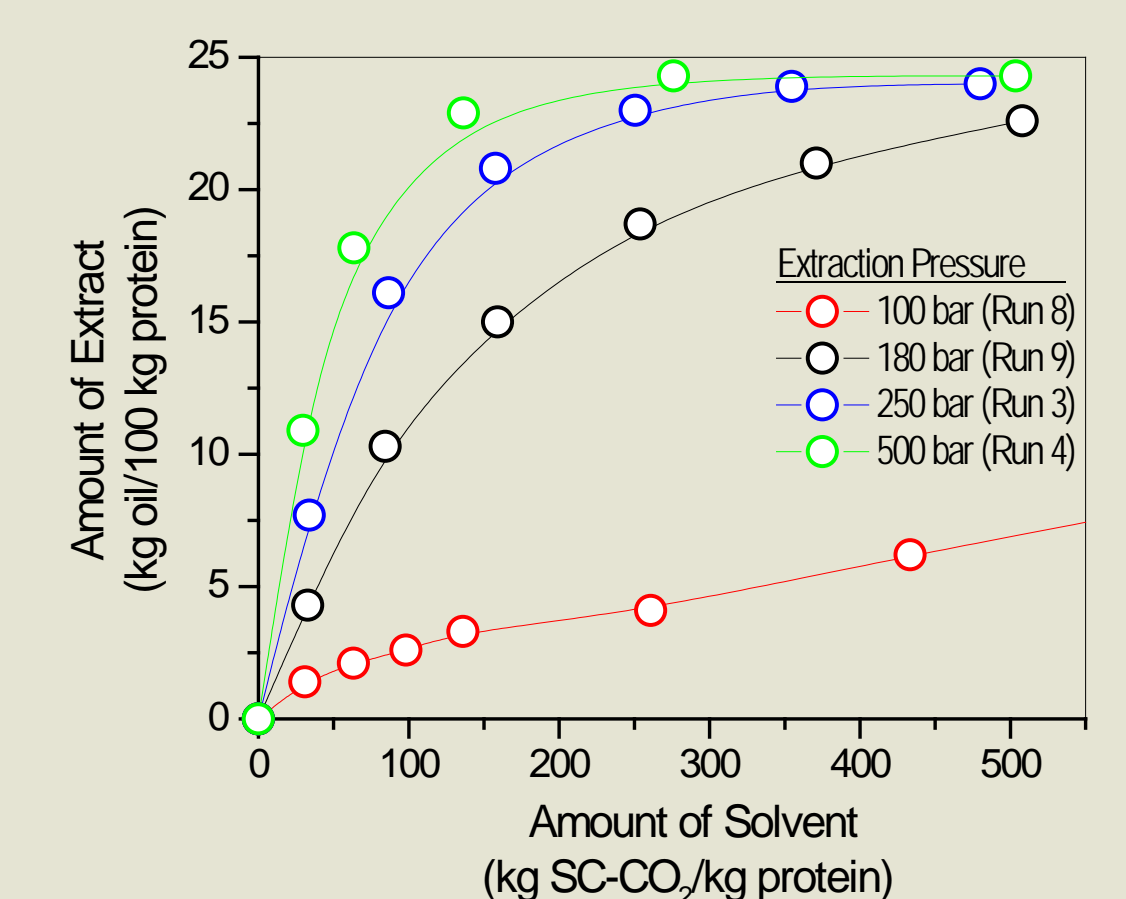
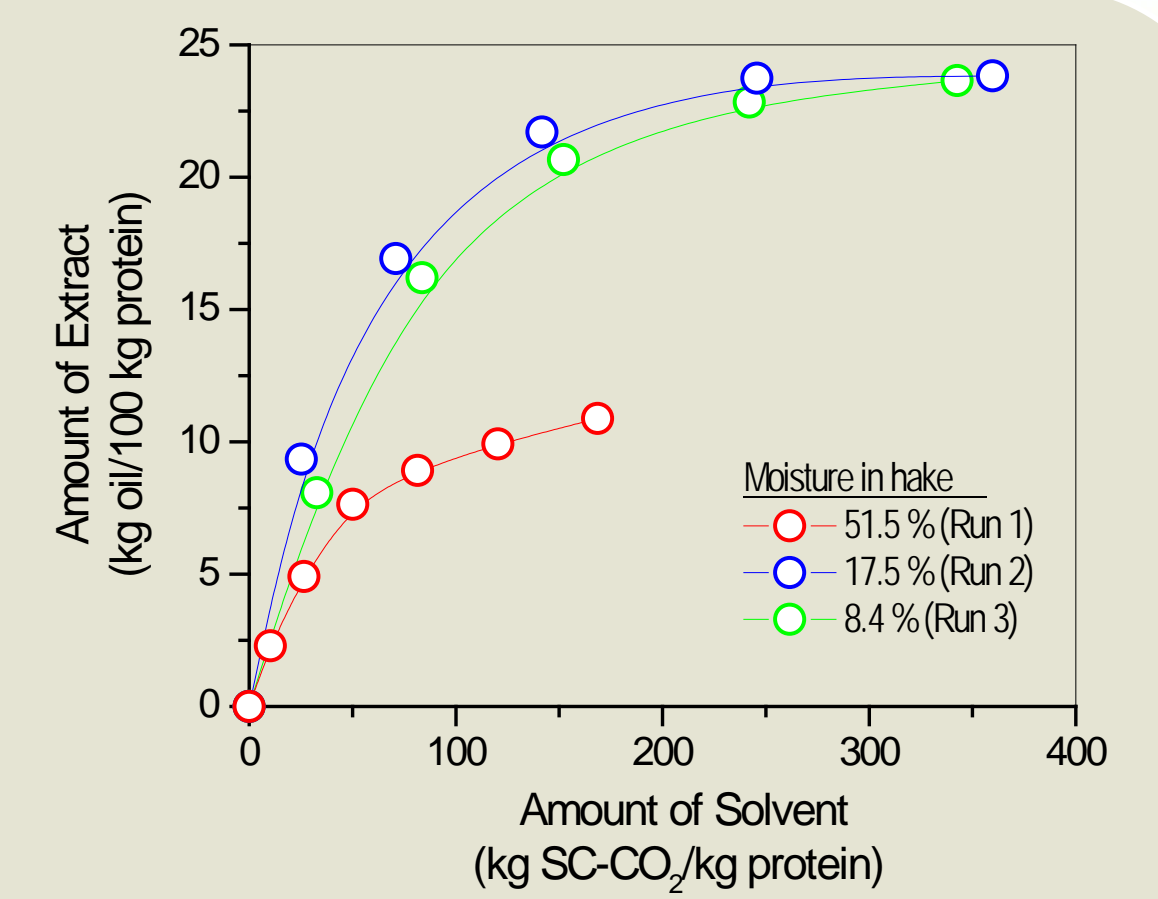
