UNIVERSITÉ D'AVIGNON
ET DES PAYS DE VAUCLUSE
MINISTÈRE DE L'ENSEIGNEMENT SUPÉRIEUR ET DE LA RECHERCHE

INRA
SCIENCE & IMPACT

Valorisation des coproduits agroalimentaires grâce à la bioraffinerie et l'éco-extraction du végétal

S. PERINO, M. TURK et F. CHEMAT

UMR A 408, SQPOV, Equipe GREEN

Université d'Avignon

sandrine.perino@univ-avignon.fr

Groupe de Recherche en Eco-Extraction de produits Naturels (GREEN)

Eco Extraction

adebiotech COPROinov

COPRODUITS

INNOVATIONS ET FILIÈRES, QUELLES SONT LES NOUVELLES STRATÉGIES ?

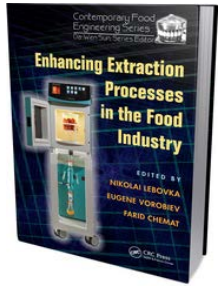
11 & 12 octobre 2016

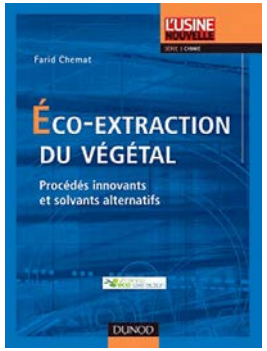
Cité des entreprises de santé et de biotechnologies, BIOCITECH ROMAINVILLE-GRAND PARIS

UNIVERSITÉ D'AVIGNON
UNIVERSITÉ D'AVIGNON ET DES PAYS DE VAUCLUSE

Groupe de Recherche en Eco-Extraction de produits Naturels (GREEN)

Université d'Avignon et des Pays de Vaucluse





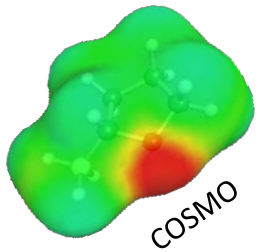
Missions

Green extraction of natural products on lab and pilot scale to approach an optimal consumption of raw materials, solvents and energy:

(1) improvement and optimization of existing processes,
(2) using non-dedicated equipment,
(3) innovation in processes and procedures but also in discovering alternative solvents.

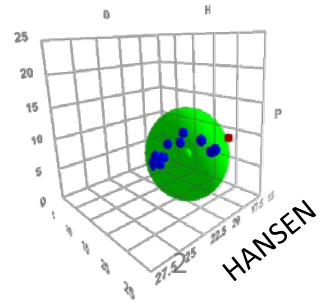
Fields of Application

Cosmetics, food, pharmaceutical, perfumes, biofuel industry……



Equipment

Batch and continuous ultrasonic devices for lab and pilot scale
Lab and pilot microwave ovens. Microwave autoclave
Analysis Techniques : GC/FID, HPLC/DAD, HP-TLC



OUTLINE

PART. 1: CONCEPTS AND PRINCIPLES OF ECO-EXTRACTION OF NATURAL PRODUCTS.

PART. 2: ENRICHMENT OF EDIBLE OIL WITH SEA BUCKTHORN BY-PRODUCTS USING ULTRASOUND ASSISTED EXTRACTION

PART. 3: VALORIZATION OF GINGER BY-PRODUCTS: A BIO-REFINERY CONCEPT

PART. 4: VALORIZATION OF FOOD BY-PRODUCTS

PART. 5: PRODUCTION OF AROMATIC EXTRACTS FROM FRUITS BY-PRODUCTS: NATAROME PROJECT

PART. 1:

CONCEPTS AND PRINCIPLES OF ECO-EXTRACTION OF NATURAL PRODUCTS.

PLANT EXTRACTION

Plant material

HERBS, SPICES
FRUITS, FLOWERS
VEGETABLES, …..

Contact

Filtration

Centrifugation

PERCOLATION
MACERATION
DECOCTION
INFUSION
HYDRODISTILLATION
….

Plant Extract

COSMETICS
FOOD
FRAGRANCES
*PHARMACE*UTICAL,….

Extraction of Natural Products: Industrial Problems

- Extraction time
- Problems of degradation
- Energy cost
- « Batch » Extraction
- Use of solvents from fossil resources
- Need for new products
- Reduction of waste: solid and liquid

Request from Industry : Room temperature, rapid extraction, without solvent or water, eliminate wastes, continuous process, and competitive in price and quality.

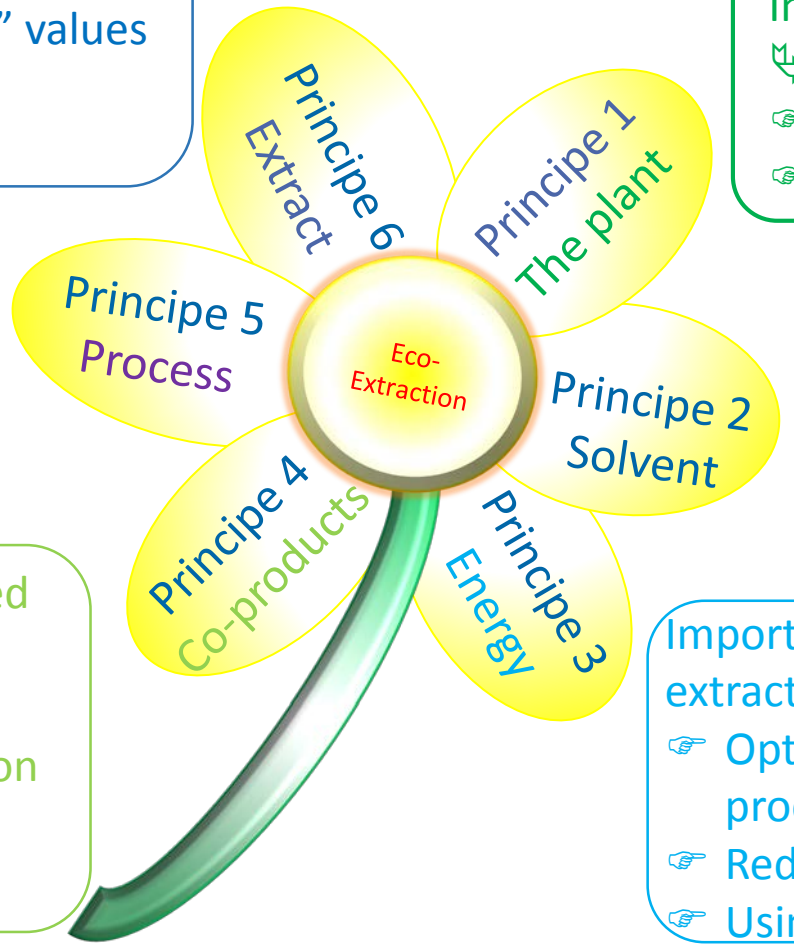
Green Extraction

Six Principles of Green Extraction

Contaminated extracts, not comply with the regulations
☞ Obtain a non-denatured and bio-degradable extract with “green” values instead of contaminants

