Influence of antioxidant location on the protection of oil encapsulated in powder

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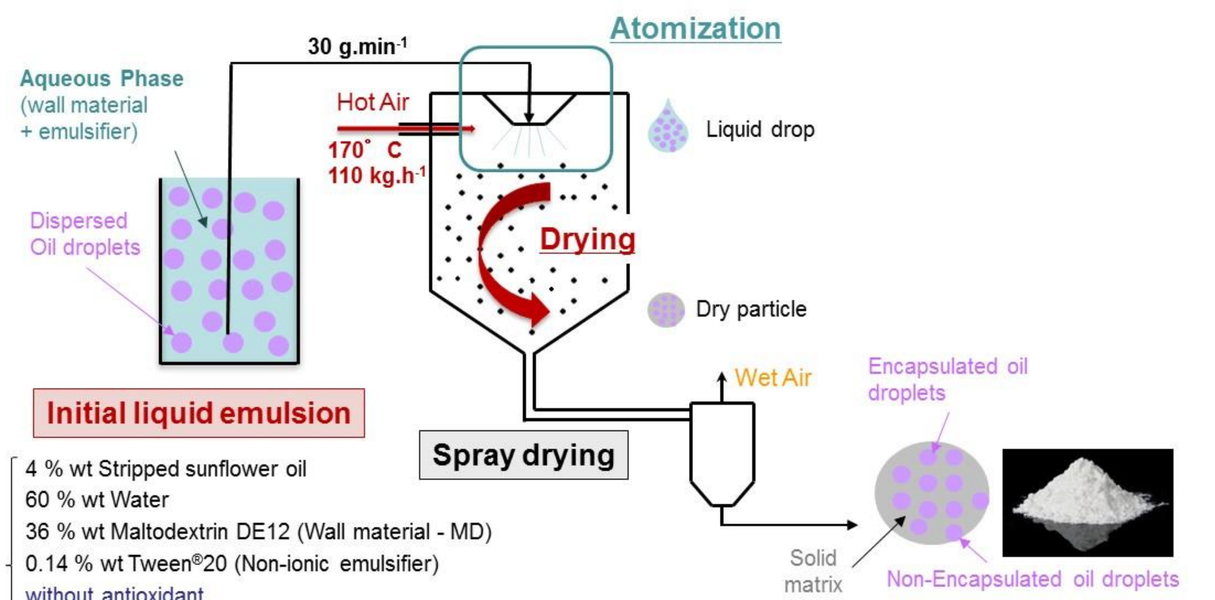
The encapsulation of Poly Unsaturated Fatty Acids (PUFAs) in a solid matrix is used to prevent or delay their degradation by providing a physical barrier against the environment. The addition of antioxidant in the formulation is expected to enhance PUFAs oxidative stability.
In liquid emulsions, the effectiveness of antioxidants is known to depend on their distribution between the oil and aqueous phase.
In this study, the impact of the lipophilic or hydrophilic character of phenolic antioxidants on the oxidative stability of encapsulated PUFAs was investigated following the evolution of conjugated dienes and antioxidant residual content during accelerated ageing test.

Materials & Methods

PUFAs encapsulation by spray drying emulsions at pilot scale



4 % wt Stripped sunflower oil
60 % wt Water
36 % wt Maltodextrin DE12 (Wall material - MD)
0.14 % wt Tween®20 (Non-ionic emulsifier)
without antioxidant
or with α-Tocopherol (500 ppm//oil)
or with Chlorogenic acid (1000 ppm//MD)

Homogenization

Rotor-stator (16,000 rpm, 3 min)
+
High pressure (300 bar, 2 stages)

d_{50} ~ 1 µm
(Monomodal)

Dry emulsion

10 % wt Sunflower oil
90 % wt Maltodextrin DE12
0.35 % wt Tween®20
± AO

3 Powders

Powder	Antioxidant
P0L	-
PαL	α-Tocopherol
PCL	Chlorogenic acid

Physico-chemical characterization of powders and initial and reconstituted emulsions

***Size and size distribution*:** Laser light diffraction (MasterSizer 2000, Malvern, Fr) wet and dry mode for emulsions and powders respectively.

