Detection of early decay on citrus using hyperspectral transmittance imaging technology coupled with principal component analysis and improved watershed segmentation algorithms

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Abstract

Decay caused by *Penicillium* spp. fungi is one of the main problems affecting marketing of citrus fruit after harvest because the fungal infection can spread fast from a small number of decayed fruit to the whole consignment. However, the automatic detection of decayed citrus is still a challenge. Early decay of citrus happen on surface peel and present a obvious symptom of water-soaked with cell tissue collapse, which may offer the feasibility of transmittance imaging mode to detect decayed region of citrus. In this study, image processing methods including principal component analysis (PCA), pseudo-color image transformation technology and improved watershed segmentation algorithms (IWSA) were employed to analyze the feasibility of decay detection based on the scanned hyperspectral transmittance images (325–1098 nm) of sound and decayed oranges. The results show that PC3 image is promising for decay segmentation. G components extracted from pseudo-color images of PC3 were selected to enhance image contrasts between decayed and sound tissues, and then decayed regions were segmented perfectly by IWSA whether the defects located on the edge or center position of oranges. However, stem-end tissue had similar features with decayed tissue and therefore were easily misidentified as decayed tissues for those decayed samples with stem-end tissue, and so stem-end identification was carried out. PC2 image and R components extracted from pseudo-color images of PC2 were promising for stem-end identification, then IWSA and morphological parameters were used to extract stem-end region. The stem-end was marked in both operations of decay segmentation and stem-end identification, hence decayed region were further determined for eliminating the misclassification interference of stem-end tissue on decay

detection by removing the stem-end region from the operation of decay segmentation. For a validation set including of 84 decayed and 66 sound fruit, the success rates were 93 % and 96 %, respectively, and 94 % for decayed, sound and all fruit. Hyperspectral transmittance imaging offers a novel method for automatic detection of early decayed orange caused by fungus.