

Quality Characterization of Arabica Coffee Soaked at Different Fruit Maturity Levels

Husnah Ansari¹, Reta Reta^{1*}, Zaimar Zaimar¹, Sitti Nurmiah¹, Nadiyah Nur², Syamsia Syamsia³, and Arnida Mustafa¹

¹Department of Agriculture Technology, Pangkep State Polytechnic of Agricultural, Pangkajene Kepulauan, 90655, South Sulawesi, Indonesia

²Department of Food Science, Hasanuddin University, 90245, Makassar, South Sulawesi, Indonesia

³Department of Agribusiness, Muhammadiyah University, Makassar, South Sulawesi, Indonesia

Abstract. This research investigates the effect of hot water soaking on the physical, chemical, and sensory properties of Arabica coffee before pulping. The study employed a Completely Randomized Design with factorial arrangements to compare container types (plastic and stainless steel) and cherry ripeness levels (red, semi-ripe, green). Physical quality assessments adhered to SNI standards, while chemical and sensory evaluations employed validated titratable acidity protocols and SCAA cupping procedures. Results show that soaking reduced defect counts, improved grade classifications, and preserved balanced acidity. Green cherries benefited most, achieving Grade 1 quality when soaked in plastic containers. Sensory analysis indicated consistently high scores in uniformity, sweetness, and clean cup attributes, with no taints detected. The findings suggest that soaking facilitates cleaner fermentations and mitigates pulping challenges for firmer cherries. Economically, the method offers a cost-effective quality upgrade suitable for smallholder integration into existing workflows. Environmental considerations underscore the importance of effective water management and effluent treatment in supporting sustainable growth and expansion. This work contributes to the growing body of post-harvest innovation literature by positioning soaking as a viable, low-complexity intervention for improving speciality coffee quality. Future studies should optimise soak parameters for different cultivars and climates, and correlate quality gains with specific biochemical and sensory markers.

1 Introduction

Indonesia is the world's fourth-largest coffee producer [1, 2, 3]. The main varieties that are widely produced in Indonesia are robusta and arabica [4]. Coffee from the Toraja region has long been recognized for its distinctive aroma and flavor [6]. Postharvest handling, particularly fruit maturity at harvest and pre-fermentation treatment, plays a critical role in the final quality of coffee [7]. Farmers often harvest all remaining fruits once 90% of the cherries are ripe, resulting in mixed maturity levels during processing. This results in low

* Corresponding author: retariskinapolitani@gmail.com

productivity and quality of coffee production [8]. The global Arabica coffee market has experienced substantial growth over the past decade, with Indonesia playing a pivotal role as the fourth largest producer, contributing approximately 683.64 million kilograms annually, or about 11% of global production. Within Indonesia, the Tana Toraja region has established itself as a leading source of high-quality Arabica coffee, celebrated for its distinctive flavor profiles and sensory appeal [10,11]. This recognition has been amplified by the surging demand for speciality coffee worldwide, which has incentivised producers to adopt sustainable and innovative agricultural practices that enhance both quality and productivity. Such developments underscore Indonesia's significant influence on the global coffee industry and its potential for further market expansion.

Post-harvest handling is a decisive factor in determining the physical and sensory attributes of Arabica coffee beans. The processes of cherry selection, fermentation, drying, and storage have a direct impact on the quality of the final product. For example, inadequate fermentation conditions can produce undesirable flavors and aromas, reducing consumer acceptance and lowering market value. Conversely, carefully managed post-harvest processes can enhance key sensory qualities such as aroma, acidity, and body, thereby increasing coffee's appeal and competitiveness in both domestic and export markets [13]. Producers in regions such as Aceh and Toraja have increasingly adopted sustainable, environmentally friendly processing practices that not only enhance coffee quality but also bolster local economies. These factors collectively highlight the importance of post-harvest innovation as a cornerstone of competitive advantage in the global coffee trade.

