of 2-monoacylglycerol from olive pomace oil

Ethanolysis

Free fatty acid + Ethanol —Lipase→ Fatty acid ethyl ester + H_2O

TAG/DAG/MAG + Ethanol —Lipase→ Fatty acid ethyl ester + 2-monoacylglycerol + H_2O



Olive pomace oil

Valuable products: 2-monoacylglcerol and Biodiesel

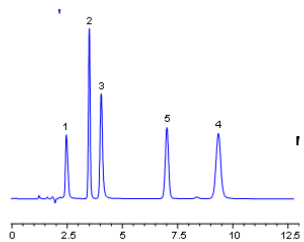
Experimental method

Optimisation of 2-MAG synthesis reaction

Reactants:
Refined olive pomace oil + Ethanol

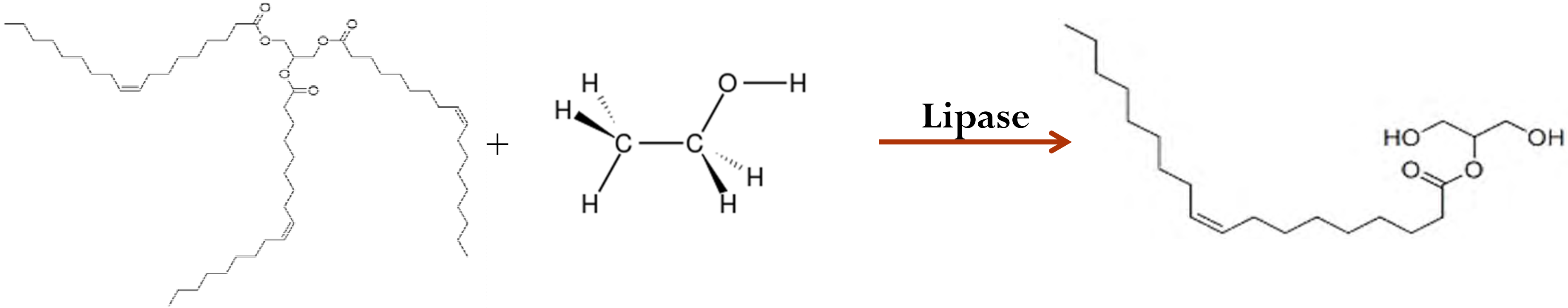
Optimisation parameters

- **Lipase type**
- **Enzyme concentration**
- **Ethanol:oil molar ratio**
- **Reaction temperature**
- **Reaction time**



Determination of 2-MAG yield (%) using Thin Layer Chomatography (TLC/FID)

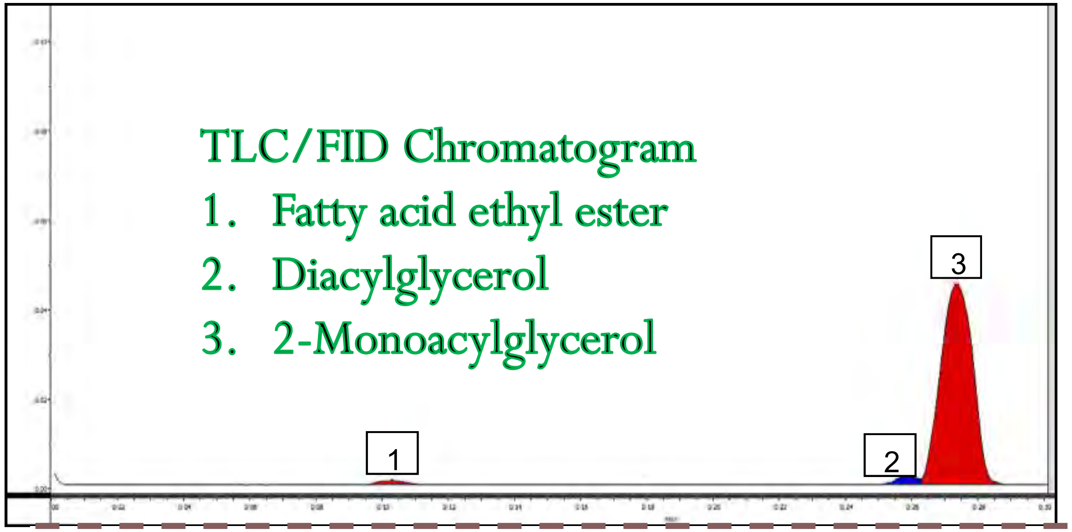
Optimum conditions



Yield of 2-monoacylglycerol >84%

- **Lipase from *Candida antractica***
- **Enzyme concentration: 10% (wt% of oil)**
- **EtOH: oil molar ratio: 50:1**
- **Reaction temperature : 45°C**
- **Reaction time: 5 hr**

