CROPIQ: AN INTEGRATED MACHINE LEARNING FRAMEWORK FOR NUTRIENT DENSITY PREDICTION AND EXPORT-GRADE QUALITY ASSESSMENT OF SRI LANKAN MANGO AND BLACK PEPPER

P. L. A. Isidari Heleshika Alwis[1] & H. M. C. Ratnayake[2]*

[1]School of Computing and Engineering, University of West London (UWL), United Kingdom

[2]American Education (ANC), Sri Lanka

*Corresponding author: isidarialwis11@gmail.com

Abstract

Sri Lanka's agricultural sector requires reliable and scalable approaches to crop quality assessment and disease identification, as conventional inspection remains labour-intensive and dependent on subjective visual assessment. This study presents CropIQ, an integrated artificial intelligence decision-support framework combining Near-Infrared Spectroscopy (NIRS) and deep learning-based image analysis for mango (Mangifera indica) quality assessment and black pepper (Piper nigrum) disease classification. A quantitative experimental methodology was employed using the publicly available *Dataset of NIR Spectrum for Intact Mango Fruits* from Mendeley Data comprising 186 mango samples and 1,563 variables, including spectral measurements and measured soluble solids content (SSC), vitamin C and titratable acidity. SSC was operationalised into Low (<9 °Brix), Medium (9–<10 °Brix), and High (≥10 °Brix) categories, with original class counts of 7, 5 and 174, respectively, and classified using a Random Forest model. Class balancing using Synthetic Minority Over-sampling Technique (SMOTE) was performed before partitioning, producing 522 observations and an 80:20 split with 105 test observations; consequently, the resulting 92.38% accuracy was reported as preliminary rather than an independent estimate of generalisation. For black pepper, 3,155 images from the Sri Lanka PepperMate dataset, obtained from Zenodo, were partitioned into training (1,490), validation (830) and held-out test (835) sets across four classes: Healthy, Little Leaf, Slow Wilt and Thrips. MobileNetV2 transfer-learning achieved 92.81% held-out test accuracy and a macro-F1 score of 0.9276. SHAP (SHapley Additive exPlanations) was used for exploratory spectral-feature interpretation. CropIQ integrates the models into a web-based decision-support interface; export suitability is presented as model-derived guidance rather than regulatory certification. Overall, the findings demonstrate the feasibility of integrating heterogeneous spectral and image-based learning within a unified crop-assessment workflow, while leakage-controlled evaluation, independent datasets, validated ground-truth protocols and export-quality criteria remain necessary for future deployment.

Keywords: Artificial Intelligence, Machine Learning, Precision Agriculture, Crop Quality Assessment, Explainable AI