Determination of banana quality indices during the ripening process at different temperatures using smartphone images and an artificial neural network

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Abstract

Banana quality and ripening stages were studied at four different temperatures (20, 25, 27.5, and 30 °C) using a smartphone camera and an artificial neural network (ANN). Changes in chemical and physical properties such as firmness, total soluble solids (TSS), pH, and ratio of pulp to peel, were determined and the relationship with color features ($L*a*b*$, hue, saturation, value [HSV], and luminance and chrominance [YUV]) were extracted from red, green, blue (RGB) images. ANN models based on color features were used to predict the quality indices of bananas during the ripening process. In addition, the developed models were verified by the coefficient of determination (R^2), root mean squared error (RMSE), and the ratio of performance to deviation (RPD). The ANN model predicted the firmness and TSS of banana efficiently, with R^2 values higher than 0.96 and RMSE values less than 72.32 and 1.40 for firmness and TSS, respectively. However, the ANN model was not suitable for predicting the pH value and ratio of pulp to peel with R^2 values less than 0.60 and RMSE values of over 0.20 and 0.23 for pH and the ratio of pulp to peel, respectively. Thus, we demonstrated a post-harvest methodology to determine the ripening status of bananas by predicting their quality indices during the ripening process on a smartphone camera using ANN, and suggest smartphone camera as a potential tool to estimate product quality.