2-Monoacylglycerol



2-Monoacylglycerol

Purity of 96.00% by solvent extraction

Oleic acid (83.23%) & Linoleic acid (15.01%)

Desirable for pharmaceutical applications

- TR 2014 10227 B (2018). Pirina yağından enzimatik yolla 2-monoasilgliserol üretimi.
- Keskin, H., Kocak Yanık, D., Mucuk H.N., Göğüş, F. Fadıloğlu, S. (2016). Valorization of Olive Pomace Oil with Enzymatic Synthesis of 2-Monoacylglycerol, Journal of Food Science, 81, C841-C848.

Pomegranate pomace and seed

Pomegranate (1 tonne) → **Juice** → Pomegranate juice

Pomegranate (1 tonne) → **Waste** → Pomegranate pomace+peels (560 kg)

Pomegranate pomace+peels (560 kg) → Pomegranate pomace (80 kg)

Pomegranate pomace+peels (560 kg) → Peels (480 kg) → Phenolic extracts

Pomegranate pomace (80 kg) → Drying → Pomegranate seeds (16 kg)

Pomegranate seeds (16 kg) → Pomegranate seed oil (6 kg)

Microwave assisted extraction of pomegranate seed oil

Pomegranate seed

Extraction

Pomegranate seed oil

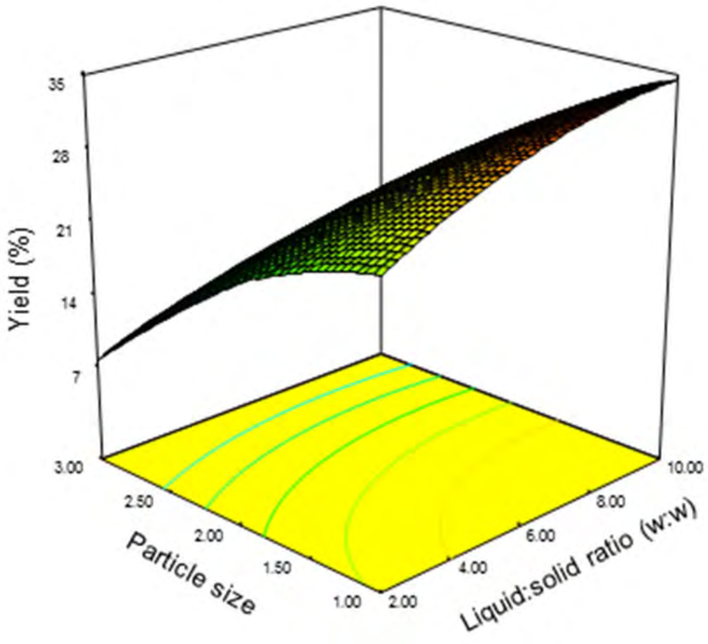
Optimum extraction conditions:

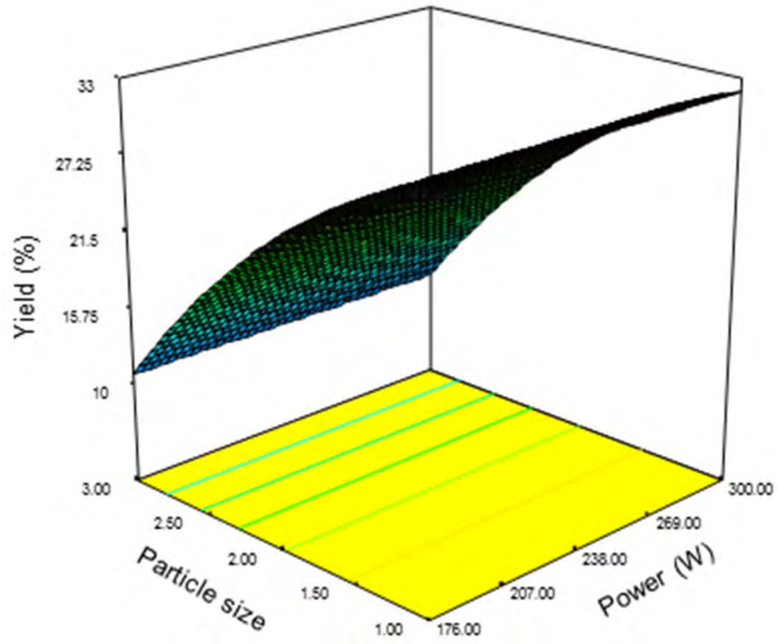
Power: 296 W

Liquid:solid ratio: 10:1

Time: 5 min

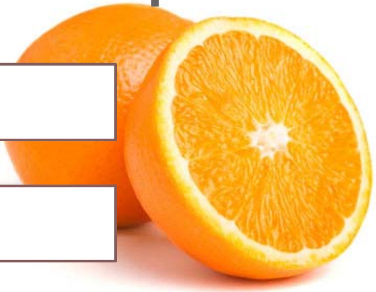
Yield: 33.94 (wt.)%





Çavdar, H. K., Yanık, D. K., Gök, U., Göğüş, F. (2017). Optimisation of Microwave-Assisted Extraction of Pomegranate (Punica granatum L.) Seed Oil and Evaluation of Its Physicochemical and Bioactive Properties, Food Technology and Biotechnology, 55, 86-94.

Citrus fruits production flow diagram

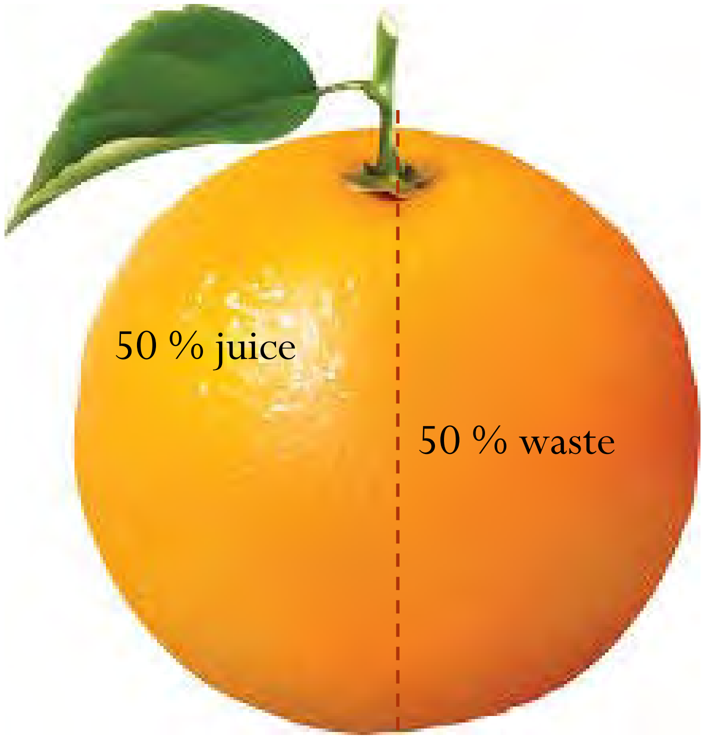


- Fruit (**2 tons**)
- Washing
- Sorting
- Sizing
- Extraction
- Pasteurization
- Separation
- Evaporation
- Fruit juice concentrate