***Particle morphology*:** Scanning Electron Microscope (Quanta 200, FEI, US) under low vacuum (0.6 Torr) and 20 kV accelerating voltage + breakage for inner microstructure.

Ageing test

- **Accelerated thermo-oxidation conditions** : 60°C, 50% RH
- 30 g powder distributed in 3 open vessels (3 samples/analysis)
- Regular sampling (> 20 days)

Climatic chamber

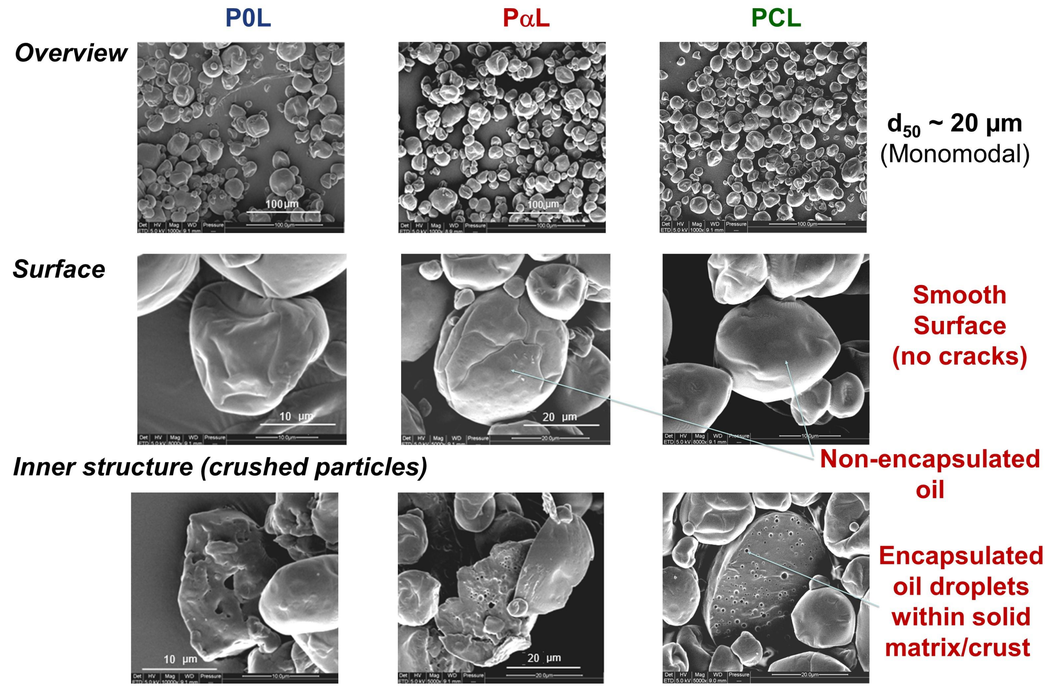
Oil oxidative stability & antioxidant content

Conjugated dienes content - Primary oxidation products
- Extraction of oil-organic phase as described in [1].
- Measurement of Specific Absorbance SA by UV spectrophotometry at 234 nm *(Standard ISO 3656/2011)*
- *Calculation of* Specific Absorbance variation ΔSA = SA(t) – SA(0)

α-tocopherol or chlorogenic acid content
High Pressure Liquid Chromatography as described in *[1]*.

