

# Detection of subsurface bruising in fresh pickling cucumbers using structured-illumination reflectance imaging

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## Abstract

Pickling cucumbers are susceptible to bruising during harvest and postharvest handling. It is thus desirable to segregate bruised fruit before they are marketed as fresh products or processed as pickles. Structured-illumination reflectance imaging (SIRI) is an emerging optical imaging modality for food quality inspection. This study reported the first demonstration of SIRI for detecting subsurface bruising in fresh pickling cucumbers. Two independent sets of images, i.e., direct component (DC) and amplitude component (AC), were demodulated from phase-shifted sinusoidal pattern images at 740 nm; AC was found more effective than DC for ascertaining bruises that exhibited no visual symptoms. Classification models based on support vector machine were built using extracted image features, to classify cucumbers into bruised and normal classes. The highest classification accuracy of 91 % was achieved by the ensemble of DC, AC and their ratio (AC/DC) images, which represented 7.6 percentage-point improvement over that obtained using the DC images alone. Using features selection for five sets of image features led to further improvements in the classification performance. Incremental evaluation of top 50 most informative features resulted in an averaged overall accuracy of 94 %, with the highest accuracy of 97 % attained by 31 features; and using a subset of only 5 features, 3 from AC and 2 from DC, also produced a high overall accuracy of 96 %. This study demonstrates that SIRI can provide a potentially effective means for visualizing subsurface bruising in pickling cucumbers, which otherwise could barely be achieved by imaging under uniform illumination, and thus for enhancing the differentiation of normal and bruised fruit. More research is, however, needed to optimize and implement SIRI for real-time inspection of cucumber defects.