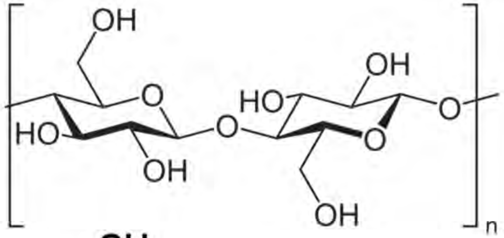
Extraction →

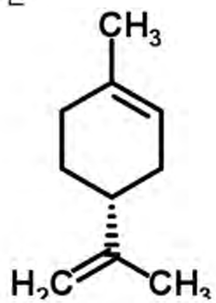
- Peel waste (1 ton) (mc:75-80%) **(11€/ton)**
- Pressing (mc: 30-35%)
- Drying (250 kg) (mc: 10%) → Seeds (10 kg)
- Solid waste (240 kg) (mc: 10%) **(0,4€/kg)**

Pectin and limonene

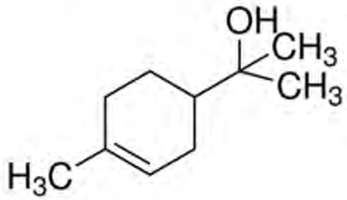


Celulose



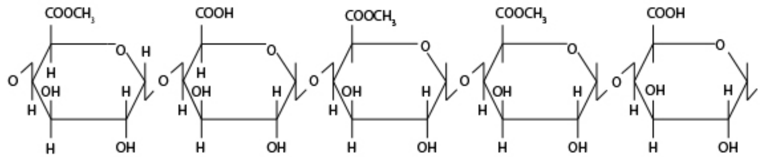


D-limonene



Alfa-terpineol

Pectin

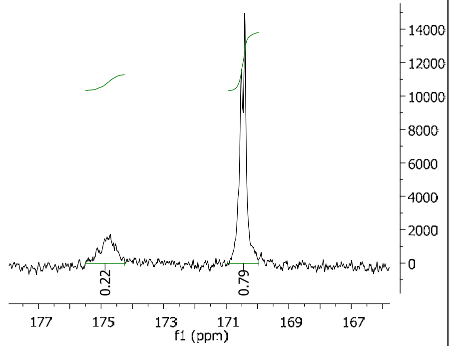


Microwave assisted extraction of pectin from grapefruit

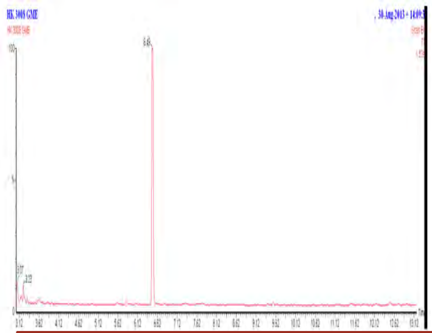
Grapefruit peels

Microwave Extraction
125°C, 15 min

