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Geographical Origin Discrimination of Thai Durian Using Multi-Elemental Profiles by ICP-MS.

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Abstract

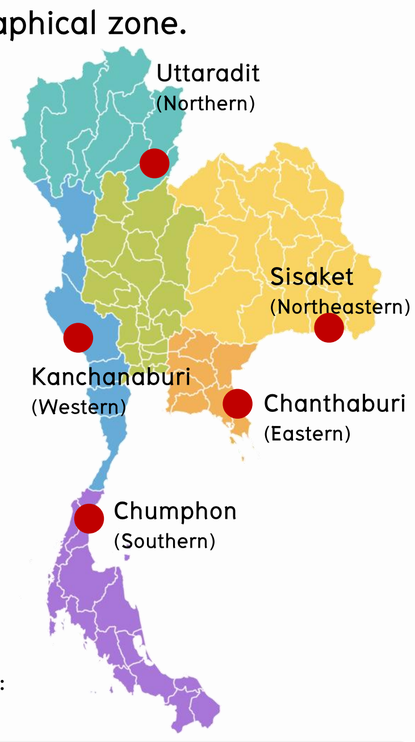
Geographical Indication (GI) authentication is essential for protecting the quality, reputation, and market value of Thai durian. This study evaluates the potential of multi-elemental composition as a chemical fingerprint for geographical origin discrimination. Durian samples were collected from five major production regions in Thailand—Uttaradit, Sisaket, Kanchanaburi, Chanthaburi, and Chumphon—along with samples of unknown origin. Elemental concentrations in seed, pulp, peel, and stalk tissues were determined using inductively coupled plasma mass spectrometry (ICP-MS). The analytical method showed excellent performance, with high linearity ($R^2 \geq 0.995$), low limits of quantification, and acceptable precision. Significant differences ($p < 0.05$) in elemental composition were observed among geographical origins and tissue types. Non-edible tissues, particularly peel and stalk, exhibited higher macro- and trace-element concentrations than edible tissues, highlighting their enhanced discriminatory potential. Linear Discriminant Analysis (LDA) using selected elements (Mg, K, Ca, Mn, Fe, and Zn) revealed clear clustering of samples from known regions, while samples of unknown origin showed elemental similarity to specific regional groups. Overall, multi-element profiling combined with exploratory chemometric analysis provides a practical approach for preliminary durian origin traceability and GI authentication.

Materials and Methods

1. Sample Collection

Fresh durian samples were collected from 5 major durian-producing regions of Thailand representing different geographical zone.

Upon arrival at the laboratory, each fruit was separated into 4 tissues: seed, pulp, peel, and stalk. Additional samples of undisclosed origin ("unknown samples") were included to evaluate the discriminatory performance and practical applicability of the proposed elemental fingerprinting approach.



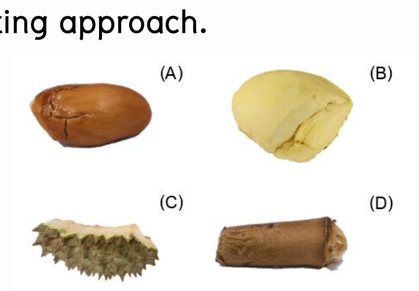
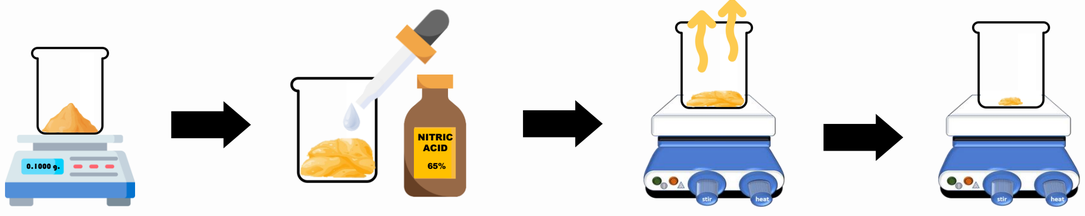


Fig.1 Morphological parts of durian used for multi-element analysis: (A) seed, (B) pulp, (C) peel, and (D) stalk

2. Sample Preparation and ICP-MS Analysis



weight (0.1 g) of the sample → 3.0 mL of 65% % HNO_3 → heated on a hot plate at 150 °C until near dryness → 10 mL of 2% HNO_3 → ICP-MS รุ่น 7700x, Agilent

3. Statistical and Chemometric Analysis

Two-way ANOVA ($p < 0.05$) with LSD post hoc testing was used to assess the effects of geographical origin and tissue type.

LDA was performed separately for each tissue using standardized (z-score) data. The first two discriminant functions explained >80% of the variance, showing clear regional clustering and supporting the use of elemental fingerprints for GI screening and unknown sample assessment.

Results

1. Analytical Performance and Method Validation

The instrument was optimized for the determination of macro- and trace elements, including Na (23), Mg (24), Al (27), K (39), Ca (43), Cr (52), Mn (55), Fe (56), Co (59), Ni (60), Cu (63), Zn (66), As (75), Rb (85), Sr (88), Cd (111), Ba (137), and Pb (208).

The ICP-MS method demonstrated excellent linearity (R^2 = 0.9954–0.9999), sensitivity (LOQ: 0.03–0.27 µg L^{-1}), and precision (%RSD: 0.2–6.3%). These results confirm reliable and reproducible multi-element determination in durian tissues, suitable for subsequent statistical and chemometric analyses.

2. Multi-Element Composition of Durian Samples

Significant differences ($p < 0.05$) in elemental concentrations were observed among geographical origins and tissue types. Macro-elements (Mg, K, Ca) showed pronounced regional variability, likely reflecting differences in soil and agro-environmental conditions.