Old methods, expensive process…
☞ Reduce operation units
☞ Safe, robust and controlled processes

Large quantity of residues generated by the extraction
Valorisation of those co-products:
☞ Identification and characterization
☞ Harvest conditions
☞ Valorisation opportunities



Intensive extraction
↳Overexploitation of plant resources
☞ Towards renewable resources,
☞ Varietal selection.

⇨Massive use of petro-chemical solvents
⇨ Set up of REACH

Important energy consumption linked to the extraction
☞ Optimisation and/ or assistance of existing processes,
☞ Reduce energy consumption,
☞ Using innovative technologies.

PARTIE 2:ENRICHMENT OF EDIBLE OIL WITH SEA BUCKTHORN BY-PRODUCTS USING ULTRASOUND ASSISTED EXTRACTION

Eur. J. Lipid Sci. Technol. 2012, 114, 453-460.

Research Article

Enrichment of edible-oil with sea buckthorn by-products using ultrasound-assisted extraction

Farid Chemat[1], Sandrine Périno-Issartier[1], Lynda Loucif[1], Mohamed Elmaataoui[1] and Timothy J. Mason[2]

Context

Processing of sea buckthorn berries

Whole fruits

Hydraulic Press

Presse cake with residual carotenoids

Enrichment in residual carotenoids of sunflower oil : to produce a high-value oil

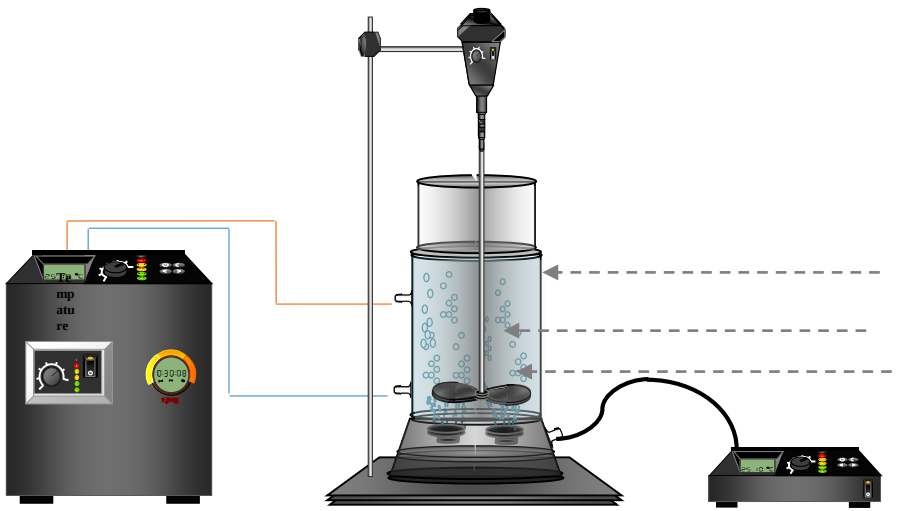
Ultrasound assisted extraction (UAE)

- **Design of experiment – Central Composite Face-Centered design**
  - Study of ultrasonic intensity and temperature

    -To improve the direct enrichment of edible oil with SBT carotenoids

    -To determine the optimal conditions of UAE.

OPTIMUM
Power : 0.67 $W.g^{-1}$, Temperature : 40 °C



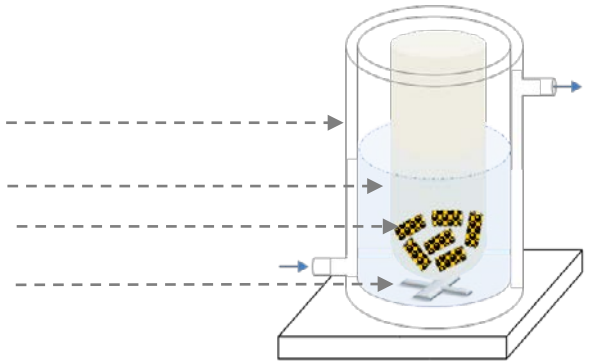
Ultrasound-assisted extraction

Thermostated reactor

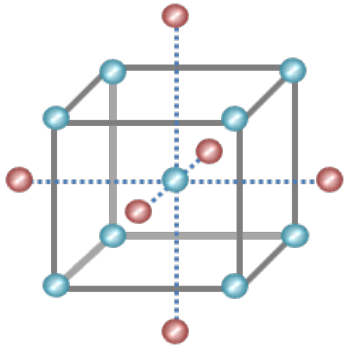
Oil

SBT by-product

Magnetic stirred



Conventional extraction

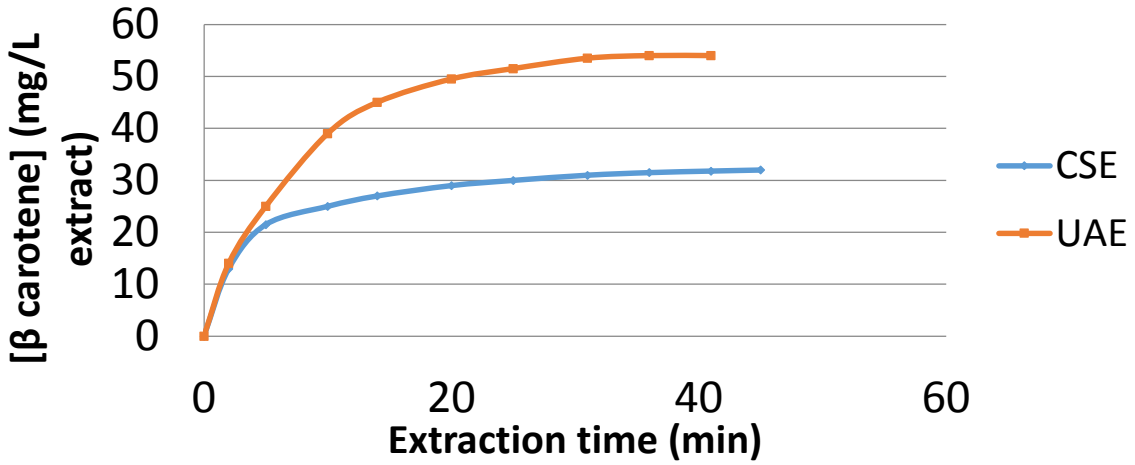


Response :