Pectin



Microwave Extraction
300 W, 5 min



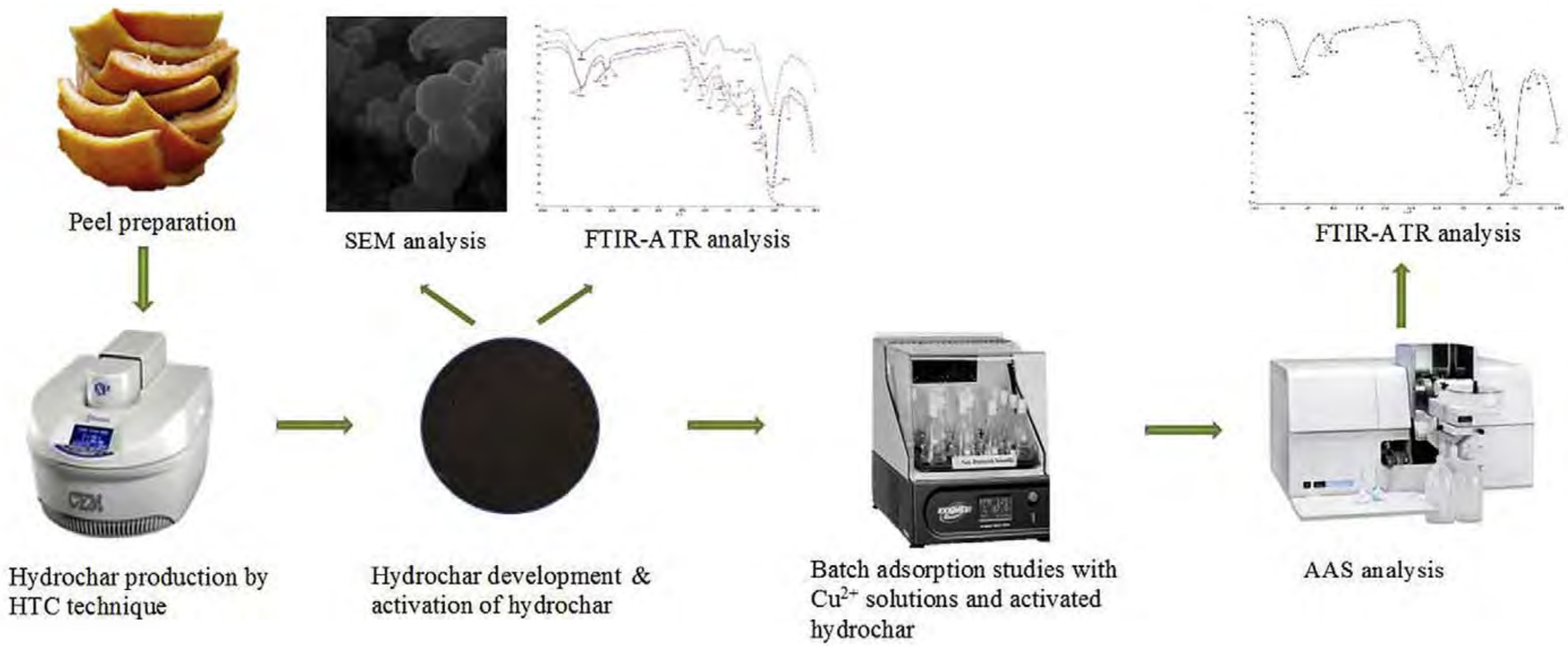
D-Limonene

Pectin yield (21.09 wt.%)
D-Limonen yield (1 wt.%)

(a) (b)

(a) Pectin extracted by conventional method
(b) Pectin extracted by microwave assistance

Carbonaceous material from grapefruit peel with Microwave implemented low temperature HTC



Semercioz, AS.; Gogus, F.; Celekli, A.; Bozkurt, H. (2017). Development of carbonaceous material from grapefruit peel with microwave implemented-low temperature hydrothermal carbonization technique for the adsorption of Cu (II). Journal of Cleaner Production, 165, 599-610.

