Title Multivariate image analysis: An optimization tool for characterizing damage-related attributes in magnetic resonance images of processing tomatoes

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Abstract

Processors desire in-line, nondestructive methods for characterizing whole tomatoes. During peeling, severely damaged tomatoes will disintegrate, leading to loss of product, increased need for wastewater treatment, and other costly problems. Thus, the purpose of this research was to develop an in-line method to detect damaged processing tomatoes, focusing on the pericarp tissue of the fruit. Magnetic Resonance (MR) imaging characterizes the environment of water protons in plant tissue, resulting in contrast between image pixels corresponding to damaged and sound tissue. Many types of MR imaging sequences are available; in this research, the Multivariate Image Analysis (MIA) methods of Partial Least Squares, Partial Least Squares-Discriminant Analysis, and Soft Independent Modeling of Class Analogy were used to determine the optimal MR pulse sequences for tomato pericarp damage assessment. This work encompasses three studies: one performed in the 2007 tomato harvest season, in which pericarp damage was measured off-line using conductivity score only, and two performed in 2008, in which pilot peeling outcomes, texture measurements, and acoustic measurements were used in addition to conductivity score. The multivariate images were created by varying key parameters in different MR pulse sequences; the average pixel intensities in regions of interest corresponding to the pericarp were used as the independent variables in the MIA analyses. The numeric (conductivity score, texture measurement, and acoustic impact measurement) and categorical (peeling outcome) response values were used as the dependent variables. With low error rates under cross-validation, MIA of MR images was successful at quantitatively predicting conductivity score and peeling outcomes. While the numeric values of the texture and acoustic impact measurements could not be predicted by MIA of MR images with error rates low enough for industrial implementation, these values could be predicted in a semi-quantitative manner (*i.e.* MIA predicts whether the value would be relatively high or relatively low). The MIA approach also identified multiple MR pulse sequences that are key to predicting the off-line pericarp measurements. This work has demonstrated that damaged tomato pericarp tissue can be efficiently characterized in-line using

multivariate MRI, thus furthering knowledge in the field of postharvest quality assurance of processing tomatoes.