- Carotenoids content

Conventional process intensification using Ultrasound

Extraction kinetics of SBT by-products with and without US



	CSE	UAE
β-carotene (mg/L extrait)	14,58	18,06
Caroténoïdes totaux (mg/L extrait)	52,65	63,84
Temps d'extraction(min)	120	30

Extraction of β-carotene was enhanced by the procedure as shown in this table.

PART 3: VALORIZATION OF GINGER BY-PRODUCTS: A BIO-REFINERY CONCEPT

Green Chemistry

PAPER

CrossMark click for updates

Cite this: *Green Chem.*, 2016, **18**, 3106

Towards a "dry" bio-refinery without solvents or added water using microwaves and ultrasound for total valorization of fruit and vegetable by-products

M. Jacotet-Navarro,[a,b,c] N. Rombaut,[a,b] S. Deslis,[a,b] A.-S. Fabiano-Tixier,[a,b] F.-X. Pierre,[c] A. Bily[b,c] and F. Chemat*[a,b]

Context

- Ginger production in 2015: 2,140,451 t (*FAOSTAT 2015*)
- Valorization of press cakes considered as waste in high valued compounds

Fresh ginger rhizomes

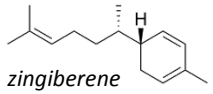
Juice processing

Ginger press cake

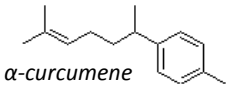
Ginger juice

Ginger press cake

Essential oil

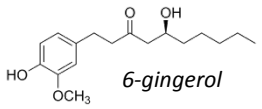


zingiberene

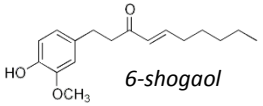


α-curcumene

Phenolics

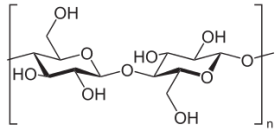


6-gingerol



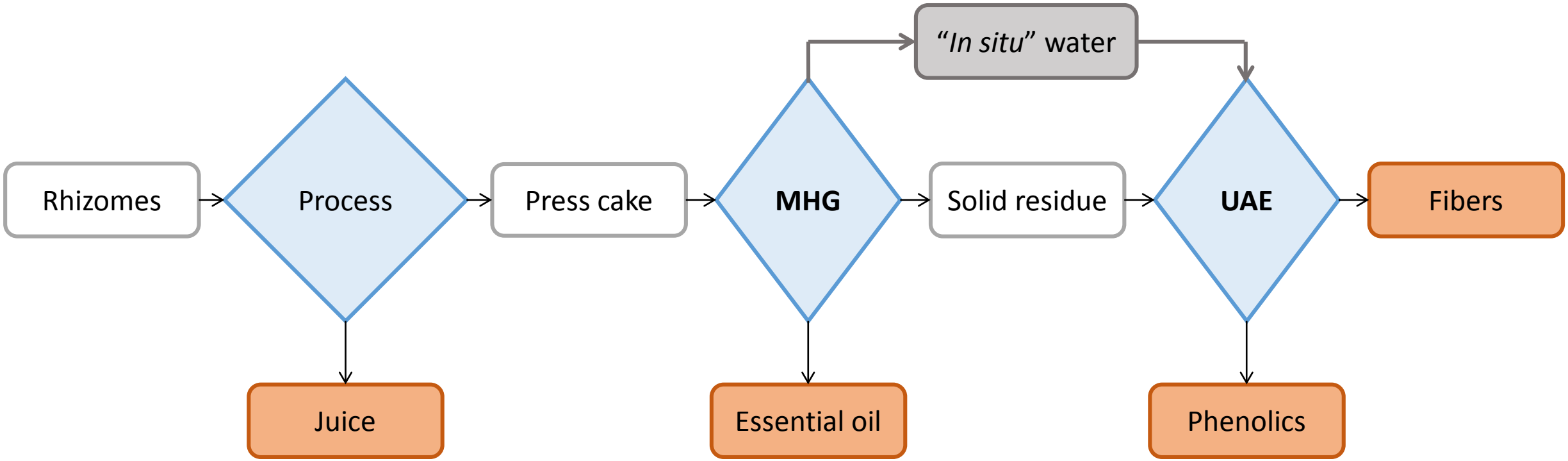
6-shogaol

Fibers



Concept developed in the study

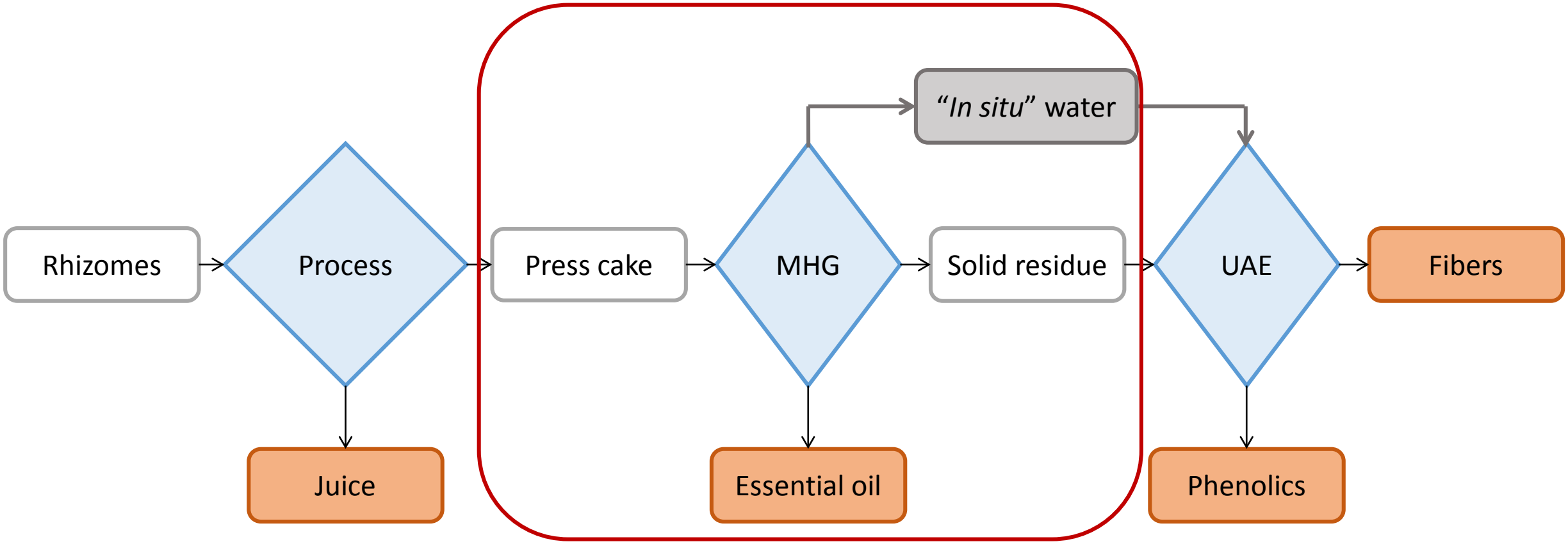
- Ask from industry: rapid, cold and organic solvent-free extraction to obtain high quality product, competitiveness



MHG: Microwave Hydrodiffusion and Gravity
UAE: Ultrasound Assisted Extraction

→ A "dry" bio-refinery concept

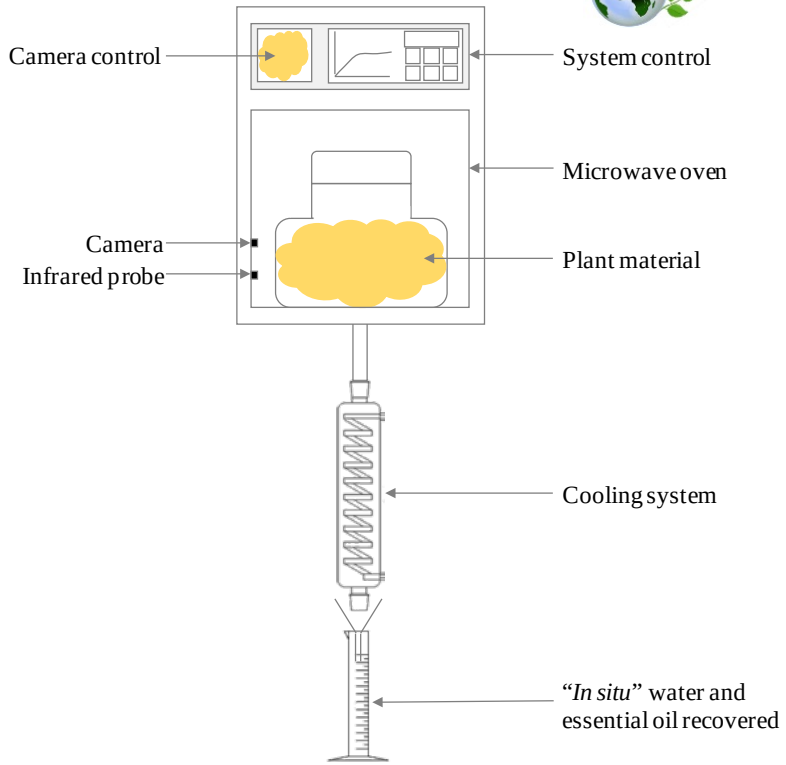
1st step: Microwave Hydrodifffusion and Gravity (MHG)