Pistachio Production By-products

Pistachio

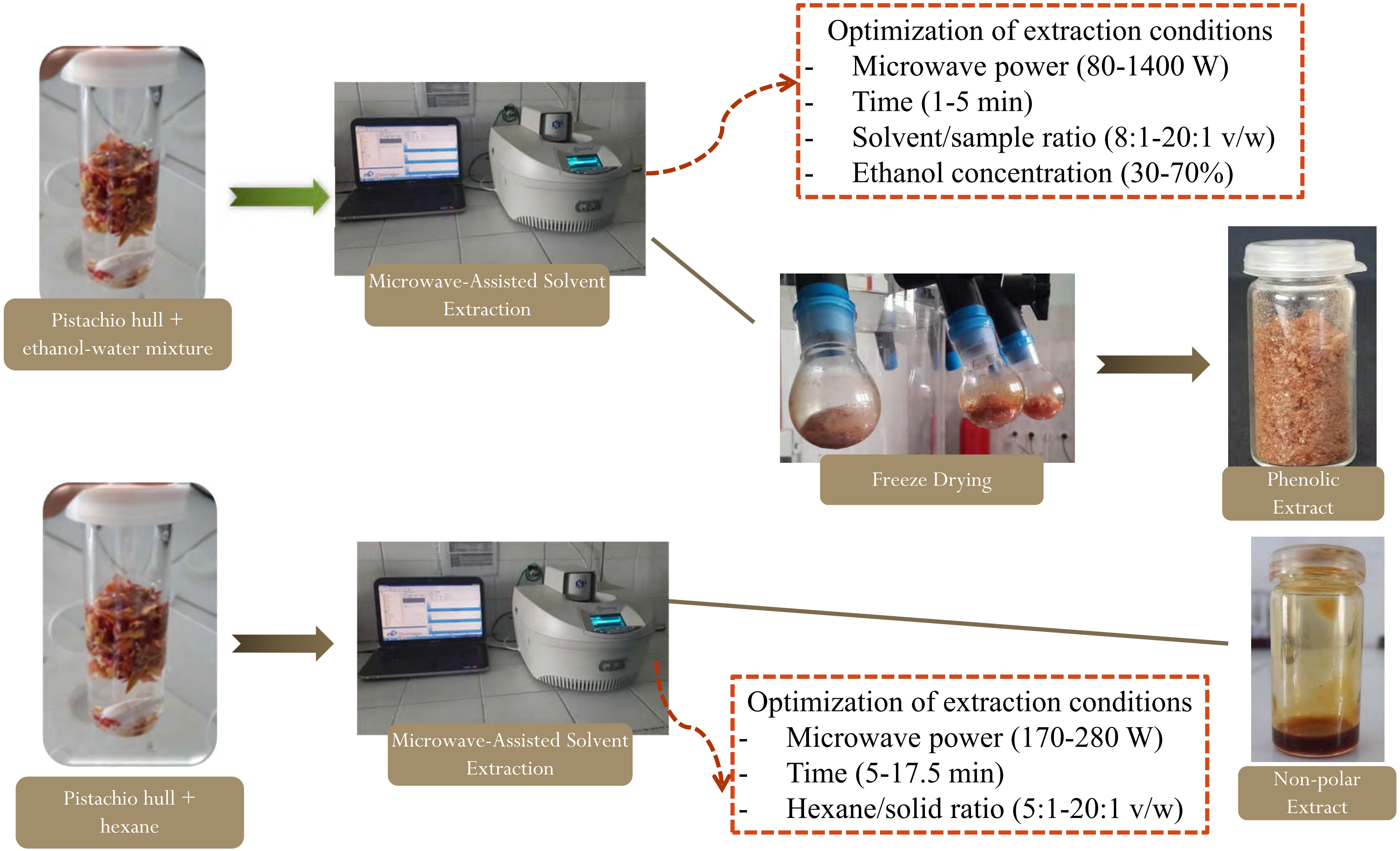
Hull

- protein
- fat
- minerals
- vitamins
- essential oil
- phenolic components

Shell

- Cellulose
- Hemicellulose
- Lignin

❑ Extraction of non polar compounds (Hull)

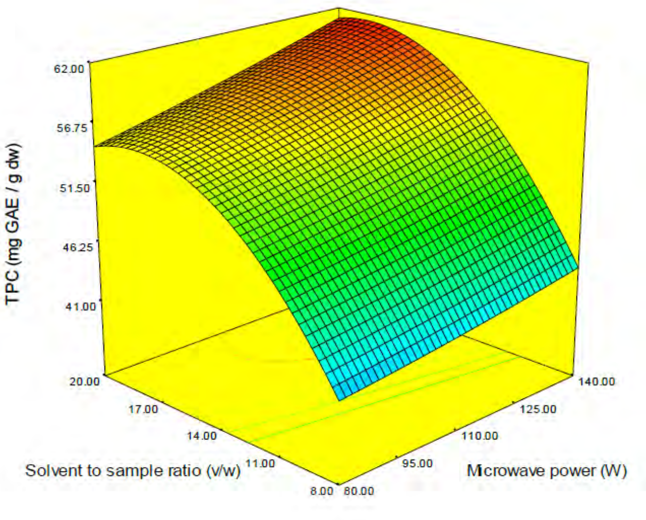


- Özbek, HN; Yanik, DK; Fadiloglu, S; Cavdar, HK; Gogus, F. (2018). Microwave-assisted extraction of non-polar compounds from pistachio hull and characterization of extracts. Grasas y Aceites, 69, e260.