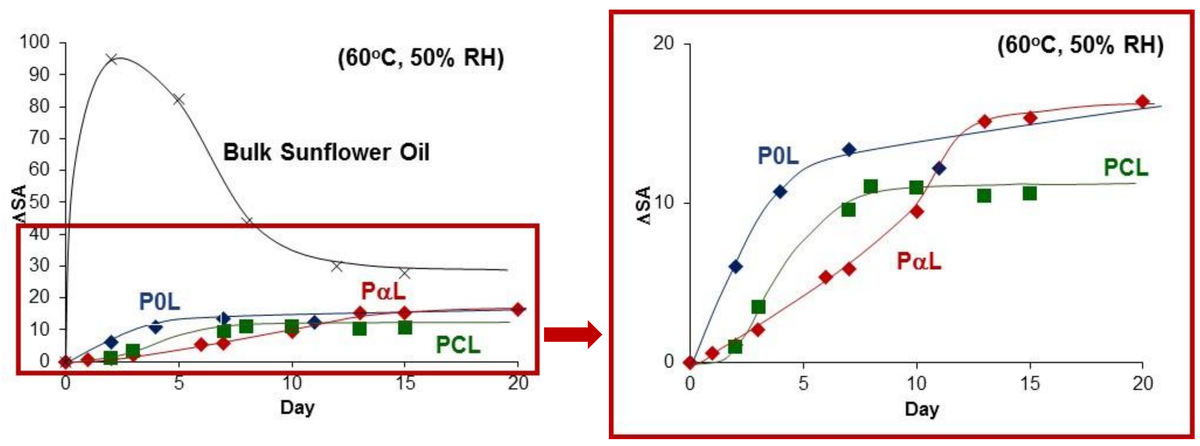
Results & Discussion

Particle morphology & microstructure



d_{50} ~ 20 µm
(Monomodal)

Evolution of Conjugated Dienes production (ΔSA) and antioxidant content (residual %) during accelerated ageing test

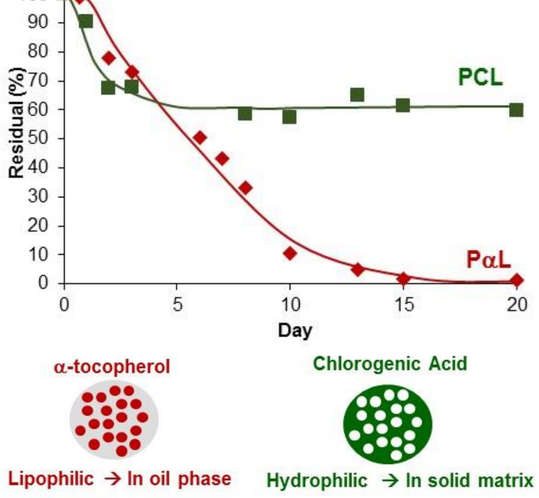


✓**Lower oil oxidation in powder than in bulk**

✓**Beginning of oil oxidation in powders**
- Delayed ~ 2 days with chlorogenic acid
- Slowed down with α-tocopherol

➢ **Oil protection**
α-tocopherol more efficient than chlorogenic acid during the 10 first days of ageing

✓ **Antioxidant consumption in powders**
- Only 40% of chlorogenic acid consumed rapidly during the 2 day lag phase
- α-tocopherol consumed progressively within ~10 days bringing oil protection



→ Antioxidant efficiency depends on its distribution within the different macro-domains of the dry emulsion
→ Large fraction of chlorogenic acid has been preserved in the solid matrix / appeared not efficient for oil protection

Conclusion & Perspectives

Oil encapsulation in powder by spray drying reduced its oxidation rate.

Oil protection was improved when an antioxidant was added, but the antioxidant must be chosen taking into account its polarity and partition between the oil and solid phases:

Lipophilic α-tocopherol located in oil droplets was directly in contact with the oil allowing to slow down its oxidation, whilst for hydrophilic chlorogenic acid, entrapped within the solid matrix, only the small fraction in contact with the oil droplets brought protection.

As a consequence, α-tocopherol was totally consumed whilst chlorogenic acid was partially preserved.

The actual location of both antioxidant within the different phases of the dry emulsion still has to be checked. The combination of both lipophilic and hydrophilic antioxidants could provide complementary effects regarding oil protection.

References

[1]. *Hernandez-Sanchez et al., Food Res. Int., 2016*

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32nd EFFoST International Conference
Nantes, France
6-8 November 2018

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