Effects of bruising of ‘Pink Lady’ apple under impact loading in drop test on firmness, colour and gas exchange of fruit during long term storage

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Abstract

The bruising phenomenon of apple fruit under impact loading is still a very important problem to be solved in order to design optimal harvest and processing systems and for ensuring the quality of the fruit during long-term periods of storage. This study focused on deformation simulation of apples (cv.’ Pink Lady’) under dynamic impact loading during drop tests in order to describe time-dependent bruising occurrence and the bruising effect on the postharvest fruit quality during long-term storage. In the study, analytical, experimental methods and finite element analysis based explicit dynamics simulation techniques were employed. Three drop heights (250 mm, 500 mm and 750 mm) and three impact materials (structural steel, high-density polyethylene and wood) and single fruit orientation (transverse) for the drop tests were considered. Experimental drop test, physical and chromatographic analyses at the time of harvest (first testing day) and during storage periods of 30, 120 and 210 days were realised. Physical and chromatographic analyses revealed that damaged apples lost a greater amount of weight when considering the increase in drop height. Furthermore, bruised surfaces of apples lost their luminosity just after the drop test. Ethylene production and respiration rates rapidly increased just after the fruit bruising and this increase was correlated with the drop height. Additionally, material tests revealed the yield stress point of the apple as 0.385 MPa and the simulation results provided useful visuals and numerical data related to the time-dependent bruising phenomenon. The validation study on the experimental and simulation setup revealed that bruising surface area is a more accurate measurement than bruise volume when evaluating bruising on the fruit flesh through a numerical method-based simulation study (average relative difference: 5.5 %).