Among the most influential post-harvest factors is the choice of processing method. Wet, semi-wet, and dry processing each impart distinct physical and chemical characteristics to coffee beans, with corresponding impacts on sensory qualities. Wet processing involves depulping cherries, fermenting, and washing to remove mucilage, often resulting in bright acidity and a clean flavor profile due to the reduction of fermentation by-products. Controlled fermentation during wet processing can develop complex flavor notes, although environmental conditions and genetic factors may lead to lower scores in odor and overall quality compared to dry processing in certain context. In contrast, dry processing—where whole cherries are sun-dried—tends to yield richer flavors and more complex aromas by allowing sugars from the fruit to interact with the beans over a prolonged period. However, this method requires rigorous monitoring to prevent spoilage and off-flavours, as uncontrolled fermentation can occur easily. The semi-wet method incorporates elements of both, producing balanced acidity and fruitiness that appeal to a broad consumer base.

Delayed pulping, wherein harvested cherries are not depulped immediately, poses a significant challenge to quality preservation. Extended contact between the pulp and bean promotes undesirable enzymatic activity and microbial fermentation, resulting in off-flavours and a degraded sensory profile. Such delays can also compromise the chemical composition of beans, diminishing compounds responsible for preferred flavors. Consequently, timely pulping is critical for maintaining both the intrinsic and perceived quality of Arabica coffee.

To address these challenges, various solutions have been explored, including adjustments to fermentation processes, soaking treatments, and controlled environmental processing. Soaking, particularly in hot water, has emerged as a practical approach to facilitate pulping and reduce physical defects. By softening the mucilage and parchment layers, soaking can improve processing efficiency while preserving key sensory attributes. Fermentation-based methods, such as double fermentation, have also demonstrated potential to enhance flavour complexity and uniformity, thereby further contributing to speciality-grade classification.

Coffee quality assessment is guided by standards such as the Specialty Coffee Association of America (SCAA) protocols and the Indonesian National Standards (SNI). The SCAA protocol evaluates aroma, flavor, acidity, body, aftertaste, balance, and overall harmony, with scores above 80 indicating speciality-grade quality. The SNI standard similarly outlines

criteria for both physical and chemical attributes, ensuring that coffee products meet established quality benchmarks. Adherence to these frameworks enables producers to position their coffee competitively in both domestic and international markets, reinforcing the economic and cultural value of high-quality Arabica coffee.

Despite advances in knowledge processing, research gaps persist in optimising soaking methods for different ripeness levels of Arabica cherries. While soaking has been shown to improve pulping efficiency, the extent to which variables such as container type, water temperature, and cherry maturity affect final quality has not been fully explored. Existing literature suggests that such factors may interact in complex ways, influencing both physical characteristics and sensory outcomes. This gap is particularly relevant for smallholder farmers in Indonesia, where resource limitations necessitate simple, cost-effective interventions that can reliably enhance quality without requiring extensive technological investment.

The present study aims to evaluate the impact of soaking treatments—specifically hot-water soaking using different container materials—on the physical quality, acidity, and sensory attributes of Arabica coffee cherries at varying ripeness stages. By systematically assessing these variables, the research aims to identify practical and scalable methods to enhance post-harvest handling of Indonesian Arabica coffee. The novelty of this work lies in its combined focus on container type, water temperature, and cherry maturity, offering a nuanced understanding of how these factors jointly influence coffee quality. The findings are expected to provide actionable recommendations for farmers and processors, supporting both quality enhancement and economic sustainability in the competitive specialty coffee market.

2 Methodology

This study employed rigorous experimental and analytical approaches to evaluate the effects of soaking treatments on the physical, chemical, and sensory qualities of Arabica coffee. Two key methodological frameworks were employed: an experimental design for evaluating post-harvest treatments and validated laboratory methods for quality assessment.

The experimental design selected was the Completely Randomized Design (CRD), widely recognized in agricultural research for its simplicity and ability to minimize bias through randomization. This design is particularly advantageous for controlled comparisons of processing techniques under uniform conditions, as supported by prior studies examining biochemical and sensory impacts of various post-harvest methods. The CRD structure enabled a clear analysis of the effects of soaking variables while controlling for extraneous influences.

Given the study's multifactorial nature—assessing both container type and cherry ripeness level—a factorial arrangement within the CRD framework was also considered. Factorial designs are well-suited for investigating interactions between multiple variables, offering comprehensive insights into how treatment factors collectively influence coffee quality. Prior work has demonstrated the utility of factorial designs in evaluating post-harvest processes, including the combined effects of fertilisation and drying techniques on the physical and chemical properties of coffee. This approach enhances the robustness of the results by quantifying both main effects and interaction effects.

