

Identification of common skin defects and classification of early decayed citrus using hyperspectral imaging technique

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Food Analytical Methods 14: 1176–1193. (2021)

Abstract

Automatic detection of fruit skin defects is always one of the main tasks of post-harvest processing of citrus fruit. However, it is a challenge to identify different types of defects simultaneously due to a high rate of unpredictability in texture and color of defects. In addition, as a typical spherical fruit, the uneven lighting distribution on the citrus is also one of the main problems causing low accuracy of defect detection. This study observed that the feasibility of using visible-near-infrared (Vis-NIR) hyperspectral reflectance imaging technology to identify the common seven types of skin defects on oranges and also classify the early decayed oranges from other samples simultaneously. Segmented principal component analysis (PCA), such as Vis-NIR-PCA, Vis-PCA and NIR-PCA, was first performed to reduce data dimensions and obtain the optimal principal component (PC) that was used to extract several characteristic wavelength images. Five characteristic wavelength images centered at around 540, 623, 675, 805, and 975 nm were selected based on the optimal Vis-NIR-PC2 image and weight coefficient analysis. The mean normalization method was used to correct the uneven lighting distribution on spherical orange fruit based on characteristic wavelength images. The multispectral image processing algorithms for detection of all defective oranges and classification of early decayed oranges are developed, respectively. For the investigated 397 independent test samples, an overall classification accuracy of 97.73% was obtained for differentiating normal and defective oranges based on mean-PC images combined with the improved watershed segmentation algorithm, and identification rate of 100% was obtained for classifying decayed and non-decayed oranges based on mean-PC5 and a simple global threshold. The results of this study can be used as a reference to develop the fast and low-cost multispectral image detection system for the rapid detection of defective citrus fruit and classification of specific oranges with early decay synchronously.