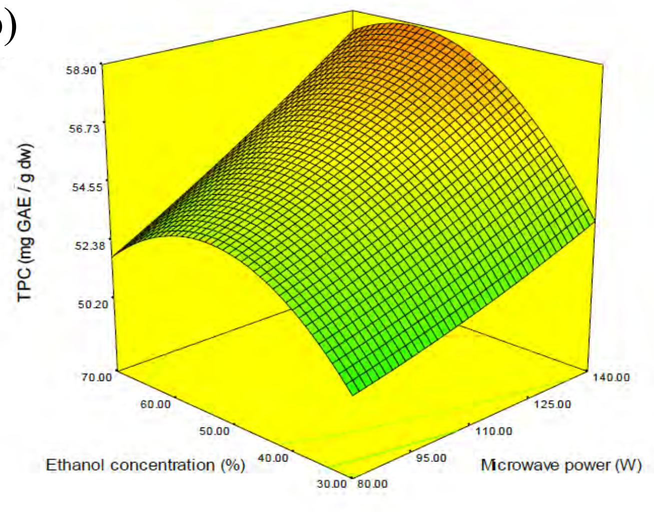
❑ Extraction of Phenolic Compounds (Hull)

Effect of MASE parameters on TPC

a)



b)

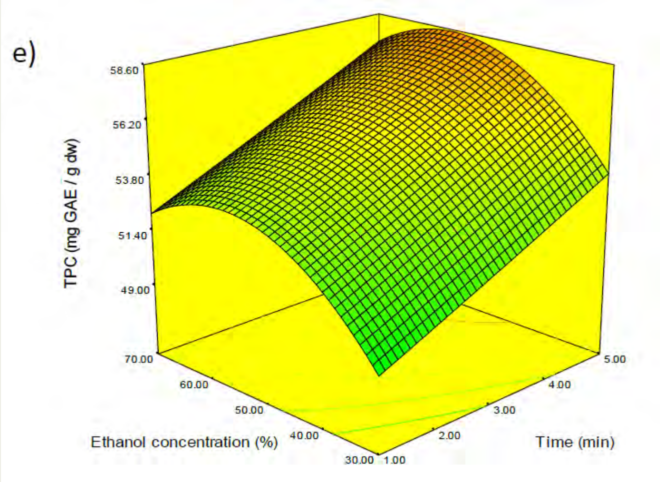


Increase in power results in increased TPC.

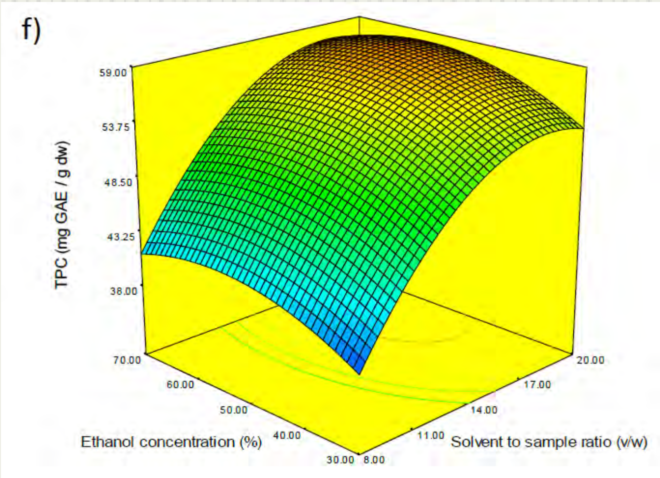
Increase in power → Cell rupture and easier penetration of the solvent into the plant structure → Enhancement in extraction

- Özbek HN, Halahlih, F., Göğüş, F., Yanık, DK., Azaizeh, H. (2019).Pistachio (Pistacia vera L.) Hull as a Potential Source of Phenolic Compounds: Evaluation of Ethanol Water Binary Solvent Extraction on Antioxidant Activity and Phenolic Content of Pistachio Hull Extracts , Online, Waste and Biomass Valorization. DOI : 10.1007/s12649-018-0512-6

