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Differentiating Philippine Robusta Coffee Origins Using X-Ray Fluorescence-Based Elemental Profiling

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Research Gap

Scientific evidence supporting the geographical authentication and traceability of Southeast Asian coffees remains limited. The lack of quantitative data linking the elemental composition of Philippine Robusta coffee (*C. canephora*) to its origin restricts opportunities for verified single-origin branding and Geographical Indication (GI) certification. This gap also makes the sector susceptible to mislabeling and fraud, highlighting the necessity for an objective, science-based approach to verify origin.

Analytical Approach

Energy-Dispersive X-Ray Fluorescence (EDXRF) was employed to obtain the elemental fingerprint of green Robusta coffee beans from four Philippine provinces. The resulting data were evaluated using chemometric techniques (PCA and LDA) and a machine learning algorithm (Random Forest / RF) to determine whether elemental patterns could differentiate provincial origins.

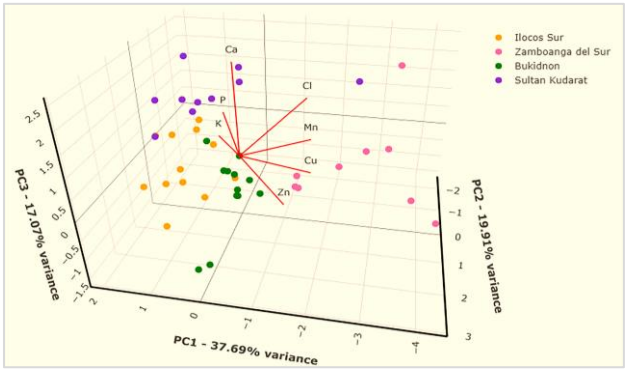
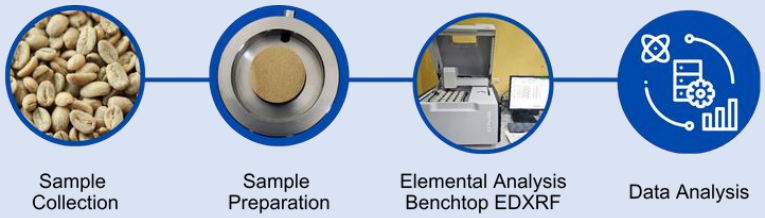


Fig. 1. 3D PCA biplot showing province-specific clustering of Philippine Robusta coffee samples based on elemental composition. *Adapted from Gines et al., Food Chemistry, 478 (2025) 143676.*

Methods

- **Samples:** 43 green Robusta coffee samples collected from Ilocos Sur (12), Bukidnon (12), Sultan Kudarat (10), and Zamboanga del Sur (9).
- **Elements Analyzed:** K, P, Ca, S, Cl, Fe, Cu, Mn, Sr, and Zn



Results

- **Elemental Variability:** Welch's ANOVA identified seven significant elements (K, P, Ca, Cl, Cu, Mn, and Zn) among provinces. These elements were used for PCA and LDA, while all ten elements were analyzed using RF.
- **PCA:** Revealed province-specific clustering (Fig. 1). Elements Cu, Mn, Cl, and Zn mainly influenced PC1; K and P contributed to PC2; and Ca dominated PC3.
- **LDA:** Yielded 79% classification accuracy (Fig. 2), highlighting Zn, Mn, Cl, Cu, Ca, K, and P as key discriminating variables.
- **RF:** Improved classification to 84% accuracy, ranking Fe, Cl, Ca, Mn, Cu, and Zn as the most influential elements.

Full article published in Food Chemistry (2025); see References for details.

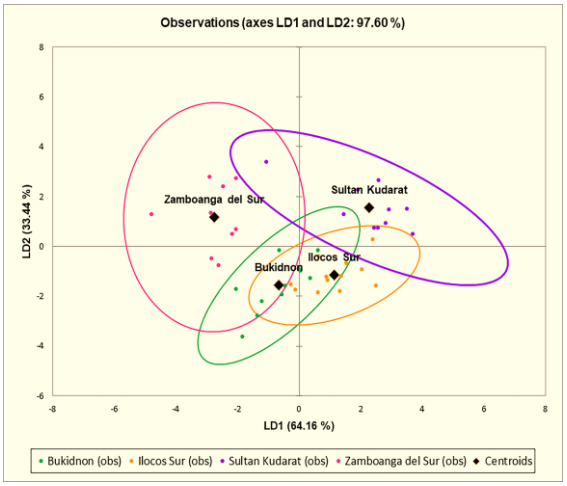


Fig. 2. LDA score plot showing the separation of Philippine Robusta coffee samples from four provinces. *Adapted from Gines et al., Food Chemistry, 478 (2025) 143676.*

Conclusions and Perspectives

EDXRF combined with chemometric and machine-learning tools effectively differentiated Robusta coffee (*C. canephora*) by provincial origin, providing baseline evidence for authentication and traceability. The approach offers a rapid, non-destructive foundation for future GI certification of Philippine coffee. Ongoing efforts focus on expanding the dataset, applying the method to other species, and exploring its broader application in traceability systems for the Philippine coffee industry.

References

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