Optimization of Arabica Coffee Fermentation Using Palm Sap: A Metabolomics-Based Study

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Abstract

Coffee fermentation plays a crucial role in shaping the chemical composition and sensory quality of coffee. This study investigated the effects of fermenting whole Arabica coffee cherries in solutions containing 10% and 20% (v/v) sugar palm sap (*Arenga pinnata*) for 48 hours, followed by conventional natural processing, on coffee metabolite profiles and microbial communities. GC–MS-based metabolomics identified various metabolites, including sugars (sucrose, glucose, fructose, and arabinose), organic acids (lactic, glycolic, glyceric, citric, and succinic acids), and sugar alcohols (inositol and mannitol). OPLS-DA showed distinct metabolic profiles among treatments, with $R^2X = 0.867$, $R^2Y = 0.863$, and $Q^2 = 0.425$. A 200-permutation test yielded R^2 and Q^2 intercepts of 0.477 and −1.080, respectively. The loading plot indicated that glycolic and glyceric acids were associated with the control, sucrose, glucose, and fructose with 10% palm sap fermentation, and lactic acid, phosphoric acid, inositol, and mannitol with 20% palm sap fermentation. Microbial profiling identified diverse bacterial and fungal taxa, including *Erwinia, Pantoea, Pseudomonas, Fusarium*, and *Yamadazyma*. These findings suggest that palm sap-assisted fermentation is associated with concentration-dependent variations in coffee metabolite profiles, highlighting its potential for modifying the chemical characteristics of naturally processed Arabica coffee.

Keyword: Coffea arabica; Arenga pinnata; palm sap-assisted fermentation; GC–MS-based metabolomics; OPLS-DA; microbial communities; natural coffee processing.

Method

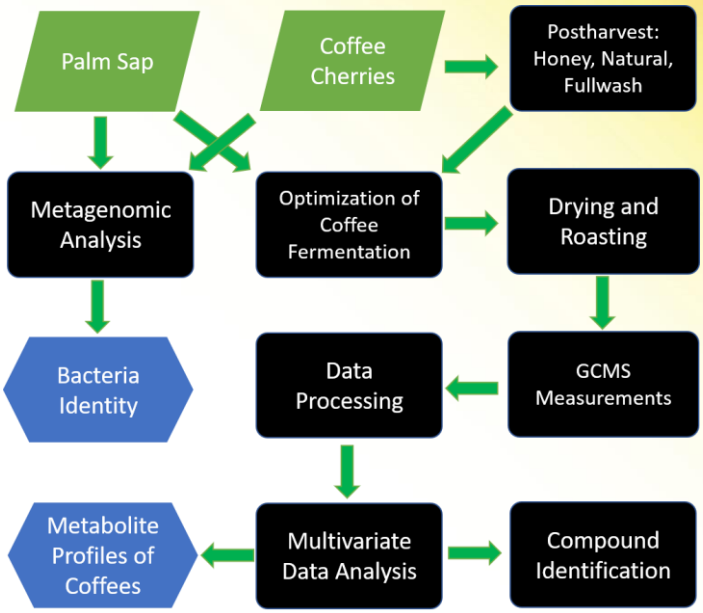


Figure 1. Research workflow

Results

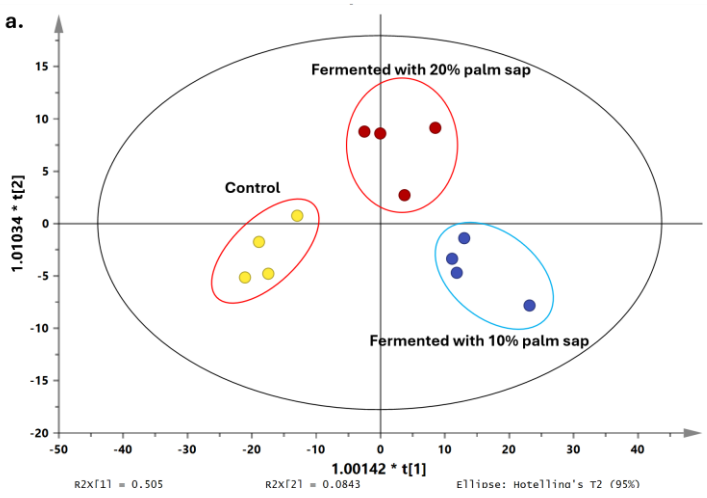
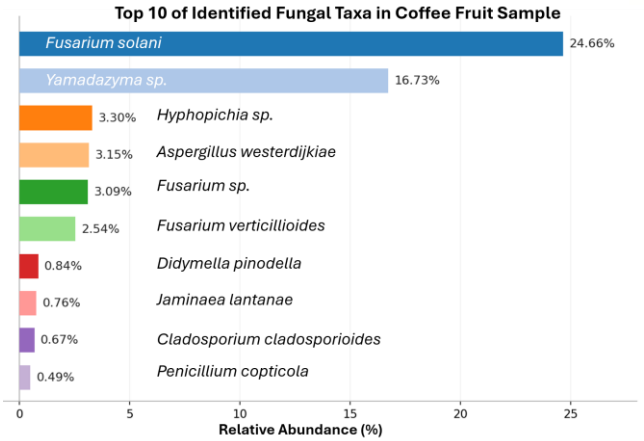
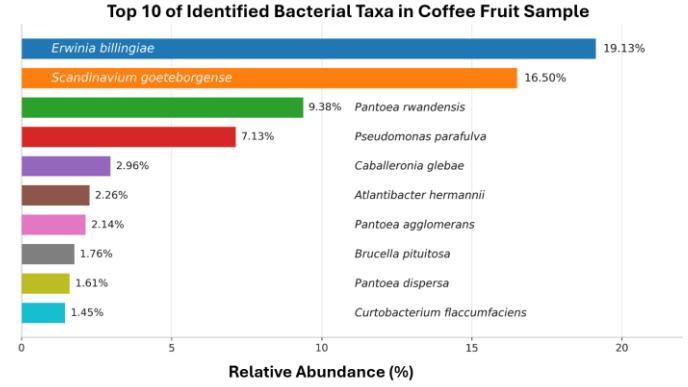


Figure 2. OPLS-DA score plot (A) and loading plot (B) of GC–MS-based metabolite profiles of Arabica coffee fermented with 10%, and 20% (v/v) sugar palm sap, and the control.





Conclusion

Palm sap-assisted fermentation influenced the metabolite profiles of naturally processed Arabica coffee. GC–MS-based metabolomics coupled with OPLS-DA revealed distinct metabolic profiles among the control, 10%, and 20% palm sap treatments, particularly in sugars and organic acids. Microbial profiling identified diverse bacterial and fungal communities potentially associated with coffee fermentation. These findings highlight the potential of palm sap as a natural fermentation medium for modifying coffee chemical composition.