

# Forced-air precooling of apples: Airflow distribution and precooling effectiveness in relation to the gap width between tray edge and box wall

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## Abstract

Forced-air precooling is a widely-used precooling technique in the food cold chain. Optimizing ventilation design of packaging systems to improve cooling uniformity and reduce energy consumption has been a hot research topic. Inner tray is an important factor contributing to cooling heterogeneity. However, the study about the design optimization of inner tray is rather limited. The present study focused on the influence of inner tray on the precooling process of apples and explored the impact of widening the gap between the tray edge and box wall on airflow distribution and precooling effectiveness. A three-dimensional model was established on the basis of an existing container being widely used in China's agricultural cold-chain-logistics industry, and the direct computational fluid dynamics (CFD) simulation method was adopted to study the precooling process. The examined gap width increments were between 0 and 0.015 m. Results indicated that properly widening the gap was an effective way to achieve the goal of enhancing precooling effectiveness, without changing the design configuration parameters of the box. For the selected two-layer package, the optimal increment of the gap width was about 0.010 m, with which the cooling time could be reduced by 18.8 %, the cooling uniformity could be increased by 16.0 %, and the energy consumption could be reduced by 21.6 % simultaneously.