


Summary

The high prevalence of osteoporosis and calcium deficiency has driven the development of functional foods from local resources, supporting United Nations' Sustainable Development Goals. This study aimed to develop freeze-dried apples enriched with antioxidants from sea buckthorn (SB) juice and calcium via impregnation, while also assessing browning enzyme activities to evaluate product quality. To achieve the goal, a three-stage study was carried out. Stage 1 optimized impregnation conditions at atmospheric pressure using various concentrations of SB juice and calcium lactate (CaL), inulin:SB juice ratios, temperatures, and processing times. It was shown that, compared to freeze-dried fresh apple (FA) and fresh apple after dipping in 1% ascorbic acid (FA+AA), the minimal antioxidant activity loss and increased calcium content were obtained in the product prepared using 93.8% SB juice (w/w), 4% CaL addition (w/w) at 30°C for 120 min. In stage 2 (adapting the conditions from stage 1 with 0 and 4% CaL), it was found that vacuum (VI) and ultrasound-assisted impregnation (US) significantly improved the antioxidant activity and calcium content of the freeze-dried product as compared to conventional (atmospheric) impregnation, FA, and FA+AA. The highest antioxidant activity was observed in VI for 200 mbar and US for 30 min at 0% CaL, while the highest calcium content was found in VI for 200 mbar and US for 20 min at 4% CaL. Stage 3 evaluated the effects of 3-month storage on the functional, enzymatic, and sensory properties of freeze-dried apples after impregnation (IMP) adapting selected stage 1 conditions. IMP had a more beneficial effect on the antioxidant activities and calcium content than FA and FA+AA. In all stages, the freeze-dried impregnated samples showed an altered composition of phenolics (dominated by isorhamnetin derivatives) and carotenoids compared to FA and FA+AA. It was found that the enzymatic browning process was dependent on the impregnating solution used, VI and US, and the storage period. The freeze-dried impregnated samples, especially those with 4% CaL, showed higher crispiness than FA and FA+AA both freshly prepared and after storage in sensory evaluation. The research confirmed that the developed product has potential as an alternative functional food aimed at reducing the risk of osteoporosis and calcium deficiency.

Keywords: antioxidants, apple, calcium, impregnation, sea buckthorn, sustainability.


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