Effect of MASE parameters on TPC



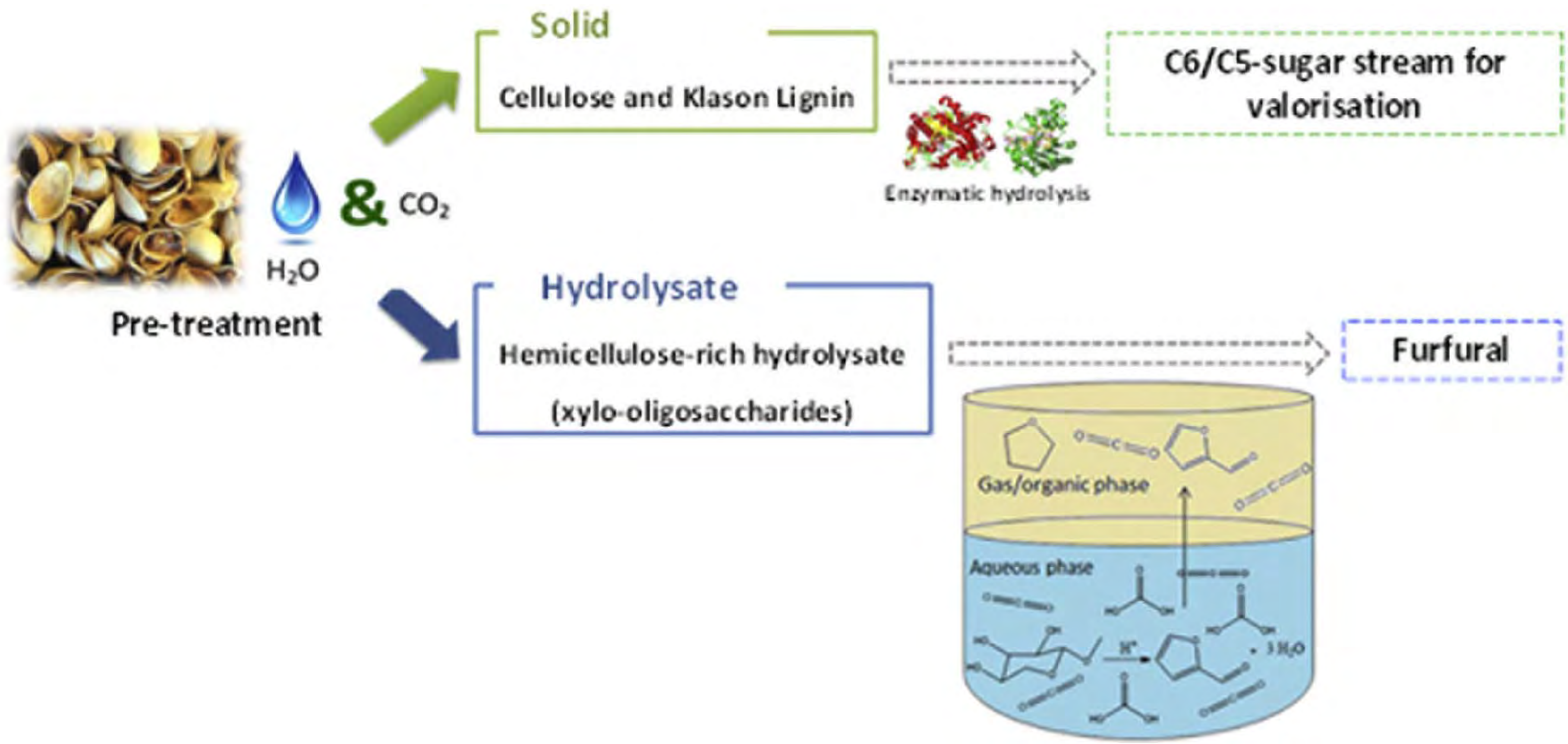
TPC increased with the increasing ethanol concentration up to 56% and then decreased at higher ethanol concentration.



The response value increase with the increase in solvent to sample ratio, but when the ratio exceeded nearly 18 (v/w), the TPC value began to decrease.

- Hatice Neval Özbek, Derya Koçak Yanık, Sibel Fadıloğlu & Fahrettin Göğüş (2019) Optimization of microwave-assisted extraction of bioactive compounds from pistachio (Pistacia vera L.) hull, Online, Separation Science and Technology, DOI: 10.1080/01496395.2019.1577444

❑ valorisation of pistachio shell by high-pressure CO2/H2O system (Shell)



Özbek, HN; Fockink, DH., Yanik, DK; Gogus, F. Lukasik, RM. (2018). The green biorefinery concept for the valorisation of pistachio shell by high-pressure CO2/H2O system. Journal of Cleaner Production, 196, 842-851

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THANK YOU