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Quantitative and Qualitative Halal Authentication Analysis of Malaysian Animal-Based Fermented Food Products Using HPLC-DAD, FTIR-ATR Spectroscopy and Chemometric Approaches

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Abstract

Halal status verification of animal-based fermented food products is critical for protecting consumer health and ensuring regulatory compliance in Muslim-majority markets. This study presents a comprehensive evaluation of qualitative and quantitative aspects of Malaysian fermented food products using integrated chemical, spectroscopic, microbiological, and chemometric approaches. Histamine quantification by HPLC-DAD revealed concentrations ranging from 44.2–570.3 mg/kg, with 47% of samples exceeding the Codex Alimentarius limit of 100 mg/kg, indicating potential chemical safety concerns. FTIR-ATR spectral profiling distinguished fermentation-induced lipid modifications and differentiated halal products from non-halal reference lard samples, revealing

distinct molecular fingerprints across animal, plant, and fermented food matrices. Chemometric analysis using principal component analysis (PCA) and orthogonal partial least squares-discriminant analysis (OPLS-DA) in the wavenumber fingerprint region (1500–650 cm⁻¹) achieved clear sample discrimination and confirmed the absence of non-halal lipid adulteration. Microbiological assessments revealed total plate counts within acceptable regulatory limits, no detection of *Escherichia coli*, and controlled levels of *Staphylococcus aureus*, indicating satisfactory hygienic quality. These amalgamated findings establish a robust, multi-modal framework for halal authentication and quality control of fermented food products with direct implications for strengthening regulatory oversight, preventing food adulteration, and ensuring consumer protection in halal-certified food systems. © 2026, Gadjah Mada University. All rights reserved.

Author keywords

chemometric; fermented food; food safety; FTIR-ATR spectroscopy; halal authentication; histamine

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