

## Quinoa (*Chenopodium quinoa Willd*) and quinoa oil



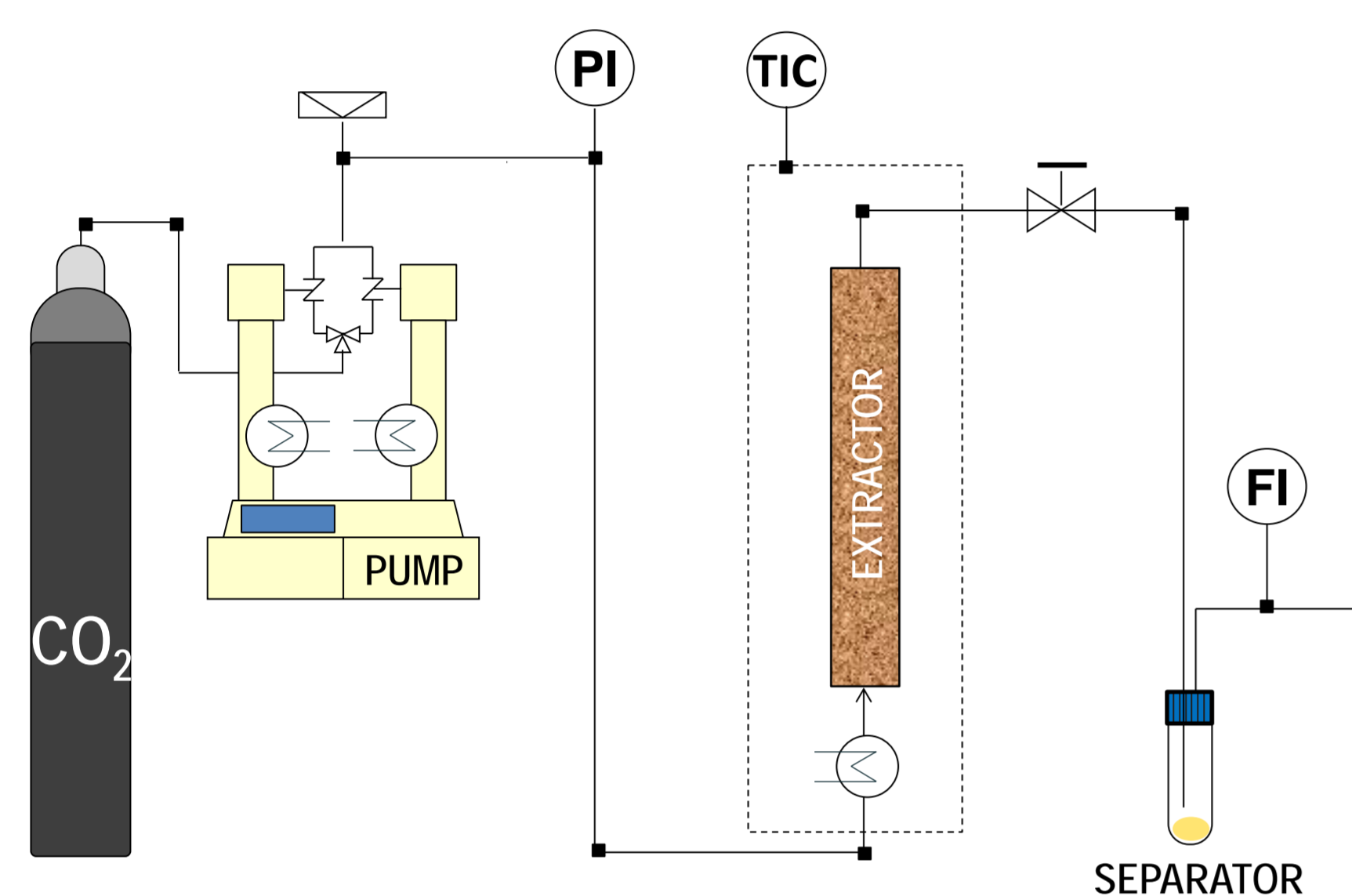
- Quinoa has the ability to grow in a wide diversity of environments
- It is rich in vitamins and minerals, and in high quality proteins (10 - 18%), balanced content in amino-acids such as lysine and methionine.
- Quinoa oil is a high quality oil (4 - 9 %) rich in unsaturated acids (mainly oleic and linoleic) and tocopherols

## Objective

- Study the influence of extraction parameters (pressure, temperature and particle size) on the extraction rate of quinoa oil (cv. Titikaka, since it is the most extensively grown in Europe due to its adaptation to the climatic conditions).
- Describe the experimental extraction curves through Sovova's mathematical model
- Analyze the quality and stability of the quinoa oil obtained by SC-CO<sub>2</sub> and compare to the oil obtained using hexane, in terms of fatty acid profile, tocopherol content and antioxidant activity.
- Analyze and compare the oil extracted from four quinoa varieties (Pasankalla, Collana and Altiplano and Titikaka) using either hexane or supercritical CO<sub>2</sub>.



