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Application of supercritical carbon dioxide to improve the quality of ready-to-use carrots and pumpkins during storage

Zastosowanie dwutlenku węgla w warunkach nadkrytycznych do poprawy jakości marchwi i dyni, gotowych do użycia, podczas przechowywania

Doctoral dissertation
Praca doktorska

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Abstract

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This study comprehensively examined how supercritical carbon dioxide (SCCD) treatment affects enzyme activity, color, carotenoid and sugar profiles, individual phenolic compounds, and antioxidant capacity in carrot cubes of varying sizes (1 cm and 2 cm) and fresh-cut pumpkins (1 cm). In carrots, SCCD reduced polyphenol oxidase (PPO) and peroxidase (POD) activities more pronouncedly in 1 cm cubes than in 2 cm cubes, while raising a*, b*, and ΔE values in 1 cm samples. Under moderate processing conditions, carotenoid content, phenolic levels, and antioxidant activity increased in 1 cm cubes. However, at harsher process parameters, these nutritional components showed more significant degradation in 1 cm cubes compared to 2 cm cubes, emphasizing that cube size substantially influences nutrient retention. Principal component and correlation analyses revealed distinct variations between selected smaller and larger cubes regarding enzyme activities and nutrient composition following SCCD. Based on these results, 1 cm carrot cubes processed at 10 MPa, 35 °C, and 45 min emerged as the most effective parameter, achieving significant enzyme inactivation alongside high bioactive compound retention.

Regarding pumpkins, SCCD processing reduced PPO and POD activities by 21% and 18%, respectively. Similar lightness (L^*) decreased, whereas redness (a^*) and yellowness (b^*) increased. Lutein, α-carotene, β-carotene, total carotenoids, glucose, sorbitol, and other polysaccharides in SCCD-treated pumpkin displayed a fluctuating trend. Furthermore, total phenolic content, ABTS, DPPH, and superoxide radical scavenging activities increased and then decreased. Under moderate SCCD conditions, coumaryloquinic acid I and II, caffeic acid glucoside, 4-hydroxybenzoic acid, and p-coumaric acid showed marked enhancements, indicating that moderate SCCD parameters can promote the release of bound bioactive compounds from macromolecules.

SCCD effectively suppressed microbial growth while maintaining low PPO and POD activity levels throughout 3 weeks of storage, thereby delaying both enzymatic and chemical deterioration of carotenoids and phenolic compounds. Additionally, SCCD expedited sucrose hydrolysis but postponed decreases in glucose and fructose, thereby curtailing quality loss over extended storage. Overall, this study highlights the promise of SCCD, especially under moderate conditions, for maintaining high-quality, nutrient-rich produce and provides a strong foundation for its broader industrial adoption in the fresh-cut sector.

Keywords: sugar, carotenoids, phenolic compounds, polyphenol oxidase and peroxidase, microbial count, minimally processed vegetables

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