2.1 Experimental site and materials

The study was conducted in a controlled post-harvest processing facility equipped for precise temperature and environmental control. Arabica coffee cherries were sourced from a single origin to ensure uniformity in genetic and environmental background. Two soaking

containers—plastic basins and stainless steel vessels—were tested. Cherries were categorised into three ripeness stages: red, semi-ripe (also known as bancut), and green.

2.2 Treatment application

Soaking treatments were performed using water heated to 90°C. Cherries were submerged in either plastic or stainless steel containers for a fixed duration before pulping. This procedure was designed to soften the mucilage, facilitating mechanical pulping and potentially reducing the incidence of defects. The application of hot water soaking draws from earlier research demonstrating its role in improving pulping efficiency without adversely affecting sensory characteristics.

2.3 Physical quality assessment

The physical quality of the coffee was evaluated in accordance with the Indonesian National Standards (SNI). Parameters included bean size distribution, measured using standardized sieves; bean moisture content, determined with a calibrated moisture meter; and bean density, assessed volumetrically. Size distribution was expressed as the percentage retained on each sieve size, with larger beans generally associated with higher market value and consumer preference. Defect analysis was conducted visually, with defects classified according to SNI categories, enabling calculation of total defect counts per sample.

2.4 Acidity measurement

Acidity was quantified through titratable acidity analysis, a validated laboratory method correlating well with perceived sensory acidity in coffee. The procedure involved brewing coffee from each sample and titrating a measured aliquot with standardised 0.1 N sodium hydroxide solution to an endpoint determined by a phenolphthalein indicator. Results were expressed as a percentage of lactic acid equivalent, facilitating direct comparison across treatments. This approach ensured analytical consistency and comparability with prior studies that examined the impacts of processing on acidity.

2.5 Sensory evaluation

Sensory quality was assessed through cupping, following the protocols of the Speciality Coffee Association of America (SCAA). Trained panellists evaluated samples for fragrance/aroma, flavor, aftertaste, acidity, body, balance, and overall impression. Each attribute was scored on a 0–10 scale, with additional points for uniformity, clean cup, and sweetness. The SCAA system's consistency and widespread acceptance ensured that results could be benchmarked against global standards for speciality coffee. Cupping sessions were conducted in a sensory evaluation laboratory under controlled lighting and ventilation to minimize external influences.

2.6 Data analysis

Data from physical, chemical, and sensory evaluations were subjected to statistical analysis using analysis of variance (ANOVA) appropriate for CRD and factorial arrangements. Significant differences among treatment means were identified using post-hoc tests at a 5% significance level. Interaction effects between container type and cherry ripeness were examined to identify potential synergies or trade-offs in quality outcomes.

3 Results and Discussion

3.1 Correlation of cherry ripeness, soaking conditions, and physical quality

The maturity stage of the coffee cherry and the soaking conditions preceding pulping were strongly associated with the physical attributes of the resulting Arabica beans. Across treatments, cherries sorted as red (B1), semi ripe/bancut (B2), and green (B3) displayed distinct patterns in moisture content, size distribution, and defect incidence. Table 1 summarizes the SNI based physical quality assessment, showing uniformly clean samples (normal smell, no insects, and no foreign matter) and treatment-dependent differences in moisture content. In particular, the A1B1 treatment (plastic basin × red cherry) presented the lowest moisture value at 4.50%, while A1B2, A1B3, A2B1, A2B2, and A2B3 recorded 9.50%, 7.50%, 6.00%, 5.50%, and 6.50%, respectively (Table 1). These values fall within the recommended ranges for safe storage and align with the expectation that riper cherries dry more quickly under similar post-harvest conditions, thereby reducing the risk of microbial deterioration during subsequent handling.

Table 1. Physical quality of Arabica coffee beans (SNI No. 01 2907 2008).