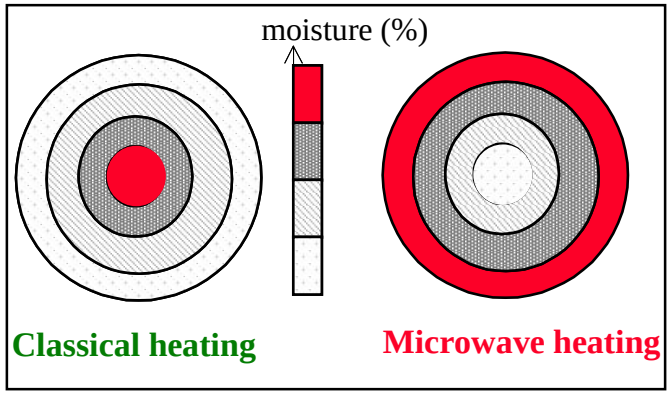


OPTIMIZATION OF MICROWAVE (MW) POWER

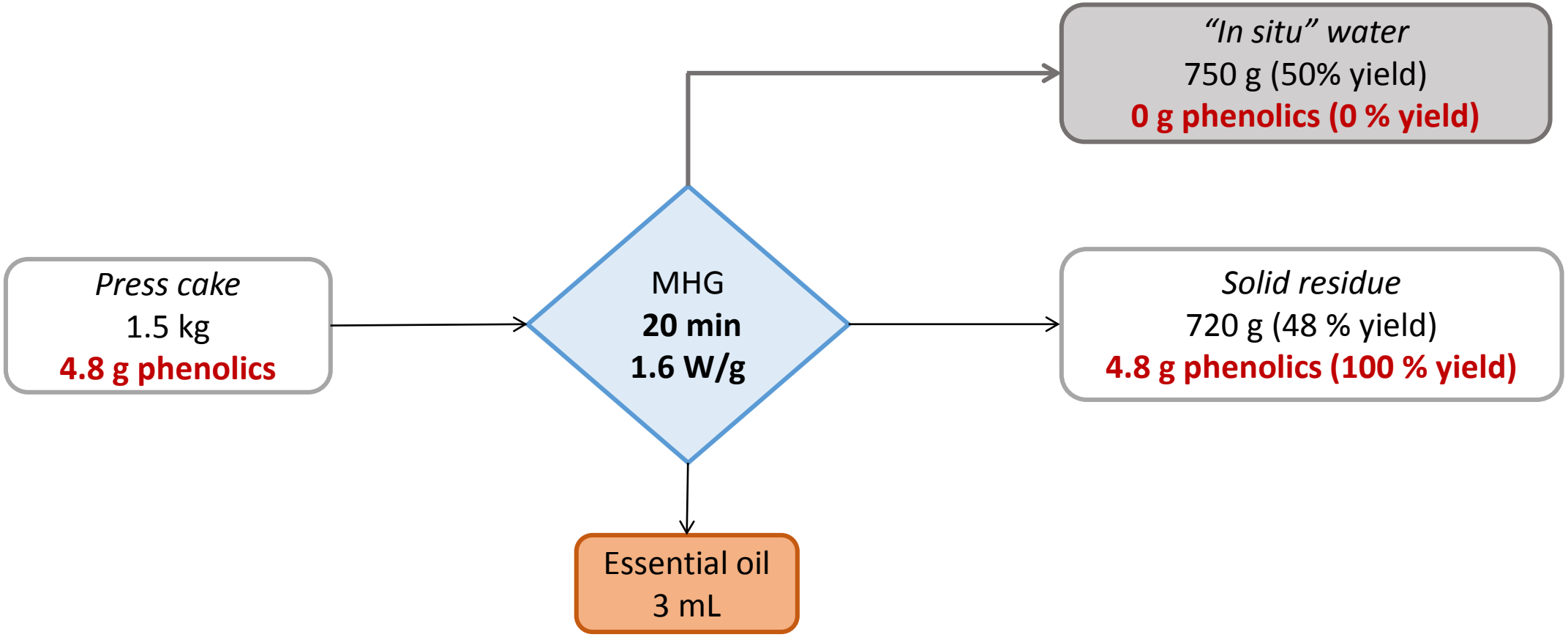
Microwave Hydrodiffusion and Gravity (MHG)

