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Real-time monitoring of heat transfer in horticultural supply chain

Tuany Gabriela Hoffmann, Ulrike Praeger, Pramod Mahajan, Martin Geyer, Reiner Jedermann, Manfred Linke

Abstract: Temperature differences between produce and the environment, in the postharvest chain of fruit and vegetables, cause heat to flow from warm to cold places. At the beginning of the cooling process, heat flows from the food to the surroundings and, during the long term storage, temperature fluctuation due to compressor on-off strategy and temperature stratification due to lack of homogenization within the cold system can take place. Temperature non-uniformities are transferred, usually delayed in time, to the fruit and vegetables in the horticultural supply chain, which can compromise food preservation. In order to monitor and analyze the impact of these temperature changes in horticultural produce supply chain, a measuring system was built based on Peltier element for detecting real-time heat exchange between apple sample and the surrounding air, during a cooling process. Peltier elements to measure the heat flow were placed at the food surface by a double-sided thermal conductive tape. Experiments were performed inside a chamber, where the air temperature and its fluctuation had a robust control. Temperature settings were chosen to represent the fluctuations observed inside real cooling facilities by a sinusoidal profile with total cycle time of 2h ranging from 1°C to 9°C. The cooling and re-warming process of an apple provided an outgoing and incoming heat flow rate in a similar quantity, around 600W/m2. A delayed thermal response in the heat flow from food was observed between 10-15min. In summary, the direct recording of the heat flow rate from horticultural produce can provide a higher quality statement of the interaction between food and environment, once other influencing phenomena are also taken into account when measuring heat flow. The information provided by the Peltier element can be used for the modeling and design of new refrigeration systems aiming food shelf-life extension and energy saving.

Keywords: Apple, postharvest, refrigeration, heat transfer, Peltier, sensor, cold storage, cool chain.