Physicochemical, structural and nanomechanical study elucidating the differences in firmness among four apple cultivars

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Abstract

A study of the physicochemical, structural, nanomechanical properties at macro, micro and nanometric scales was carried out to determine which features have the greatest influence on the firmness of selected apple cultivars (Golden Delicious, Granny Smith, Gala and Red Delicious). Physicochemical assays, microscopy techniques, image analysis, nanoindentation and spectroscopy were used to characterize the properties of the four selected apples. The data were analyzed using principal component analysis, Pearson analysis and multiple linear regression to classify apple cultivars. These techniques were also used to identify which physicochemical, micro, and nanostructural as well as nanomechanical features were most associated with apple firmness. This allowed for the creation of a mathematical model (R^2 = 0.97) for the prediction of apple firmness from evaluated variables. It was determined that the cellular architecture, stiffness of cell walls and crystallinity index of cellulose fibers were the most important factors in explaining the variability of firmness in the studied apples. This research provides novel and valuable information for understanding the role of cellular architecture, micro and nanostructure, as well as nanomechanical properties in the firmness of the studied cultivars.