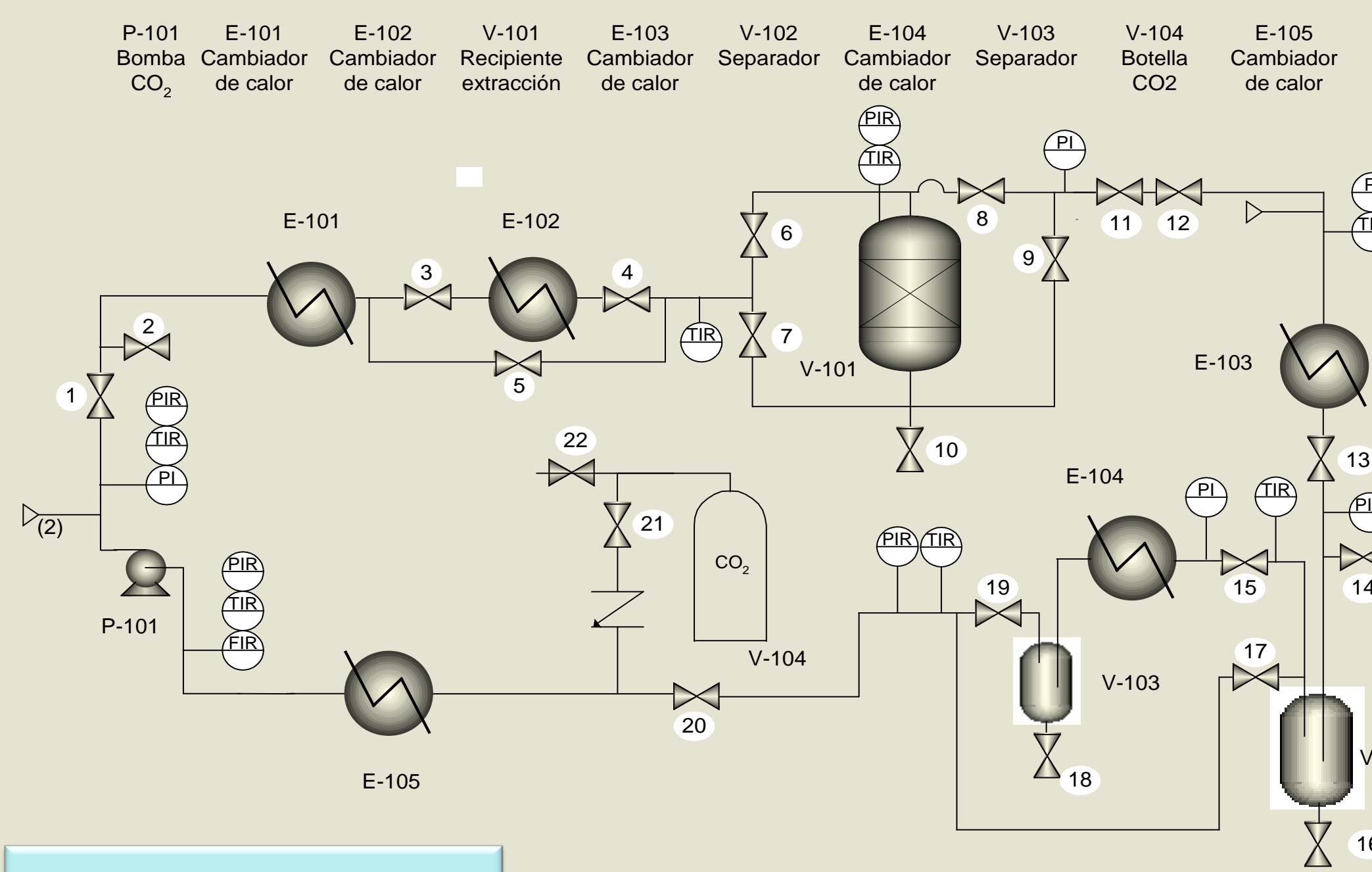


