Using low-cost smartphone-based infrared cameras to evaluate cooling and storage conditions of fresh produce

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Summary

Growth of foodborne pathogens may be observed in fresh produce when subjected to temperature abuse during postharvest handling and storage. The use of low-cost smartphone-based infrared (SBIR) cameras (**Figure 1**) in produce handling facilities may allow fast implementation of intervention strategies to control the growth of pathogens. SBIR cameras can potentially provide the industry with a "real time, non-destructive" monitoring solution to evaluate the effectiveness of hydrocooling and storage of fresh produce. Cooling rates of lettuce heads were determined during simulated immersion hydrocooling with conventional tools and/or SBIR cameras. Preliminary results suggest that SBIR cameras can effectively collect surface temperatures of lettuce heads before and after hydrocooling. Thermal images may be more effective than conventional single-point temperature measurements at supporting quicker and informed decisions to correct process deviations.

Objectives

1. To compare the performance and accuracy of SBIR cameras against a professional-grade IR camera for evaluation of proper cooling and storage conditions of whole and fresh-cut produce.
2. To develop effective user-friendly methods to operate SBIR cameras in produce handling facilities.

Methods

Refrigerated iceberg lettuce heads of different sizes were placed at 42°C for 20 h in different locations inside a pilot-scale food incubator to mimic field temperatures after harvest. Then, 6 lettuce heads were immersed in 15 L of chilled water (~5°C) for 30 min to simulate immersion hydrocooling. The temperature of the chilled water was monitored and kept constant. Type K-thermocouples connected to a data acquisition system were placed in selected lettuce heads to develop cooling rates during the simulated immersion hydrocooling (**Figure 2**). Also, thermal images of lettuce heads were taken with the SBIR cameras FLIR one PRO and Seek Compact PRO attached to an Android or iOS device. Afterwards, the lettuce heads were cut in half to measure internal temperatures.

Results to Date

Thermal images of the iceberg lettuce heads before hydrocooling are shown in **Figure 3**. The surface temperature of lettuce heads varied based on where the lettuces were placed inside the incubator (lettuce stored on lower shelves had lower surface temperatures compared with the lettuce stored on upper shelves). Surface temperature of lettuce heads after hydrocooling ranged from 5.5 to 11.5°C (**Figure 4**). Surprisingly, some of the hydrocooled lettuce heads had internal temperatures up to ~25°C (even though their surface temperatures were under 6°C). This finding may suggest that the hydrocooling times/conditions were not effective at reducing the internal temperatures of the whole iceberg lettuce to acceptable levels. This may be a food safety concern if cold-surface lettuce heads with a warm core are further shredded for the fresh-cut market.

Benefits to the Industry

- The use of low-cost SBIR cameras will facilitate the understanding of heat transfer concepts to fresh produce handlers, thereby allowing produce workers to make better and quicker decisions on process deviations that may compromise the temperatures of fresh produce during postharvest handling and storage.
- SBIR cameras also may allow quick identification of the air temperature distribution inside cold rooms and assist in the identification of critical areas.
- This 1-year proof-of-concept project will determine whether SBIR cameras can collect temperature profiles of packaged produce. This will benefit the produce industry by providing a rapid, non-contact temperature collecting method that can read through packaging materials. Furthermore, the best practices for using SBIR cameras in post-harvest handling and storage of fresh produce will be developed.

Figure 1. Smartphone-based infrared (SBIR) cameras attached to Android and iOS devices.

Figure 2. Simulated immersion hydrocooling of iceberg lettuces.

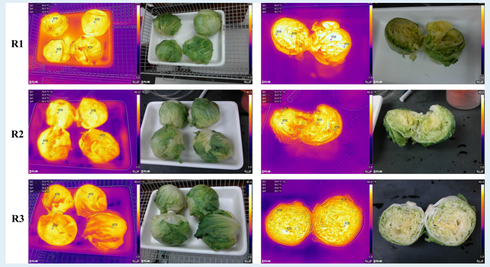

Figure 3. Thermal images (taken at room temperature of ~20°C, relative humidity ~55%) of iceberg lettuce heads stored at 40°C for 20 h. R1, R2, and R3 are replicate 1, 2, and 3, respectively. Samples for R1 were stored on higher shelves of incubator while samples for R2 and R3 were stored on middle and lower shelves of the food incubator, respectively.

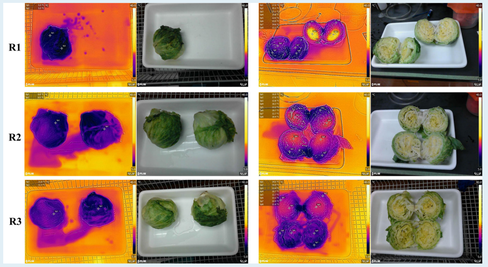

Figure 4. Thermal images (taken at room temperature of ~20°C, relative humidity ~55%) of iceberg lettuce heads after 30 min of hydrocooling at ~5°C (temperature before hydrocooling was ~40°C). R1, R2, and R3 are replicate 1, 2, and 3, respectively.