Patented Chemat et al., 2008

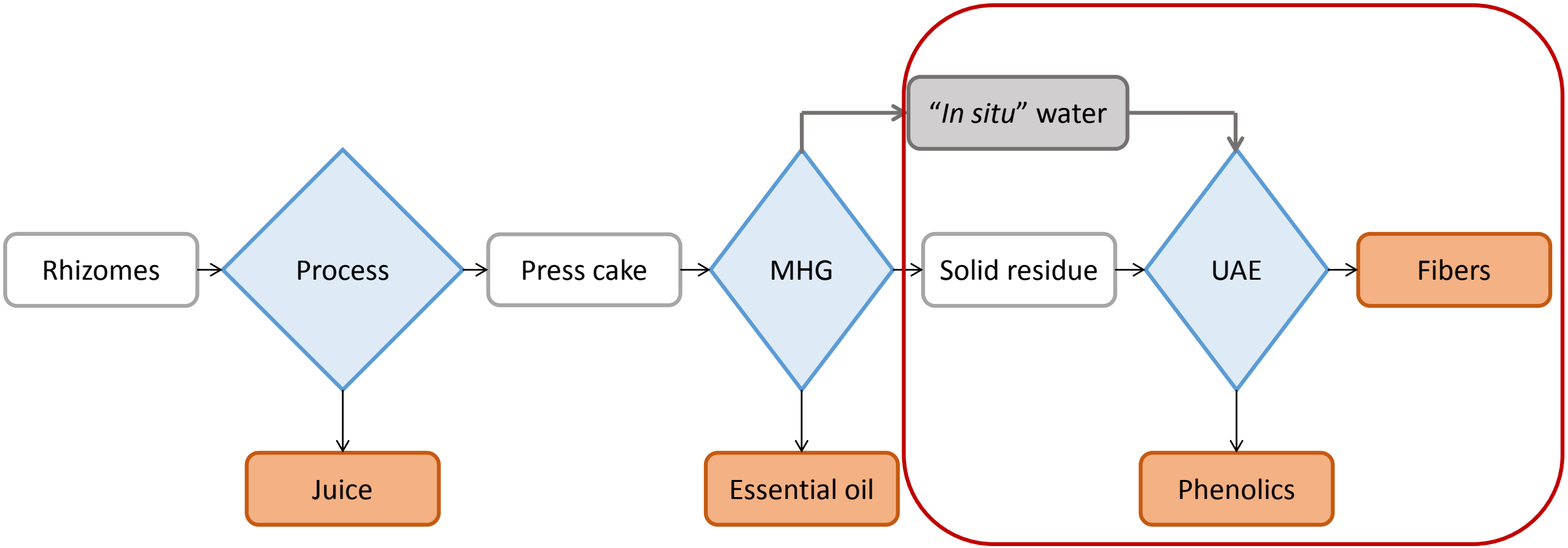




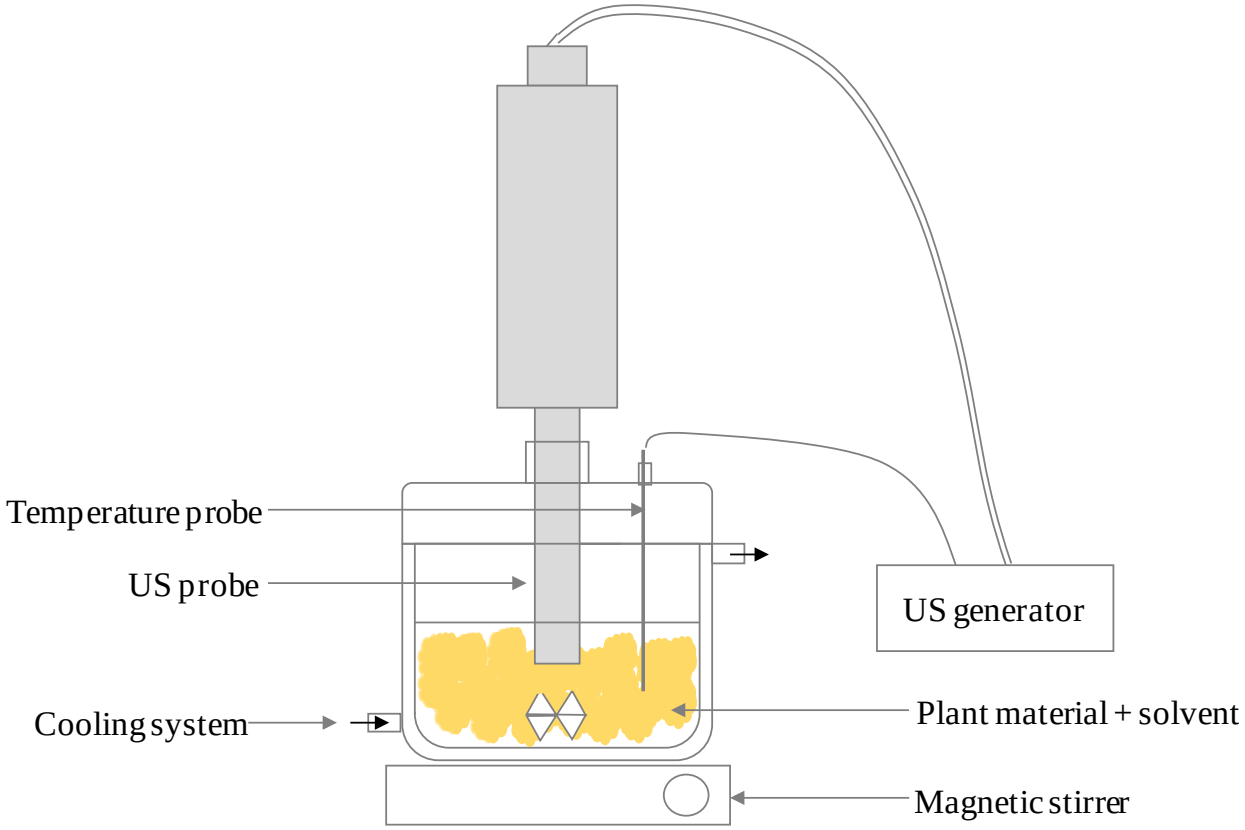
1st step: MHG assessment



2nd step: Ultrasound Assisted Extraction (UAE)



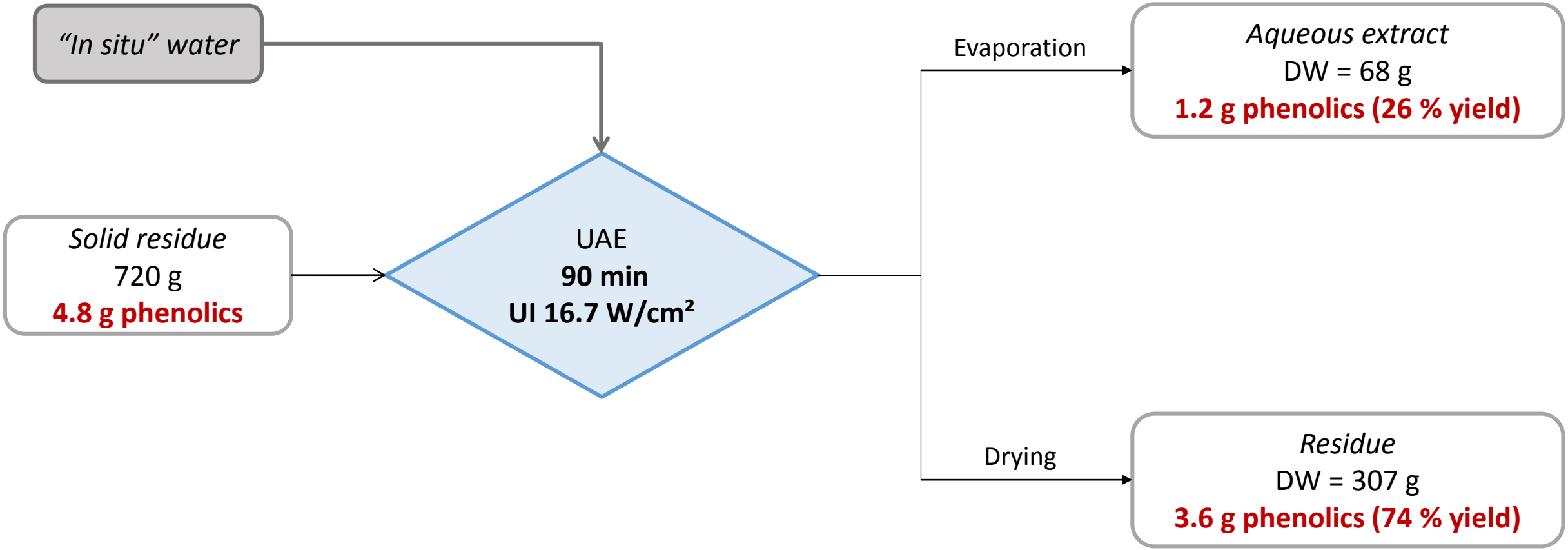
Ultrasound Assisted Extraction (UAE)



From 3 to 500 L

- Effect of ultrasonic intensity on **extraction yield** assessed (from 4.4 W/cm² to 16.7 W/cm²)
- Reference: conventional maceration (CM)