Extraction of oil from fish products or by-products or algae using supercritical carbon dioxide (scCO₂) (1-2)

- Inert atmosphere that prevents oil oxidation
- Organic solvents are avoided
- Possibility of fractionation to lower acidity
- No phospholipids extracted
- Lower temperatures than conventional methods

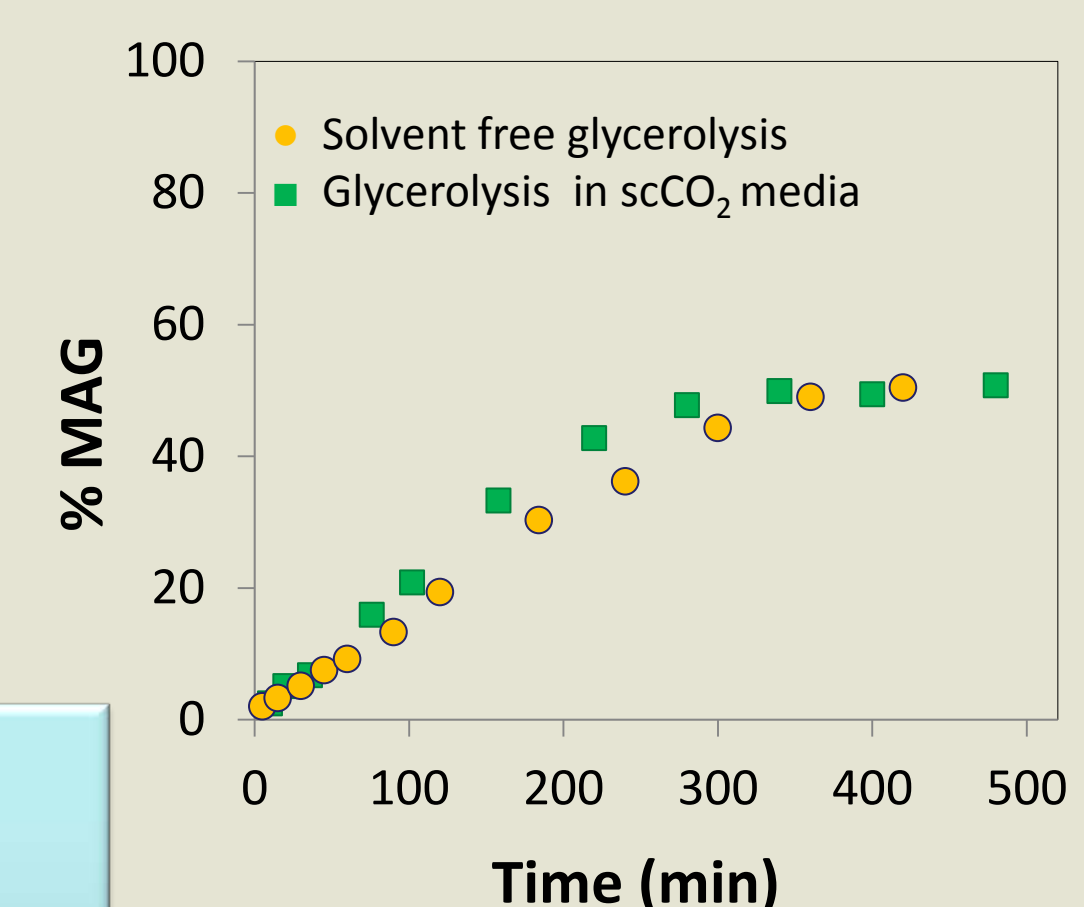
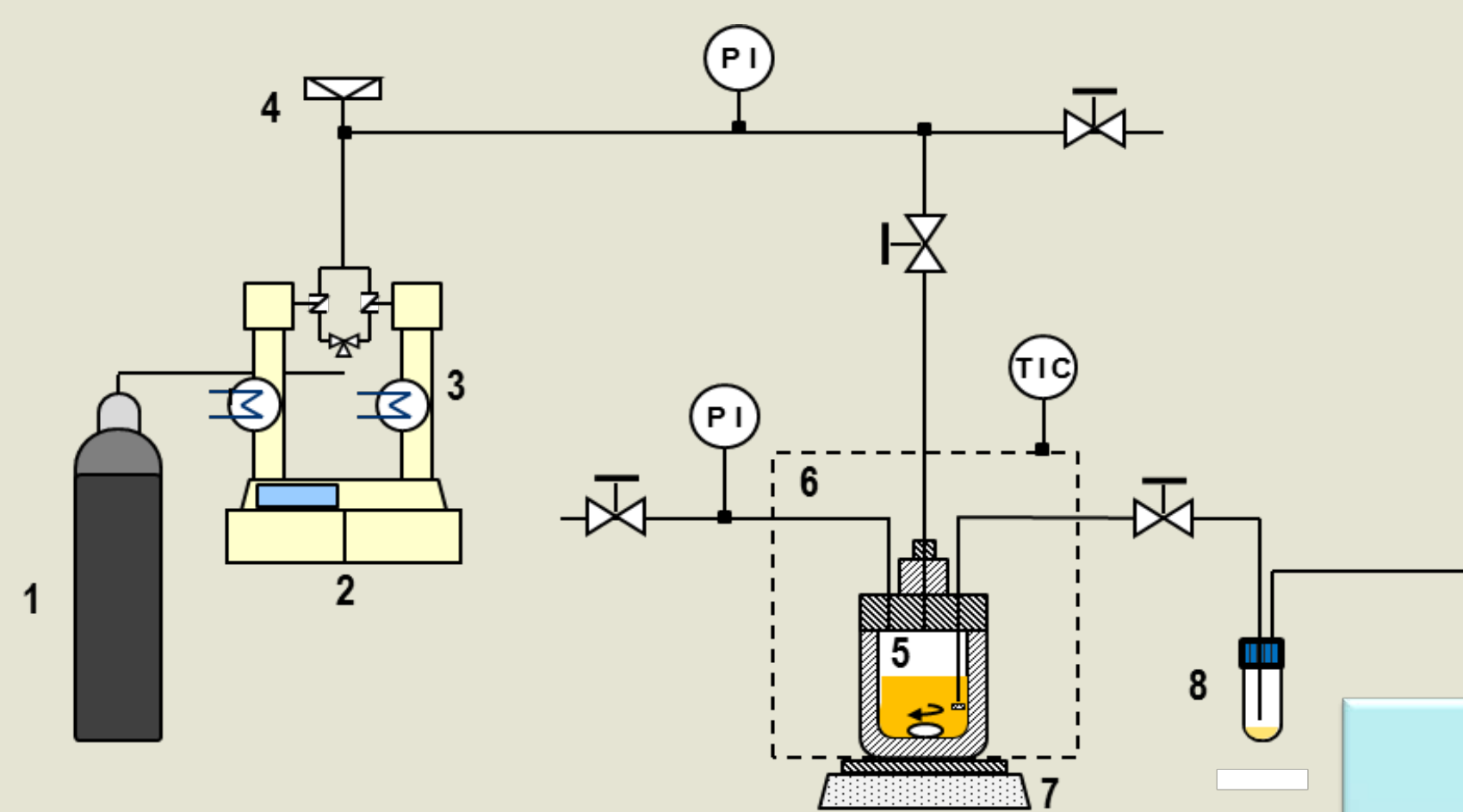
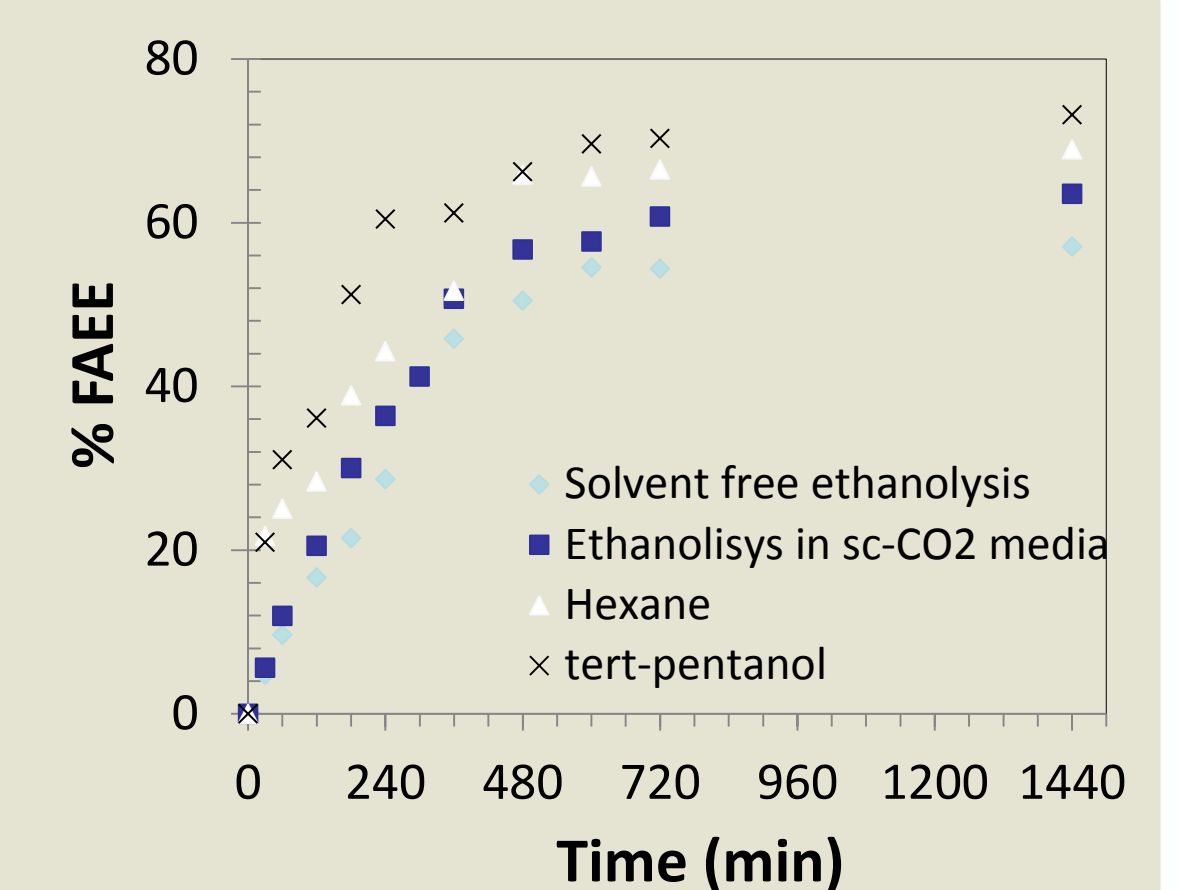
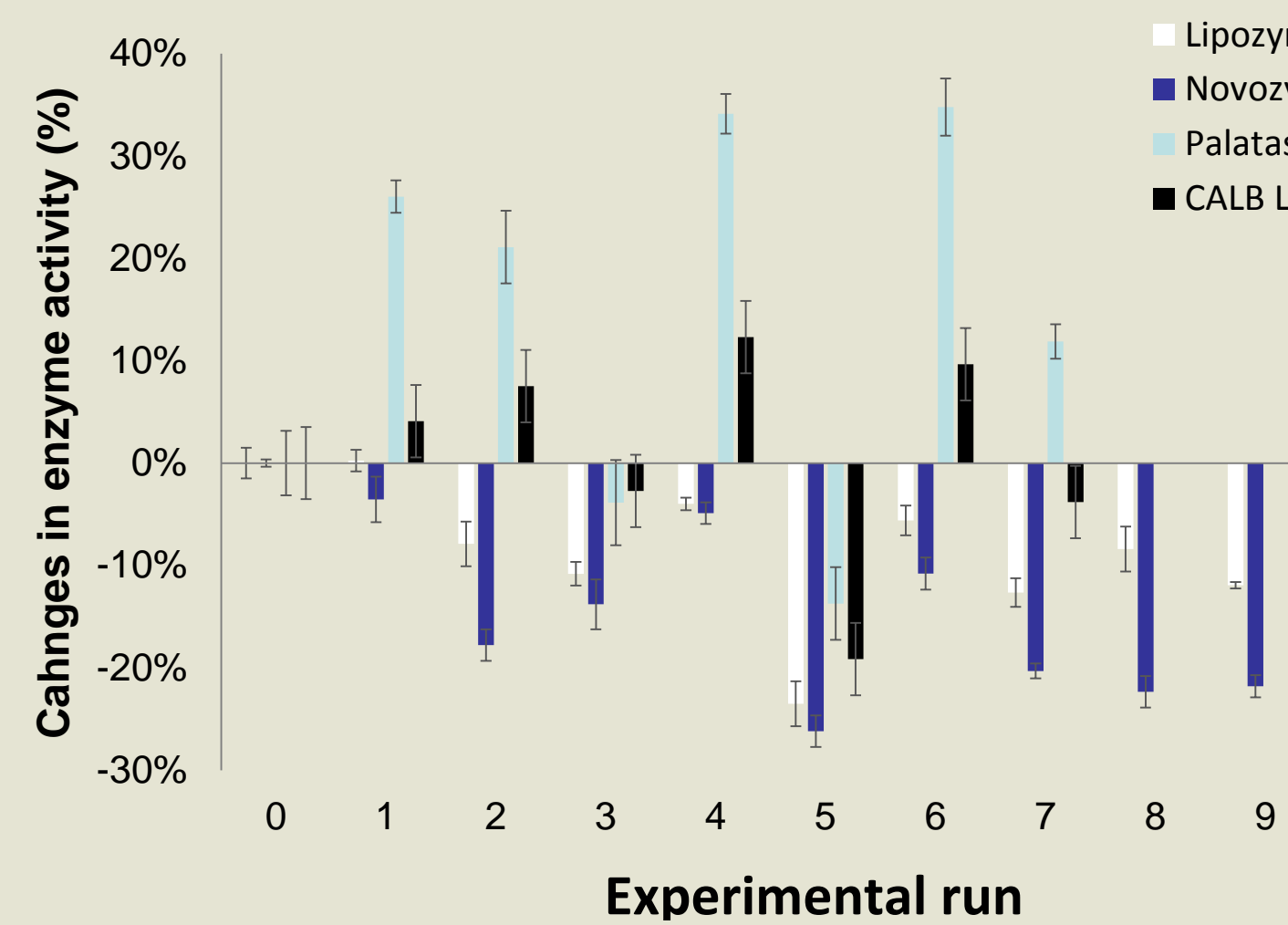


