ADVANCED CHEMOMETRIC DISCRIMINATION OF INTACT ORGANIC AND CONVENTIONAL BROWN RICE KERNELS: COMPARING NIR BENCHTOP, HAND-HELD NIR AND NIR HYPERSPECTRAL IMAGING

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INTRODUCTION

- The rising demand for healthier and more sustainable food has boosted the production and consumption of organic brown rice.
- Near-Infrared Spectroscopy (NIRS) emerges as a fast, eco-friendly, and effective analytical technique to distinguish between organic and conventional brown rice, supporting authenticity verification and quality assurance.
- The study aimed to validation the performance of 3 different NIRS devices - benchtop, handheld, and hyperspectral imaging (NIR-HSI) - to distinguish organic from non-organic brown rice kernels.

MATERIAL AND METHODS

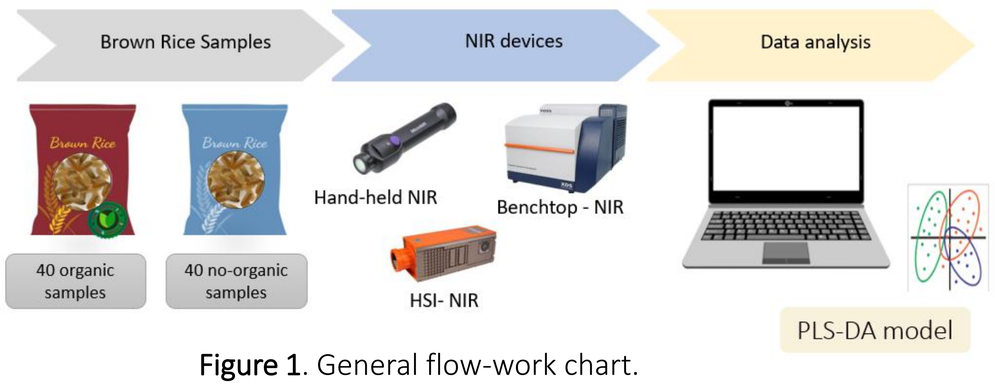

Figure 1. General flow-work chart.

- Instrument operation parameters:
  - **Benchtop device** XDS Rapid Content Analyzer (FOSS, Hillerød, Denmark): 800 nm–2498 nm at 2 nm resolution.
  - **Hand-held device** MicroNIR 1700 (Viavi Solution-Milpitas, CA, USA) : 908 nm–1676 nm at 6.2 nm resolution.
  - **NIR-HSI device** composed by ImSpector N25E spectrograph (SWIR Hyperspectral ImSpector N25E Burgermetrics, Riga, Latvia), and SWIR XEVA CL2.5 320 TE4 camera (Specim Ltd., Oulu, Finland) : 1100 nm–2400 nm at 6.3 nm resolution.
- For benchtop and handheld devices, the 80 samples were split into calibration (66 %) and validation (33 %) sets by Kennard-Stone algorithm.
- For the NIR-HSI device, a hierarchical classification system was applied (Figure 2). One image for sample was acquired (80 images), (i) 5 spectra of rice/img was used to remove background and (ii) the mean spectra of each image was used in PLS-DA models.

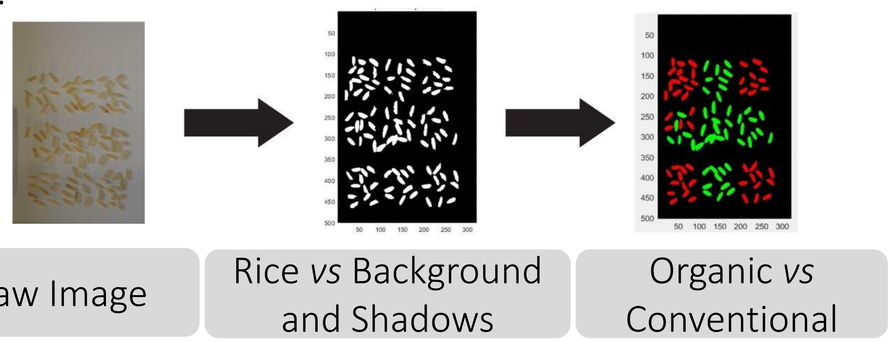

Figure 2. Hierarchical classification system. (A) Raw image, (B) classification model for rice *vs* background and shadows and (C) classification in organic *vs* conventional brown rice.

- NIR-HSI PLS-DA model was validated in two prediction modes directly from new images: (i) pixel-by-pixel and (ii)majority-pixel per rice kernel

