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Microwave-Assisted Recovery of Carotenoids from Pretreated Tomato Processing Waste: A Comparison of Conventional Grinding and Vibrational Micro-Milling

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Abstract

Tomato processing waste (TPW) represents a highly valuable source of bioactive compounds, particularly carotenoids. These lipid-soluble pigments accumulate during the ripening process in chromoplasts and chloroplasts, located mainly in the outer layer of the tomato skin. Since carotenoids are localized within cellular structures, their isolation requires disruption of the cell wall to facilitate their release and improve the extraction efficiency. For that purpose, mechanical, thermal, enzymatic and chemical pretreatments, as well as combinations of several techniques are most commonly used. The aim of this work was to investigate the impact of TPW pretreatment by grinding in a conventional coffee grinder and additional processing in a vibrational micro-mill on the yields of β-carotene and lycopene after microwave assisted extraction (MAE) in sunflower oil (SO) and eutectic solvent composed of capric and lauric acids (CLA) in a 2:1 molar ratio. Prior to the extraction of carotenoids, TPW samples were homogenized and dried in a drying oven at 70 °C. The grinding was performed for 18 s using a conventional coffee grinder, while a portion of the sample was further comminuted using vibrational micro-mill with 12 large balls (10 mm) and 24 small balls (5 mm) at 30 Hz for 15 min. The samples were prepared at solid-to-solvent ratios of 1:10 (SO) and 1:20 (CLA). MAE was performed under previously optimized conditions, depending on the extraction solvent used (SO – 4 min, 217 W; CLA – 13 min, 1800 W). After extraction, the samples were centrifuged and saponified to remove impurities and to minimize the matrix effect on carotenoid quantification by HPLC analysis. The obtained results demonstrated statistically significant differences in yields of β-carotene and lycopene in both SO and CLA TPW extracts, depending on mechanical milling pretreatment. Pretreatment resulted in significantly higher yields of both β-carotene and lycopene in SO, whereas in CLA extracts the content of β-carotene was significantly lower, in pretreated sample. A possible explanation for these results could be the formation of complexes between carotenoids and dietary fibers present in TPW, which protect them from autooxidation, particularly under extreme extraction conditions (13 min, 1800 W). The lower content of β-carotene in CLA TPW extracts may be attributed to less stable complexes with fibers compared to lycopene, likely due to differences in their structural properties.

Keywords: tomato processing waste, carotenoids, mechanical pretreatment, microwave assisted extraction