## Supercritical Carbon Dioxide extraction of quinoa oil. Extraction curves and modelling



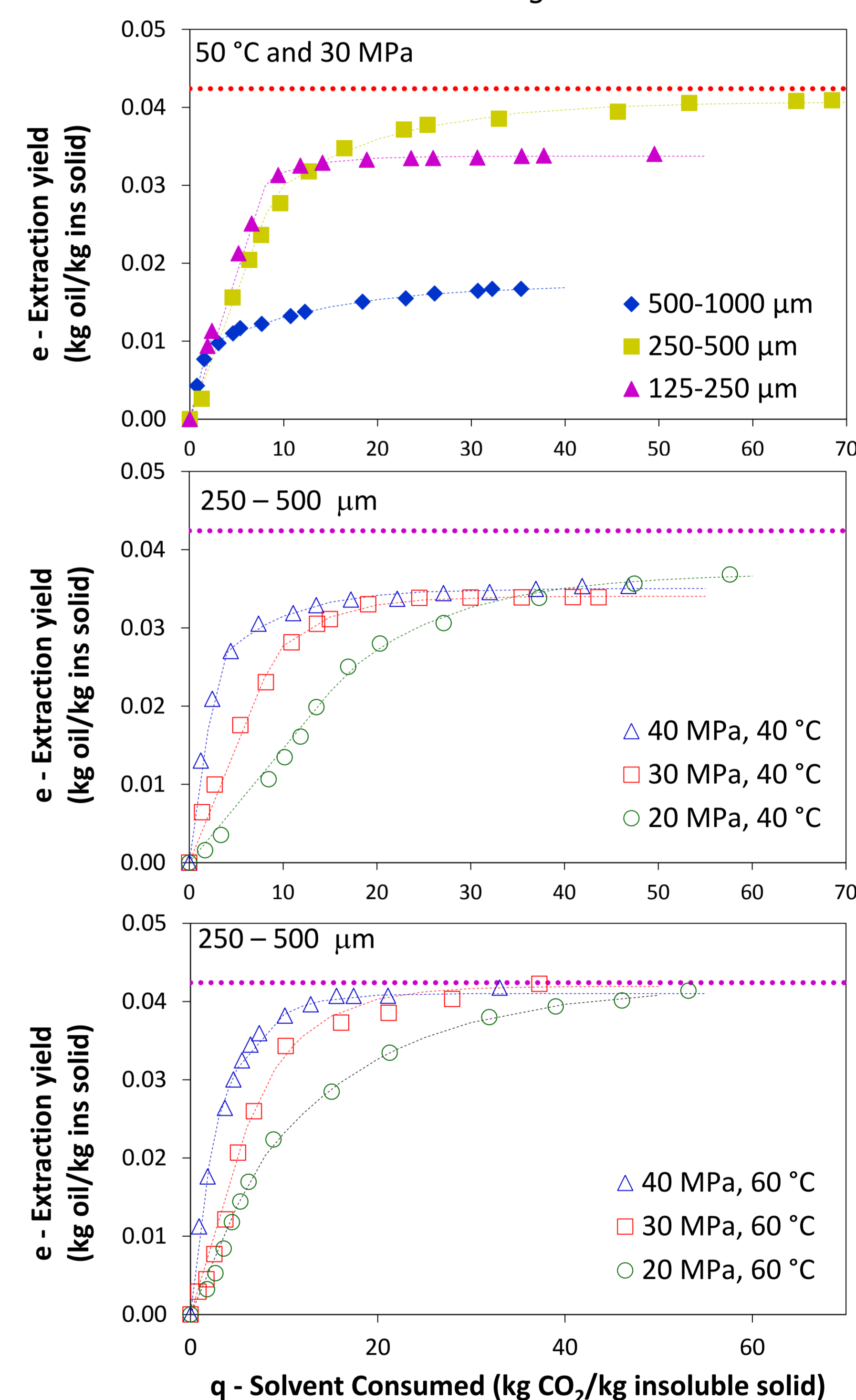
### Extraction Methodology

1. Extractor pressurization
2. Solvent circulation (2 g/min, 3 h)
3. Depressurization to atmospheric pressure.

### Fitting coefficients of Sovova's model

T (°C)	P (MPa)	y <sub>s</sub>	x <sub>u</sub>	C <sub>1</sub>	C <sub>2</sub>	K <sub>s</sub> ·a <sub>s</sub>	r	MRD (%)
40	20	0.0015	0.037	1.345	0.081	8.59E-05	0.45	8.8
40	30	0.0027	0.034	1.047	0.173	9.61E-05	0.60	6.9
40	40	0.0085	0.035	0.411	0.140	5.38E-05	0.70	2.2
50	20	0.0015	0.041	1.660	0.093	7.69E-05	0.40	3.7
50	30	0.0033	0.041	0.582	0.080	4.54E-05	0.60	6.0
50	40	0.0099	0.039	0.385	0.143	3.61E-05	0.73	4.0
60	20	0.0028	0.042	0.902	0.070	3.75E-05	0.47	9.9
60	30	0.0040	0.042	1.170	0.170	6.32E-05	0.61	12.9
60	40	0.0096	0.041	0.840	0.256	7.53E-05	0.72	2.5
500-1000 mm*		0.0050	0.017	0.525	0.077	3.41E-05	0.49	1.6
250-500 mm*		0.0033	0.041	0.582	0.080	4.54E-05	0.60	6.0
125-250 mm*		0.0037	0.034	0.490	0.207	5.11E-05	0.82	4.4

Influence of particle size, p & T on extraction rate of Titikaka oil. Dashed lines represent Sovova's model and dotted lines the oil extracted using hexane in Soxhlet.

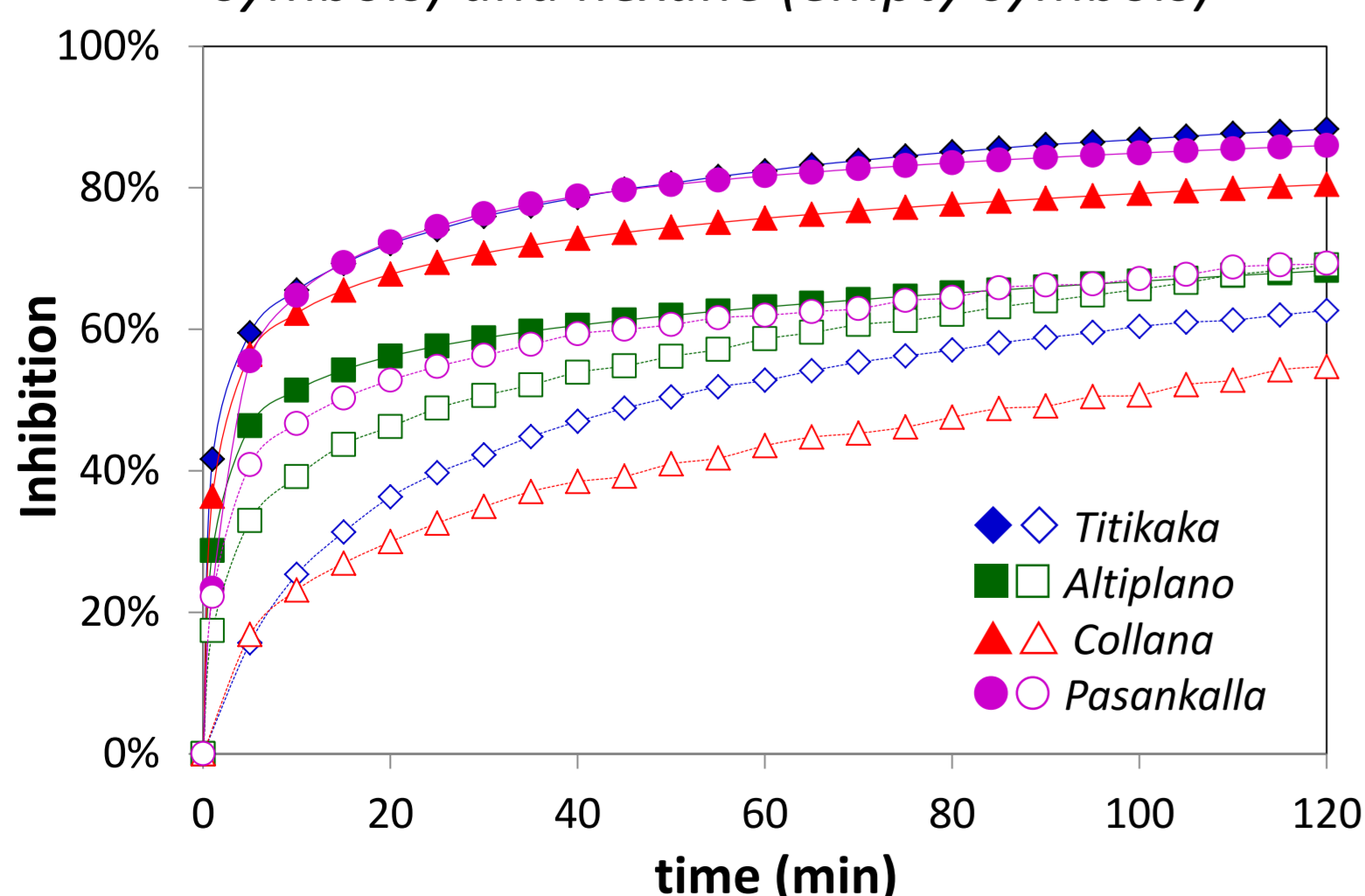


## Characterization of quinoa oil

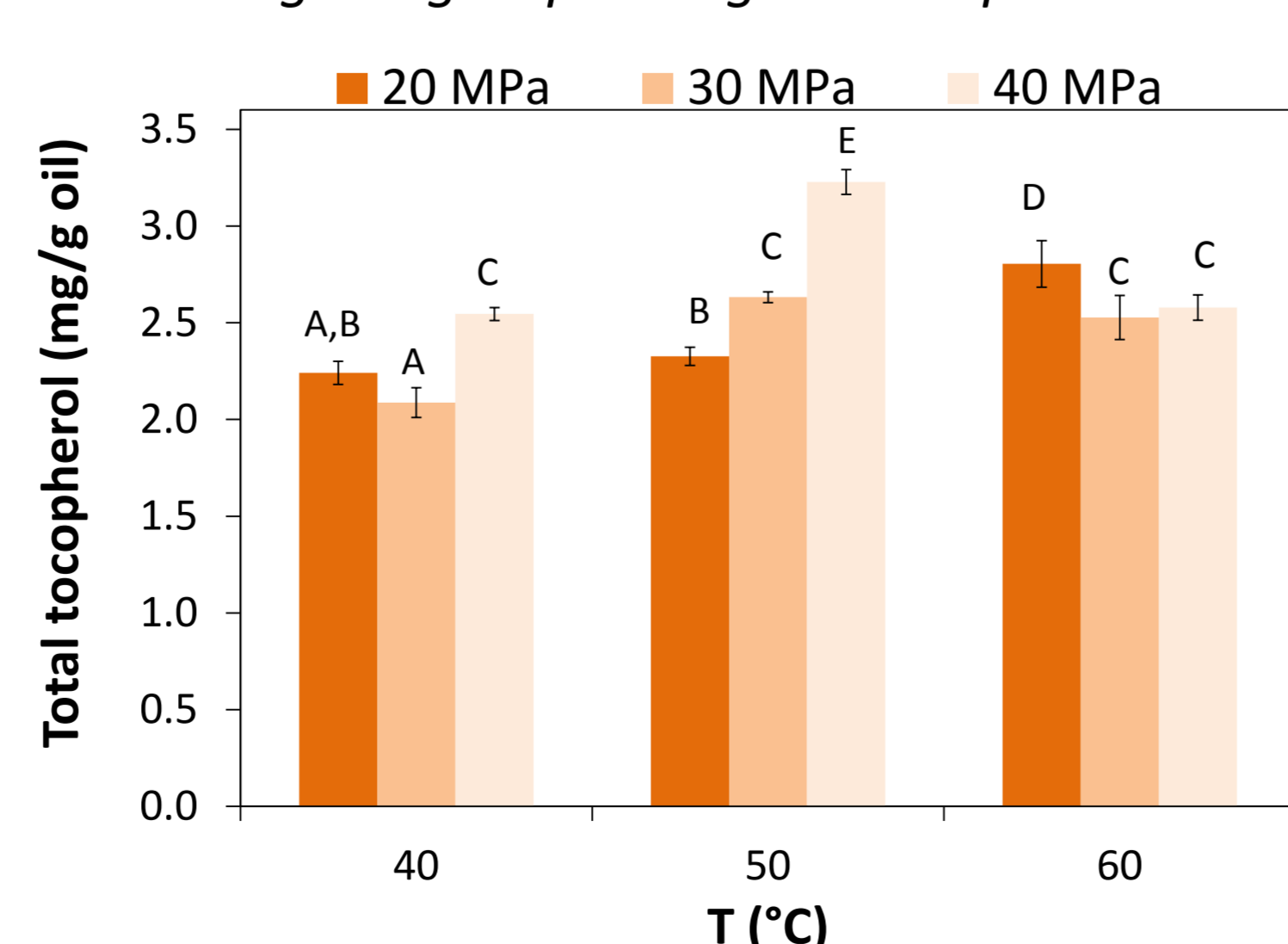
Fatty acid profile (expressed in % of fatty acid) of quinoa oil extracted with hexane (Soxhlet) and SC-CO<sub>2</sub> (40 °C, 40 MPa). Some minor fatty acids have not been considered