RESULTS

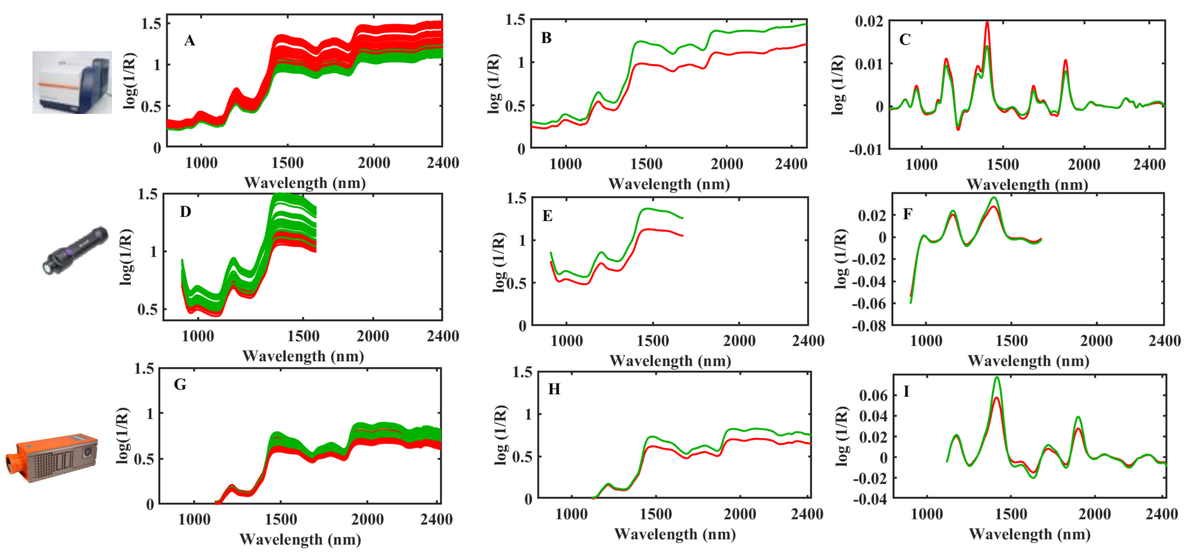

Figure 3. Raw spectral data, mean spectral data and pre-processed with first derivative from organic (--) and conventional (--) brown rice by benchtop NIR (A, B and C), handheld NIR (D, E and F) and NIR-HSI (G, H and I).

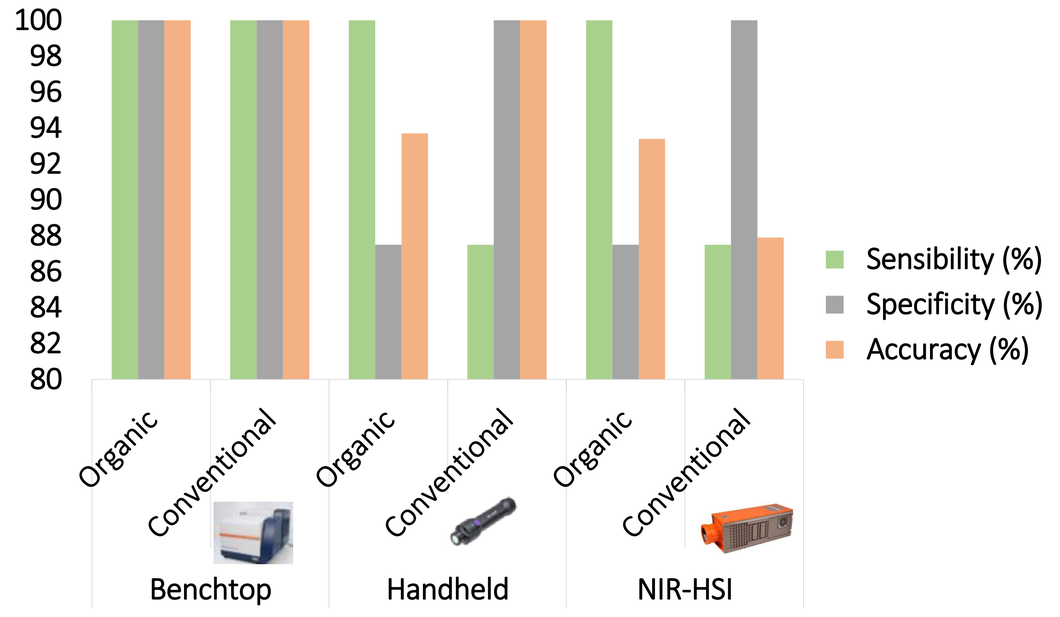

Figure 4. PLS-DA - Accuracy, sensibility and specificity for benchtop, handheld and NIR-HSI devices in validation set.

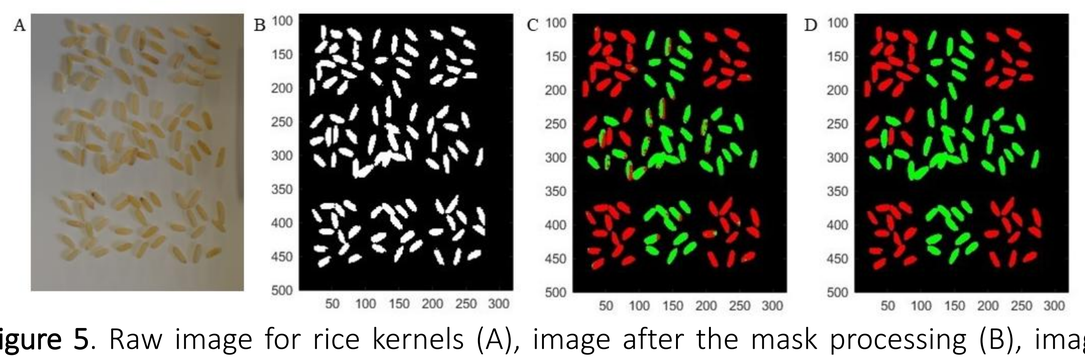

Figure 5. Raw image for rice kernels (A), image after the mask processing (B), image after the most probable prediction pixel by pixel (C) and according to the majority of pixel by kernel (D). Organic (●) and conventional (●) samples.

- PLS-DA models developed based on the spectra data obtained by the NIRS devices tested demonstrated satisfactory performance, achieving sensitivity, specificity and accuracy rates ranging from 87.5 % to 100 %, for hand-held and NIR-HSI devices and from 93.3 % to 100 % for benchtop device.

CONCLUSION

- Among the tested devices, the benchtop NIRS showed outstanding results. Based on its good performance, NIRS technology can be reliably applied to ensure the quality of organic brown rice.

- Acknowledgements: