



Research article

ADVANCED QUALITY CHARACTERIZATION OF COMMERCIAL THAI ARABICA GREEN COFFEE BEANS USING SYNCHROTRON FTIR MICROSCPECTROSCOPY AND X-RAY TOMOGRAPHY

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ABSTRACT

Thai Arabica coffee has gained increasing recognition in the specialty coffee market due to its distinctive quality attributes and continuing development in post-harvest handling. This study applied synchrotron-based techniques for advanced quality characterization of commercially obtained Thai Arabica green coffee beans representing four post-harvest processing types: dry, washed, honey, and low-temperature/low-humidity (LTLH). Moisture content was determined in triplicate for each commercial sample. Synchrotron Fourier transform infrared (SR-FTIR) microspectroscopy, combined with second-derivative spectral preprocessing and principal component analysis (PCA), was applied to evaluate biochemical fingerprints associated with lipid-, protein-, and carbohydrate-related constituents, which are important quality-related components and potential contributors to aroma and flavor development during roasting. Approximately 50 spectra were initially acquired across three separately prepared subsamples for each processing type. Moisture contents differed significantly ($p < 0.05$) among the commercial samples, with LTLH beans showing the lowest value ($10.48 \pm 0.37\%$) and honey-processed beans showing the highest value ($12.64 \pm 0.09\%$). PCA of the SR-FTIR spectra showed clustering trends among the four commercial sample groups, with PC1 and PC2 explaining 15% and 12% of the total spectral variance, respectively. Dry-processed beans exhibited relatively stronger lipid- and ester-associated spectral features, whereas the LTLH sample showed more pronounced

carbohydrate/polysaccharide-related features. Complementary synchrotron X-ray tomographic microscopy (XTM), performed on three representative beans per processing type, provided non-destructive three-dimensional visualization of representative internal air-channel organization and dense bean matrix structure. The LTLH sample showed a more continuous and well-defined air-channel pattern in the representative XTM images. Since the coffee beans were commercially obtained and were not experimentally processed under controlled conditions by the authors, the observed differences should be interpreted as comparative quality-related characteristics rather than direct causal effects of specific processing parameters. Overall, the integration of SR-FTIR microspectroscopy and XTM provides complementary biochemical and structural information that may support advanced quality assessment of commercial Thai Arabica green coffee beans.
