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Limiting factors in supercritical CO2 extraction of tomato pomace: lycopene solubility in tomato seed oil.

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PURPOSE OF THE ABSTRACT

Tomato processing byproducts (pomace-TP) are comprised of a mixture of peels and seeds that, while representing 2-4% of the fruit, contain the majority of the biologically active compounds like carotenoids, phytosterols and tocopherols. Lycopene (lyc), the main carotenoid in tomatoes, is currently produced via chemical synthesis or by conventional solvent extraction from ad hoc cultivated tomatoes; since these methods have limited sustainability, greener alternatives are being investigated. The extraction of carotenoids from TP with supercritical technologies has been applied in the latest years, and the optimal values of the main operating parameters like pressure, temperature and CO2 flow have been defined. It has been demonstrated that the use of co-solvents like vegetable oils helps to achieve higher recoveries; nevertheless, when TP extracts are produced in large scale CO2 extractors, the extraction yields are not always satisfactory. After the operating parameters have been optimized, a limiting factor which is not usually considered is the proportion between lyc and oil fraction available as own-co-solvent. Also, lyc isomers have different structures that influence their solubility: the trans isomer is found in the raw fruit and is less soluble than its cis forms. During the processing of tomatoes, trans-lyc is subjected to high temperatures and undergoes cis-isomerization. As a result, TP lyc is an isomeric mixture in which trans is still the most abundant form (?60%); nevertheless, supercritical extraction processes can change the cis/trans ratio to reach a higher cis isomers content, enhancing the overall solubility of the mixture. The objective of this study was to assess the solubility of different lyc isomeric mixtures in tomato seed oil and to define the oil content needed to guarantee lyc solubilization when TP supercritical CO2 extraction is carried out. The investigated TP was collected from a full-scale plant; peel and seed accounted for 51.17% and 48.83% d.m. TP respectively and were separated and extracted with hexane for successive analysis. TP had a lyc content of 0.609 mg g-1 d.m. TP and an oil content of 14.78% d.m. TP. With the aim of evaluating the enhancement of lyc solubility in function of cis-lyc content, two different isomeric mixtures (first mixture: trans 60% and cis 40%; second mixture: trans 20% and cis 80%) were used to perform solubilization tests in tomato seed oil. For both mixtures satisfying lyc solubilization degrees (lyc recovery > 86% lyc dosed) were found at concentrations of 0.363 mglyc/mloil and 1.759 mglyc/mloil for the first and second mixture respectively, highlighting the huge importance of the isomers ratio in defining oil amount needed.
The same TP was extracted with a supercritical apparatus, yielding an extract amount of 17.5% d.m. TP and a lyc concentration of 1.339 mg g-1extract that had an isomer composition of 49.11% trans and 50.89% cis; overall, recoveries were satisfying for the oil while were mediocre for the lyc (100% and 38.49% of the starting oil and lyc respectively). However, basing on the mass balance, the whole lyc extracted was equal to 80.63% of the TP lyc content that corresponded to a theoretical 2.624 mg lyc g-1extract, meaning that a high fraction (42.14% of the extractable lyc) was trapped in the apparatus. This data confirmed the solubilization results that showed, for similar lyc concentration and isomers composition, a solubilization degree of 44.6% and corroborate the hypothesis that lycopene/oil ratio in the TP was the main limiting factor to the extraction efficiency. Hence, we hypothesize that a higher oil content, that could be achieved with a higher seeds/peels ratio or by addition of exogenous oil, could help to achieve an almost complete extraction of lyc.

FIGURES

Added lycopene (µg/ml)	Detected lycopene (µg/ml)	Recovery (%)	Trans (%)
21	21	99.53	79
42	44	102.59	81
106	108	101.98	79
211	230	109.03	75
420	363	86.45	70
1035	580	56.03	60
2023	902	44.59	55
7126	2030	28.48	45
11691	3361	28.75	44
16101	4529	28.13	46

Added lycopene (µg/ml)	Detected lycopene (µg/ml)	Recovery (%)	Trans (%)
21	20	96.23	55
42	44	104.25	54
106	107	101.23	45
211	217	103.06	46
420	385	91.81	44
1035	895	86.42	40
2023	1759	86.93	35
7126	2994	42.01	15
11691	4333	37.06	12
16101	5435	33.75	11

FIGURE 1
lycopene recovery before isomerization

added and solubilized lycopene, recovery, trans-lycopene %

FIGURE 2
lycopene recovery after isomerization

added and solubilized lycopene, recovery, trans-lycopene %

KEYWORDS
lycopene | supercritical CO2 | tomato pomace | solubility

BIBLIOGRAPHY