

**Title** The discrete element method (DEM) to simulate fruit impact damage during transport and handling: Case study of vibration damage during apple bulk transport

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#### **Abstract**

Making use of the discrete element method (DEM) a study is presented on the influence of mechanical parameters (vibration frequency and acceleration amplitude, apple size, stack height) and fruit properties (apple harvest date, apple temperature, apple acoustic stiffness) on vibration damage of apples. As acceleration input a sine in the vertical direction was used. Realistic parameters of the Kuwabara and Kono [Kuwabara, G., Kono, K., 1987. Restitution coefficient in a collision between two spheres. *Jpn. J. Appl. Phys.* 26, 1230–1233] contact force model for ‘Jonagold’ apples and bruise prediction models were applied. As a general conclusion, major influences of mechanical parameters on the vibration damage were identified, in particular stack height and fruit size, and minor influences of fruit properties. Also a detailed study was performed to investigate the relation between apple positions in the stacking and bruise damage. It was demonstrated that the position–bruise damage relation depends on the acceleration amplitude, vibration frequency and stack height. The existence of damage chains within the centre of the apple stack was also identified, that is in accordance with the well-known force chains in bulk materials.