Omega-3 rich oil

Reaction in supercritical carbon dioxide media to obtain ethyl esters or structures triglycerides (3-6)

- Inert atmosphere that prevents reactants and products oxidation
- Organic solvents are avoided
- Lower media viscosity
- Faster reaction rates
- Media homogeneity
- Expanded media
- Lower temperatures than conventional methods

Run	p (bar)	T (°C)	t (h)	Cycles (h ⁻¹)
1	100			
2	150	50	3	0,33
3	250			
4	150	35	3	0,33
5	150	70	1	0,33
6	150	50	1	0,33
7			6	
8	150	50	3	0,67
9			1	

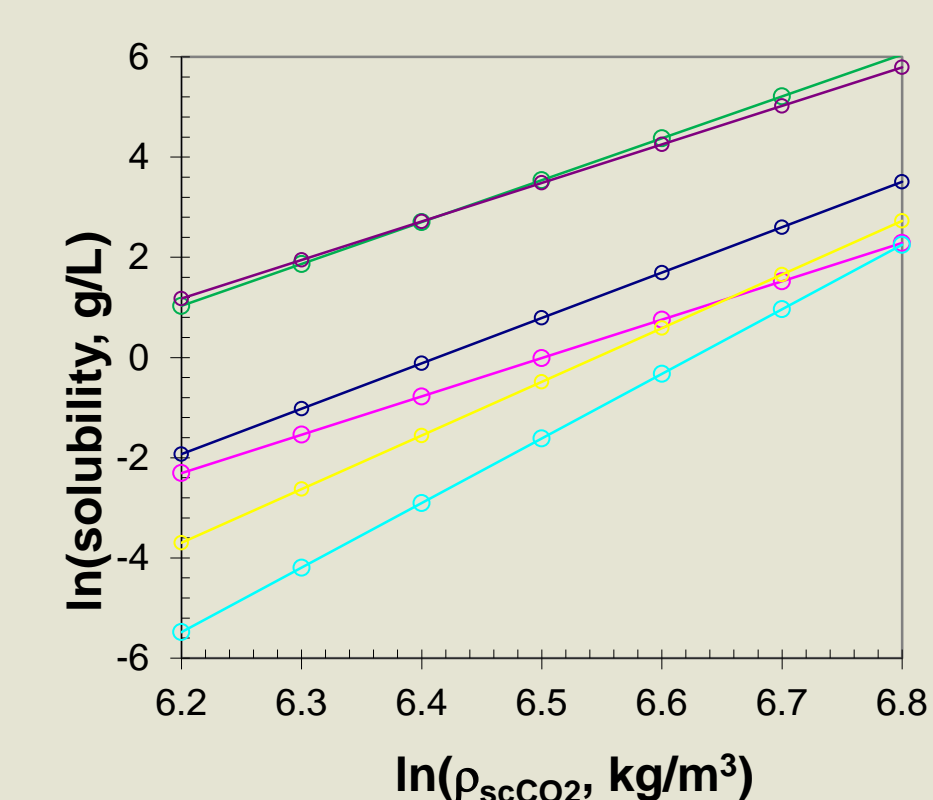


Mixture of oil derivatives

Separation of omega-3 derivatives by liquid-scCO₂ countercurrent fractionation (7)