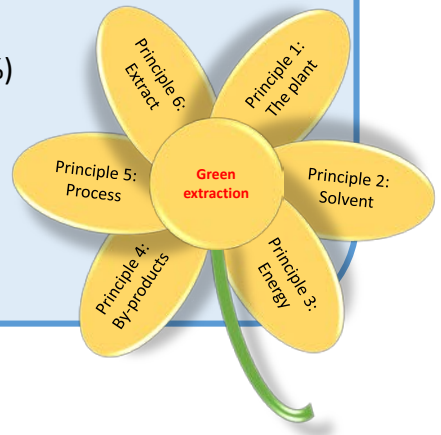
2nd step: UAE assessment

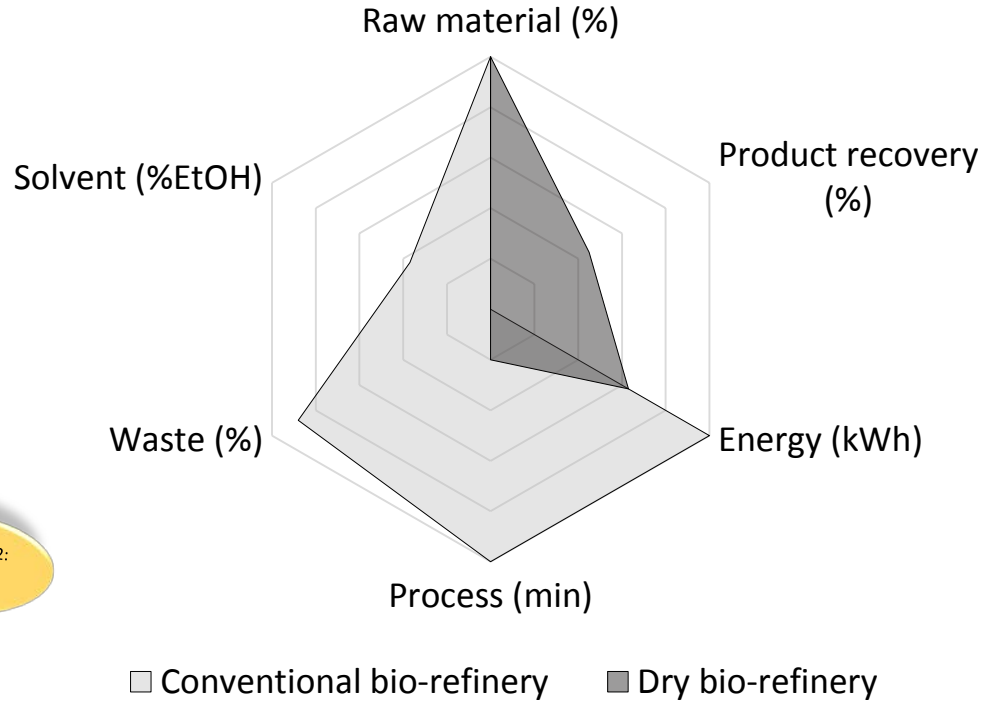


Process assessment of “dry” and conventional bio-refineries

→ Evaluation according to the six principles of eco-extraction

- **Raw material** (*principle 1*): % of valorized raw material from food processing industry
- **Solvent** (*principle 2*): $\frac{\text{mass ethanol}}{\text{total mass of solvent used in the bio-refinery}}$ (%)
- **Energy** (*principle 3*): energy consumption for the bio-refinery of 1.150 kg of raw material (extraction and evaporation steps) (kWh)
- **Waste** (*principle 4*): $\frac{\text{mass waste}}{\text{total mass of solvent +raw material used in the process}}$ (%)
- **Process** (*principle 5*): extraction duration for the bio-refinery (min)
- **Product recovery** (*Principle 6*): $\frac{\text{mass of final product recovered}}{\text{mass of available product in the plant material}}$



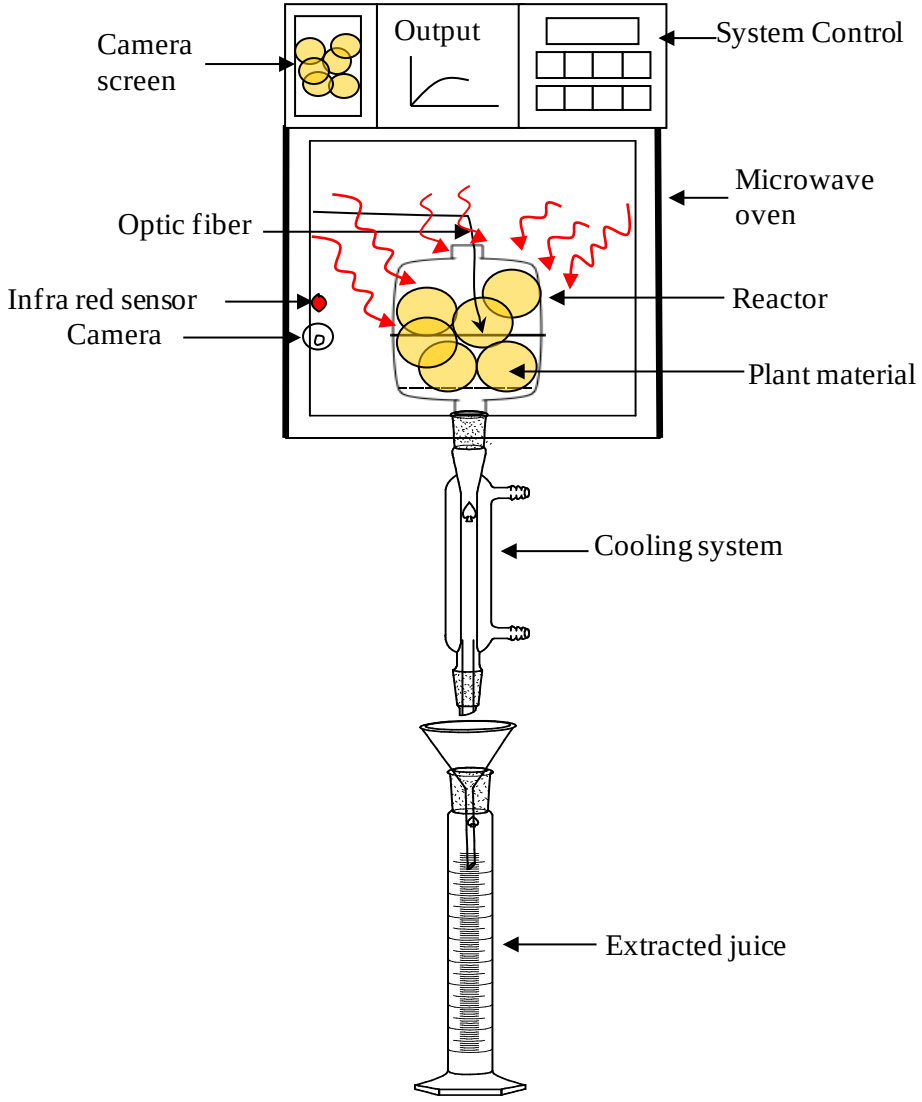


Conventional bio-refinery: hydrodistillation + ethanolic extraction
“Dry” bio-refinery: MHG + UAE

