

Green ultrasound-assisted extraction of carotenoids from peach peels using vegetable oils

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Peach (*Prunus persica*), a juicy fruit which belongs to the *Rosaceae* family, constitutes one of the most significant crops worldwide as its production can exceed 24.5 million tons (FAOSTAT, 2020). It first appeared in China and since then, it has been distinguished not only from its economic significance, but also for its special organoleptic characteristics. Specifically, peach is of great nutritional importance as it makes up a rich source of organic acids, sugars, vitamins, minerals, carotenoids, and phenolic compounds (Rudke *et al* 2023). The consumption of peaches is based on various products such as peach purée, jams, juices, gels, pulp, yogurt, tea (Aktağ & Gökmen, 2021, Vásquez-Villanueva *et al* 2015). However, during this process many by-products are created such as peach peels and kernels.

Peach peels, the exocarp of the fruit which constitutes 22.5% of this, are considered one of the main by-products of peach industry (Featherstone, 2015). Nevertheless, different studies have shown that the peels contain higher amounts of bioactive components, such as carotenoids and phenolic compounds, in comparison to the flesh and stone of the fruit (Rudke *et al* 2023). The high concentrations of these compounds contribute to the fruit's protection from extraneous effects, but at the same time affect its color (Brown *et al* 2014). Therefore, peach peels could be utilized as a naturally source of value-added components.

Carotenoids constitute one of the main categories of these compounds. These beneficial substances are characterized as natural pigments as they are responsible for the intense colors in certain plants, fruits, and vegetables. Moreover, they are also found in microorganisms, such as bacteria or fungi (Hornero-Méndez & Mínguez-Mosquera, 2000). Although numerous carotenoids have been isolated, however only a few of them appear in the human diet, where stand out for their beneficial properties (Goula *et al* 2017). In particular, according to studies, they reduce the occurrence of chronic diseases and are distinguished for their anti-cancer and antioxidant effects (Cho *et al* 2004). For this reason, the recovery and utilization of these compounds comprise a challenge.

The purpose of the present study is the holistic approach of peach waste management for the recovery of bioactive components. In an attempt to replace conventional extraction methods, due to the use of organic solvents, high energy consumption, and high operation time, research interest has been focused on environmentally friendly extraction methods. These alternative methods have the advantage of less energy consumption, in less time, smaller quantities of solvents, and in some cases higher extraction yields. Ultrasound-assisted extraction (UAE) is a typical example of these methods and is used for the recovery of carotenoids from peach peels. Another promising alternative to conventional approaches for carotenoids extraction is the use of edible oils as solvents, which offer attractive advantages, due to the oil solubility of carotenoids. Edible oil extraction can almost entirely satisfy the requirements for being a green method, including the use of solvents that are beneficial to the environment, a reduction in energy usage, and the production of a non-denatured extract free of impurities. Furthermore, the oil acts as an oxygen barrier, postponing the oxidation and degradation of the carotenoids extract (Goula *et al* 2017).

Thus, the objective of this work was to study a new process for peach peels application in food industries based on ultrasound-assisted extraction of carotenoids using different vegetable oils as solvents. In this way, an oil enriched with antioxidants is produced. Soybean oil and rice oil were used as alternative solvents and the effects of various parameters on extraction yield were studied. Extraction temperature (20-60°C), solid/oil ratio (1-3/10 g/mL), and amplitude level (20-60%) were the factors investigated with respect to extraction yield. Comparative studies between ultrasound-assisted and conventional solvent extraction were carried out in terms of processing procedure and total carotenoids content. The efficient extraction period for achieving maximum yield of peach peel carotenoids was about 50 min. High-performance liquid chromatography (HPLC) analysis was applied to determine the carotenoid profile of the obtained extracts.

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