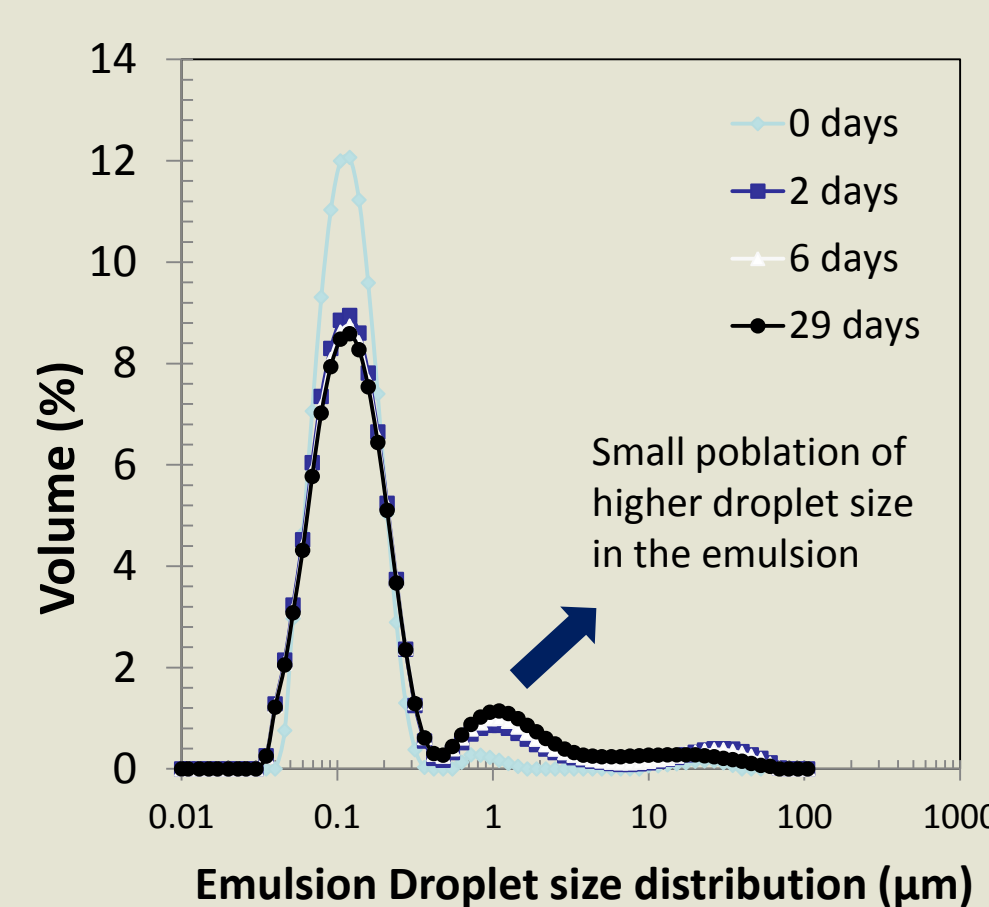
- Inert atmosphere that prevents concentrates oxidation
- Organic solvents are avoided
- Lower temperatures than conventional methods