→ Reduction of footprint with the “dry” bio-refinery

PART 4: VALORIZATION OF FOOD BY-PRODUCTS

Valorisation of food by products (lettuce) using microwave energy



Food Chemistry 204 (2016) 108–114

Contents lists available at ScienceDirect

Food Chemistry

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

Laboratory to pilot scale: Microwave extraction for polyphenols lettuce

Sandrine Périno [a,*], Jean T. Pierson [a], Karine Ruiz [a], Giancarlo Cravotto [b], Farid Chemat [a]

[a] Université d'Avignon et des Pays du Vaucluse, INRA, UMR408, GREEN Extraction Team, F-84000 Avignon, France
[b] Dipartimento di Scienza e Tecnologia del Farmaco, Università di Torino, Via P. Giuria 9, 10125 Torino, Italy

An innovative grape juice enriched in polyphenols by microwave-assisted extraction

Food Chemistry 141 (2013) 3268–3272

Contents lists available at SciVerse ScienceDirect

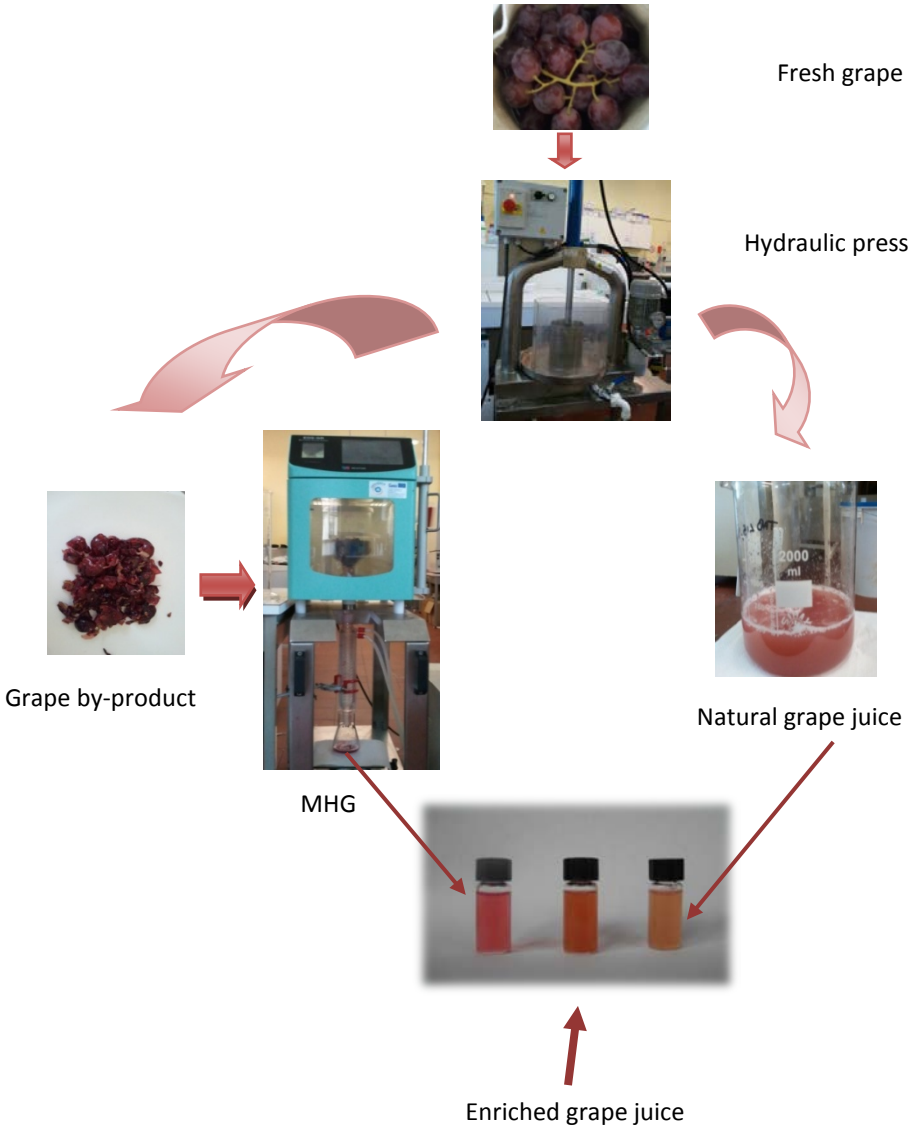
Food Chemistry

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

An innovative grape juice enriched in polyphenols by microwave-assisted extraction

Sheiraz Al Bittar, Sandrine Périno-Issartier *, Olivier Dangles, Farid Chemat

Université d'Avignon et des Pays de Vaucluse, INRA, UMR408, 84000 Avignon, France



Flavoring vegetable oils by microwave

Flavor + olive oil → MW → Flavored oil

Part 5: Production of aromatic extracts from fruits by-products:

Natarome project (2015-2019)

NATAROME+

Natarome project

- Develop new intermediate food products "clean label" that integrate technology functions previously made by the additives (flavors, textures and color)

- 5 Industrial partners:

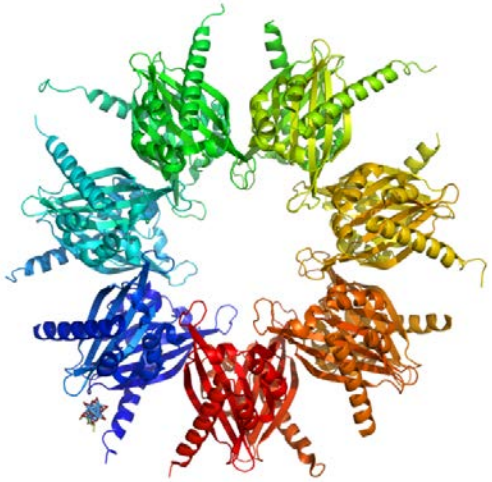
- 2 Academic partners

- Duration: 42 months
- Budget: 2,6 M€
- Consequences: 12 M€ turnover by 2019 and over 63 million after 5 years of operation
- 35 direct jobs in France

NATAROME+

Natarome project

+



Enzyme

Eco-Extraction

Jam

Fruit drink

Flavored yoghurt

Ice

Thank you for your attention