

The story of kiwifruit trauma: seeing beyond the surface with Near Infrared Hyperspectral Imaging

Silvia Grassi^{1*}, Giulia Gorla², Alessandro Grassi¹, Irene Locatelli¹, José Manuel Amigo^{2,3}

¹ *Department of Food, Environmental and Nutritional Sciences, University of Milan, Via Celoria 2, 20133 Milano, Italy*

² *Department of Analytical Chemistry, Faculty of Science and Technology, University of the Basque Country UPV/EHU, Sarriena s/n, 48940 Leioa, Basque Country, Spain*

³ *Ikerbasque, Basque Foundation for Sciences, María Díaz de Haro, 3, Bilbao, 48013, Spain*

E-mail: silvia.grassi@unimi.it

Kiwifruits can easily suffer damage during picking, harvest handling, transport, or other forms of mechanical stress. This issue is inconsistent with marketing requirements and may result in significant economic and reputational losses (Hou 2012). In this contest, the study aims to assess the feasibility of rapidly detecting occurrence and progression of mechanical damage on kiwifruit by a non-destructive technique: Near Infrared Hyperspectral Imaging (HSI).

A representative sample of kiwifruits from the green cultivar produced in different countries (Spain and Portugal) was collected from local sellers in Bilbao, Spain. The samples were stored at room temperature (25 ± 1 °C). Various types of fruit damage were investigated through impact tests, compression tests, and their combination. Reference techniques were employed to assess destructive parameters such as pH, soluble solid contents, and titratable acidity. Hyperspectral data were acquired using a SWIR camera (Specim, Spectral Imaging Ltd., Oulu, Finland) (**Figure 1a**) at different sampling time after inducing the damage. The acquired spectral data were analyzed using HYPER-Tools 3 software (Mobarakhi 2018). Interesting challenges arise from the physico-chemical characteristics of kiwi, including the brown colour of the peel, its opacity, and the high-water content, which may complicate HSI analysis (Liu 2023). Thus, several steps were considered to identify similarities between chemical and physical changes in the fruit images and the progression of mechanical damage. First of all, preprocessing techniques such as derivatives and scattering removal were tested. Then, principal component analysis (PCA) and K-means clustering models were developed. Finally, the relationship between moisture and the reference parameters with time was investigated (**Figure 1b**).

The developed method could aid in preventing damaged fruits from entering the fresh market while facilitating alternative uses such smoothies' preparation.

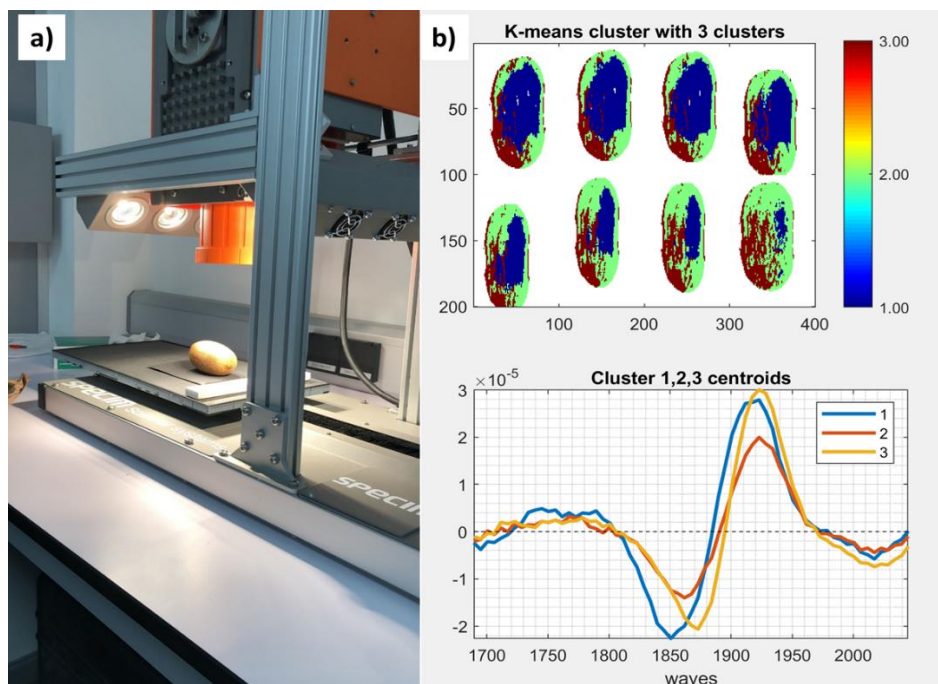


Figure 1. a) Example of the acquisition process. b) Example of results obtained from K-means clustering analysis on a restricted range of wavelengths. Upper: distribution of the clusters. Bottom: centroid of the cluster

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References

Hou 2023: Hou, Junming ; He, Zhenhu ; Liu, Deyu ; Zhu, Ziang ; Long, Zhenghang ; Yue, Xiang ; Wang, Wei. Mechanical Damage Characteristics and Nondestructive Testing Techniques of Fruits: A Review.” *Food Sci. Technol* 43 (2023) DoI: <https://doi.org/10.1590/fst.001823>

Liu 2020: Liu, Yanjun ; Yang, Zhijing ; Cao, Jiangzhong ; Ling, Wing-Kuen ; Liu, Qing. Detection of Invisible Damage of Kiwi Fruit Based on Hyperspectral Technique. *Advances in Brain Inspired Cognitive Systems*. Cham: Springer International Publishing. 373–382. Web. DoI: https://doi.org/10.1007/978-3-030-39431-8_36

Mobaraki 2018: Mobaraki, N; Amigo, JM. HYPER-Tools. A graphical user-friendly interface for hyperspectral image analysis. *Chemometrics and Intelligent Laboratory Systems* 172:15 (2018) 174-187. DoI: <https://doi.org/10.1016/j.chemolab.2017.11.003>