Omega-3 PUFA concentrates

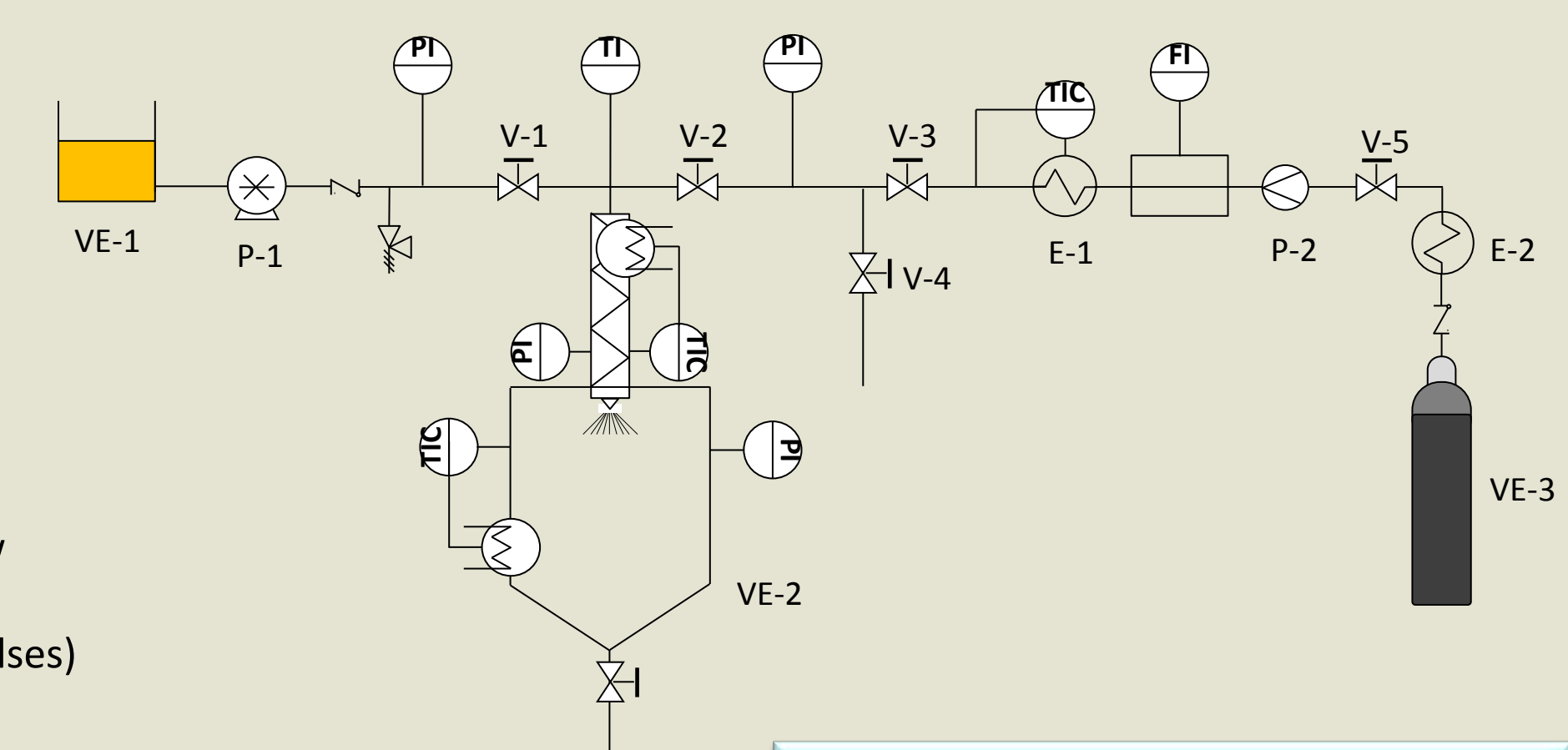


Omega-3 encapsulation by PGGs-Drying

- Inert atmosphere avoid concentrates oxidation
- Mask odors and flavors
- Low temperatures prevent product degradation



O/W emulsion
Omega-3 concentrate: 6 % w/w
OSA Starch: 24 % w/w
Ultrasounds time: 180 s (5 s pulses)
Amplitude: 100%



Formulations of omega-3 PUFA concentrates

- Rubio-Rodríguez, N., de Diego, S.M., Beltrán, S., Jaime, I., Sanz, M.T., Rovira, J. Supercritical fluid extraction of the omega-3 rich oil contained in hake (*Merluccius capensis*-*Merluccius paradoxus*) by-products: Study of the influence of process parameters on the extraction yield and oil quality (2008) *Journal of Supercritical Fluids*, 47 (2), pp. 215-226.
- Rubio-Rodríguez, N., De Diego, S.M., Beltrán, S., Jaime, I., Sanz, M.T., Rovira, J. Supercritical fluid extraction of fish oil from fish by-products: A comparison with other extraction methods (2012) *Journal of Food Engineering*, 109 (2), pp. 238-248
- Melgosa, R., Sanz, M.T., Solaesa, Á.G., Bucio, S.L., Beltrán, S. Enzymatic activity and conformational and morphological studies of four commercial lipases treated with supercritical carbon dioxide (2015) *Journal of Supercritical Fluids*, 97, pp. 51-62.
- Melgosa, R., Sanz, M.T., Solaesa, Á.G., Beltrán, S. Phase behaviour of the pseudo-ternary system carbon dioxide + ethanol + fish oil at high pressures (2017) *Journal of Chemical Thermodynamics*, 115, pp. 106-113.
- Melgosa, R., Sanz, M.T., Solaesa, Á.G., De Paz, E., Beltrán, S., Lamas, D.L. Supercritical carbon dioxide as solvent in the lipase-catalyzed ethanolysis of fish oil: Kinetic study (2017) *Journal of CO₂ Utilization*, 17, pp. 170-179.
- Solaesa, Á.G., Sanz, M.T., Melgosa, R., Beltrán, S. Substrates emulsification process to improve lipase-catalyzed sardine oil glycerolysis in different systems. Evaluation of lipid oxidation of the reaction products (2017) *Food Research International*, 100, pp. 572-578.
- Güçlü-Üstündağ, Ö., Temelli, F. Correlating the solubility behavior of fatty acids, mono-, di-, and triglycerides, and fatty acid esters in supercritical carbon dioxide. *Industrial and Engineering Chemistry Research*, 39, 12, pp. 4756-4766

Acknowledgments: Financial support from the Junta de Castilla y León and ERDF for project BU055U16 and OB's contract is gratefully acknowledged. To MINECO for EDP's Juan de la Cierva contract (FJCI-2014-19850) and RM's pre-doctoral contract (BES-2013-063937). To University of Burgos for AGS's pre-doctoral contract.

