

Essential oil-loaded chitosan liposomes as a smart strategy to extend the shelf life of blueberries

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Blueberries are highly appreciated for their flavor and their high content of bioactive compounds, with well-known health-promoting properties [1]. However, they have a short shelf life [2] and edible coatings enriched with essential oils (EOs) represent a promising natural approach to extend shelf life while preserving quality and reducing food waste caused by the disposal of aesthetically imperfect but edible fruits, a strategy often adopted to satisfy consumers' aesthetic preferences [3].

The aim of this study was to develop a natural tool to extend the shelf life of fresh blueberries by combining the properties of chitosan with the antioxidant and antimicrobial activities of basil and fennel EOs. A rapid and novel method for the preparation of liposomes was developed, able to deliver both chitosan and the EOs. The formulations were characterized in terms of size, PDI, and ζ -potential. SAXS, TEM, FT-IR, and the fluorescent probe DPH were used to investigate the structure, morphology, molecular interactions, and bilayer fluidity. Finally, the long-term stability was evaluated using DLS, and monitoring pH during storage. The chemical composition of the EOs, the samples and untreated and treated blueberries, was evaluated by using Headspace-Solid-Phase Microextraction-Gas Chromatography-Mass Spectrometry techniques showing that estragole and anethole were the main components of BEO and FEO, respectively. The nanotoxicity of the formulations was assessed using Caco-2 cells.

Finally, the ability of the developed samples to preserve fresh blueberries during storage was evaluated showing a reduced weight loss and improved retention of phenolic, flavonoid and antioxidant compounds for 21 days, extending blueberry postharvest shelf life.

[1] M. Bezerra, et al. s, *Comp Rev Food Sci Food Safe* 23 (2024) e13354.

[2] S. Cao, et al. *Food Qual Saf* 9 (2025) fyaf038.

[3] I.E. de Hooze, et al. *Food Quality and Preference* 56 (2017) 80–92.