Application of biospeckle laser imaging for early detection of chilling and freezing disorders in orange

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Abstract

The potential application of laser biospeckle imaging technique and its methods of image processing to detect chilling and freezing disorders in orange was assessed. Four temperature treatments were applied to fruits for 16 h including no chilling and freezing, chilled at 1 °C, placed in freezer at −7 °C, and placed in freezer at −20 °C, respectively to simulate sound, chilled, moderate freezing, and extreme freezing conditions. Two coherent laser lights were then used to illuminate the samples in both back-scattering and forward-scattering arrangements. Biospeckle images were processed by using graphical and numerical procedures. Twelve features were extracted from the biospeckle images and they were then used to classify the oranges. The classifiers were included soft independent modeling of class analogy, linear discriminant analysis, quadratic discriminant analysis, artificial neural networks (ANN), and support vector machines. The results showed that both graphical analysis and biospeckle laser parameter could monitor biological activity resulting from the action of temperature changes responsible for chilling and freezing damages. Moreover, the forward-scattering arrangement resulted in the best prediction power with equal classification accuracies of 100 % for sound, chilled, moderate freezing, and extreme freezing classes by the ANN classifier. We conclude that the biospeckle imaging technique could be considered an alternative and useful tool for chilling and freezing assessments of oranges.