Peel and stalk consistently contained higher macro- and trace-element concentrations than pulp and seed, indicating stronger potential for geographical discrimination and GI authentication.

The unknown sample (UNK1) fell within regional ranges, supporting the feasibility of multi-element fingerprints for preliminary origin assessment.

3. LDA modeling for origin traceability

The LDA score plot showed clear regional separation, with the first two discriminant functions explaining most of the variance. Macro- and trace elements jointly contributed to regional differentiation.

Partial overlap among clusters likely reflects similar environmental and agricultural conditions. Unknown samples clustered near Chanthaburi and Chumphon, indicating compositional similarity rather than confirmed origin.

LDA was used as an exploratory tool to assess the potential of elemental fingerprints for preliminary GI screening, not as a fully validated predictive model.

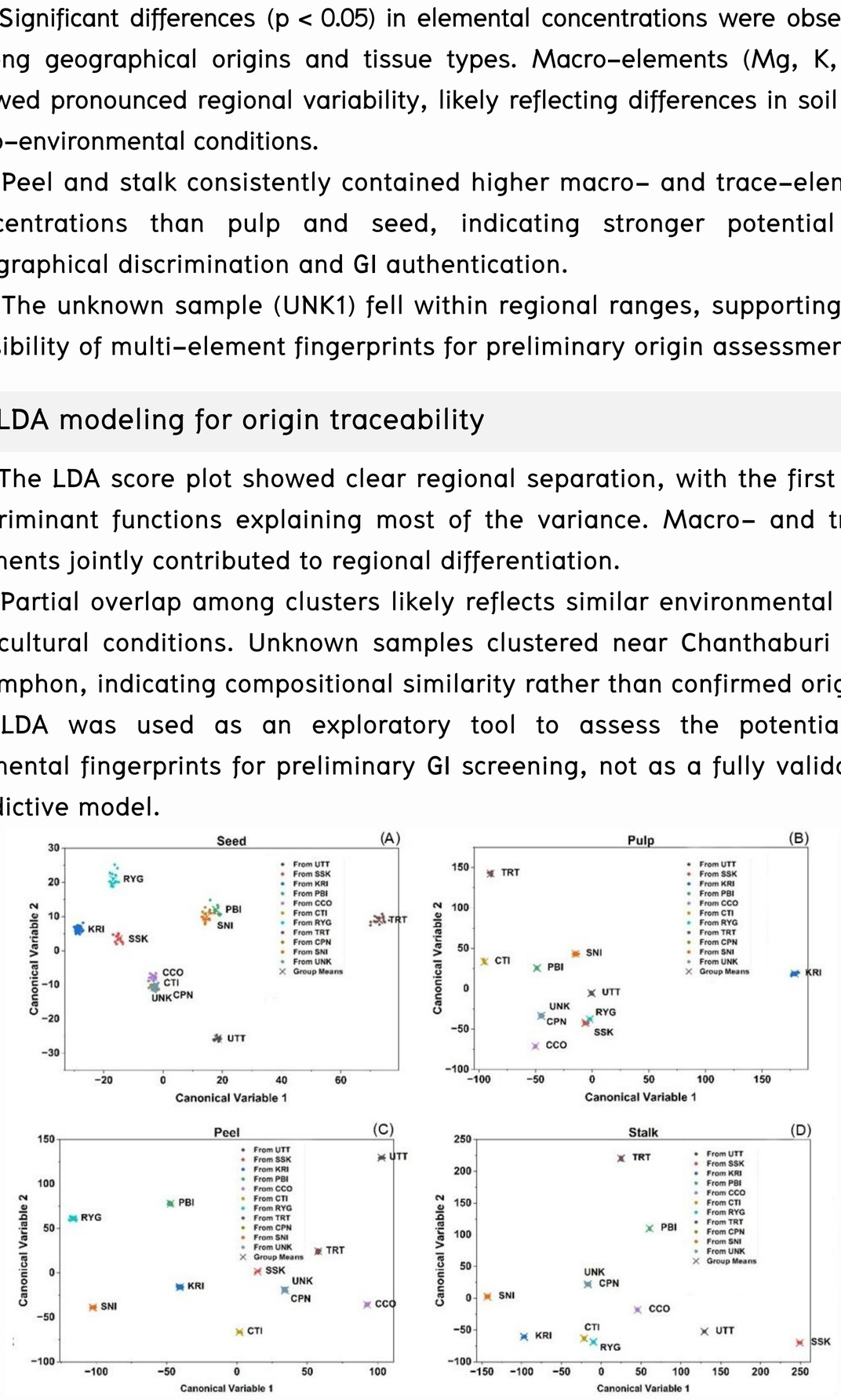


Fig.2 LDA score plots of durian samples based on selected elemental compositions (Mg, K, Ca, Mn, Fe, and Zn) for different tissues: (A) seed, (B) pulp, (C) peel, and (D) stalk. LDA score plots based on z-score standardized elemental concentrations.

Discussion

The validated ICP-MS method provided reliable multi-element data for chemometric analysis. Elemental variation was influenced by geographical origin and tissue type, with macro-elements (Mg, K, Ca) showing strong regional differences. Peel and stalk preserved stronger geographical signals than edible tissues, offering greater discrimination potential.

Exploratory LDA revealed meaningful regional clustering, though partial overlap reflected shared agro-environmental conditions. Unknown samples showed compositional similarity to certain regions but were not definitively assigned.

Overall, multi-element profiling combined with chemometrics supports preliminary GI screening of Thai durians, with further studies recommended to improve robustness and predictive power.

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