Fatty acids (%)		Titikaka		Altiplano		Collana		Pasankalla	
		Hexane	SC-CO <sub>2</sub>	Hexane	SC-CO <sub>2</sub>	Hexane	SC-CO <sub>2</sub>	Hexane	SC-CO <sub>2</sub>
Palmitic	C16:0	9.0 ± 0.2	9.5 ± 0.2	8.4 ± 0.4	9 ± 1	9.1 ± 0.4	9.4 ± 0.5	11.9 ± 0.1	12.7 ± 0.9
Stearic	C18:0	0.6 ± 0.0	0.5 ± 0.0	0.9 ± 0.0	0.8 ± 0.0	0.8 ± 0.0	0.7 ± 0.0	0.6 ± 0.0	0.6 ± 0.0
Oleic	C18:1n-9	21.4 ± 0.5	18.8 ± 0.5	31 ± 2	27.2 ± 0.5	27 ± 1	26 ± 1	26.4 ± 0.1	26 ± 2
Vaccenic	C18:1n-7	1.3 ± 0.1	1.4 ± 0.0	0.8 ± 0.0	1.1 ± 0.1	0.9 ± 0.0	1.1 ± 0.1	1.6 ± 0.1	1.4 ± 0.2
Linoleic cis&trans	C18:2n-6	56 ± 1	56 ± 2	46 ± 2	47 ± 1	52 ± 2	52 ± 3	43.2 ± 0.3	45 ± 3
α-linolenic	C18:3n-3	6.2 ± 0.2	6.4 ± 0.2	7.9 ± 0.5	8.2 ± 0.3	3.8 ± 0.2	3.6 ± 0.2	8.3 ± 0.3	9.1 ± 0.7
Arachidic	C20:0	0.5 ± 0.0	0.4 ± 0.0	0.7 ± 0.0	0.6 ± 0.0	0.7 ± 0.0	0.5 ± 0.0	0.5 ± 0.0	0.4 ± 0.0
Gondoic	C20:1n-9	1.4 ± 0.1	1.4 ± 0.0	1.6 ± 0.1	1.5 ± 0.1	1.8 ± 0.1	1.7 ± 0.1	1.9 ± 0.0	1.6 ± 0.1
SFA		11.5 ± 0.2	11.5 ± 0.3	11.5 ± 0.6	11.4 ± 0.2	12.1 ± 0.5	11.7 ± 0.6	14.5 ± 0.1	12.7 ± 0.9
MUFA		26.0 ± 0.7	25.9 ± 0.9	35 ± 2	33.7 ± 0.9	32 ± 1	32 ± 2	33.7 ± 0.3	33 ± 3
PUFA		63 ± 2	63 ± 2	55 ± 3	55 ± 2	56 ± 3	56 ± 3	51.8 ± 0.3	54 ± 4
Total FA (mg/g oil)		821 ± 11	809 ± 12	870 ± 22	873 ± 12	844 ± 18	775 ± 20	765 ± 3	847 ± 31

Inhibition of the activity of the radical DPPH of oil extracts using CO<sub>2</sub>-SC at 40 MPa and 40 °C (full symbols) and hexane (empty symbols)



Total tocopherols in oil extracted from Titikaka using SC-CO<sub>2</sub>, letters indicate the homogeneity among the groups using the LSD procedure



## Concluding Remarks

- The extraction rate increased with pressure.
- In the initial extraction period, temperature did not play a significant role on the extraction rate, just a slight increase in the solubility of the oil; however, temperature affects the extraction rate once the maximum extraction rate is passed, with higher extraction rates the higher the temperature.
- The optimal quinoa particle size was found to be in the range 250-500 mm
- SC-CO<sub>2</sub> oil is of higher quality than hexane oil in terms of antioxidant activity and tocopherols profile when extracted at 40 MPa and 40 °C, regardless the quinoa variety used.
- The extraction method did not influence the fatty acid profile.
- Titikaka oil presented the highest PUFA content
- All in all, supercritical fluid extraction using CO<sub>2</sub> has been found to be a suitable technology to extract high quality oil from different varieties of quinoa seeds.