Abstract

Active packaging involves addition of active compounds to improve functionalities of the film and can be used as edible film or coating. The Ascorbic acid/Vitamin C (VC) as an active material enhances film's antioxidant and preservative properties. Due to its susceptibility to various factors, VC can be encapsulated to minimise its degradation for use in food applications. So, the study aims to examine various encapsulation methods for VC and investigate its potential application in edible film or coating.VC was encapsulated in polyelectrolyte complex (PEC) formed between chitosan (Cs) and alginate (Alg) polysaccharides. The effect of pH modification of the solution, concentration of VC, quantity of Cs and Cs: Alg mass ratio on PEC formation and VC encapsulation were evaluated. The optimized process was obtained at a VC concentration of 0.15 M, 200 mg Cs and a mass ratio (Cs: Alg) of 1:0.75. This allowed higher VC loading (22.07%) with the lowest particle size (718±31.53 nm) compared to 1:1 and 1:0.95 mass ratio. VC release was found to be higher for 1:0.75 (Cs: Alg) mass ratio in acidic conditions than pH 7.4. The PECs exhibited higher oxidation stability in presence of transition metals compared to unencapsulated VC due to its controlled release. Electrospraying method for VC encapsulation in Cs nanoparticles was investigated, where Cs concentration (1-2% w/v), VC content (0.25-0.75 w/w Cs) and voltage (21-25 kV) were varied. The Response surface methodology and multi-objective genetic algorithm suggested optimum processing parameter at 2% (w/v) Cs concentration, VC: Cs mass ratio of 0.75:1 and an electric voltage of 21 kV. This global optimum combination exhibited 251.1±59.03 nm particle size with 36.6 % loading capacity and an encapsulation efficiency of 85.42%. The particles obtained from these two encapsulation methods were studied for antioxidant activity and antibacterial activity and characterized using Scanning Electron Microscopy (SEM), Fourier Transform Infrared (FTIR) spectroscopy, Differential Scanning Calorimetry (DSC), X-Ray Diffraction (XRD) techniques. Encapsulated VC, obtained from PEC and electrospraying method as well as two other methods named coacervation and nanoliposome, were incorporated in edible film to assess VC retention after film drying. This suggested highest VC retention in unencapsulated form followed by PECs. The starch-based film embedded with PEC particles of different concentrations (0.5, 0.75 and 1% (w/v) referred as Film_PEC$_{1,2,3}$ respectively) was compared to Film_VCs which had equivalent amounts of VCs. This showed similar antioxidant activity and reduced mechanical, barrier properties and transparency in Film_PECs compared to Film_VC. The VC retention in storage and release from Film_VCs and Film_PECs were also assessed. The minimally processed apple subjected to edible coating with the same film forming solution (FFS) comprising PECs and VCs, were stored at 8 °C and 80% RH for 10 days. Results showed significant reduction in weight loss (%) and browning index (BI) in cut apple after coating while it also increased and maintained the VC content in apple throughout storage. Coating with highest PEC exhibited lower BI compared to coating with VC, but sensory studies suggested no difference in apple quality when coated with higher amount of PEC and VC. Overall, the study showed the effectiveness of higher concentration of VC and PECs on maintaining sensorial quality attributes by retarding browning incidence and maintaining overall acceptability of the cut apples. Another application in apple juice showed better VC retention in sample fortified with PECs containing VC compared to unencapsulated VC. The results suggested that the encapsulation effect is application specific, where there is a higher chance of VC degradation by oxidation process.

Keywords: Ascorbic acid, Edible coating, Encapsulation, Polyelectrolyte complex, Electrospraying, Chitosan, Potato starch film