Test Parameters	A1B1	A1B2	A1B3	A2B1	A2B2	A2B3
Moisture, %	4.50	9.50	7.50	6	5.50	6.50
Smell	Normal	Normal	Normal	Normal	Normal	Normal
Insect	Nil	Nil	Nil	Nil	Nil	Nil
Foreign matters	Nil	Nil	Nil	Nil	Nil	Nil

Bean size distribution corroborated the moisture findings. The proportion of beans retained on wider screens was highest in several treatments, indicating an overall prevalence of larger beans (Figure 1). This observation is consistent with evidence that physiologically mature cherries often develop larger seeds, which are frequently associated with higher market grades [5]. At the same time, soaking conditions before pulping appeared to facilitate mucilage softening and parchment pliability, thereby reducing the mechanical stress exerted during pulping and contributing to improved seed integrity. Literature suggests that poorly controlled hydration stages can increase physical stress, elevate the incidence of cracks, and predispose beans to fungal invasion during the drying process. Conversely, managed hydration—here implemented as a controlled hot water soak—mediates thermal and moisture diffusion into the cherry, helping to stabilize subsequent physical handling.

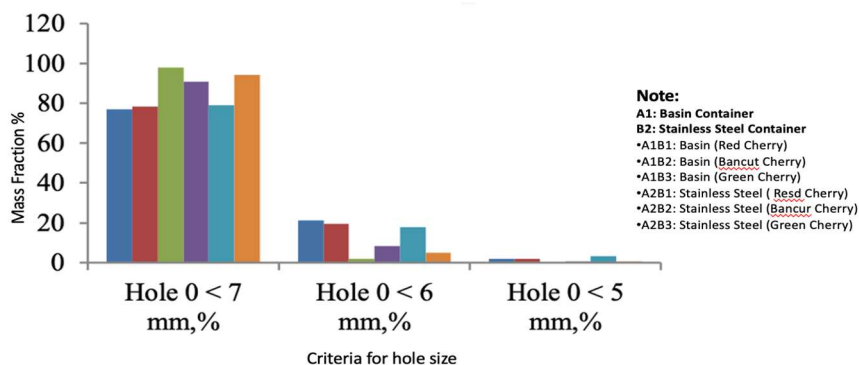


Fig. 1. Coffee bean size distribution across treatments (screen retained fractions).

Defect scores revealed marked advantages for green cherry treatments when soaking preceded pulping. The A1B3 combination yielded the lowest defect value and achieved a Grade 1 classification, while A2B3 achieved a Grade 2 classification (Figure 2). These outcomes indicate that hot water soaking before pulping is particularly effective for firm, less mature cherries, in line with reports that appropriately timed hydration can minimize parchment adherence and mechanical breakage during pulping [48]. The results also demonstrate that the choice of soaking container may modulate heat retention and convection patterns. In practice, plastic basins may cool more slowly or create different thermal gradients than stainless steel vessels, which can slightly alter mucilage softening and thereby affect defect outcomes. Such container-mediated effects are consistent with broader evidence that processing microenvironments influence physical integrity.

Collectively, these findings support two complementary conclusions. First, cherry ripeness is a primary driver of physical quality, affecting moisture, size, and susceptibility to defects, echoing the consensus that selective harvesting is central to quality management [5]. Second, properly standardised soaking conditions add measurable value by improving pulping performance and the structural integrity of beans, thereby reducing post-harvest defect rates.

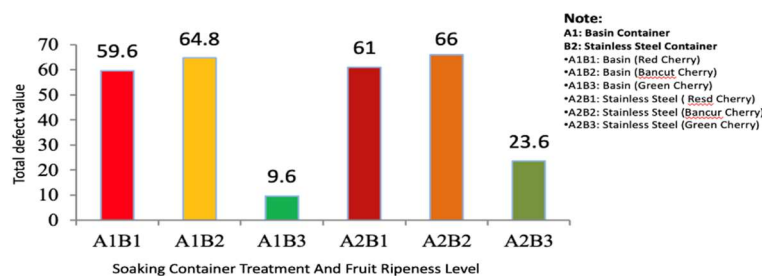


Fig. 2. Defect scores and grade assignments for each soaking × ripeness combination.

3.2 Bean size, market value, and environmental/processing drivers

The size distribution observed across treatments maps onto two dimensions of quality: market value and sensory expectation. Larger, uniform beans often command price premiums due to

aesthetics and perceived quality; in some markets, screen size functions as a de facto sorting and payment criterion. However, the relationship between size and sensory excellence is not deterministic. While larger beans can reflect prolonged maturation and potentially more complete biochemical development, flavor and aroma ultimately depend on complex chemical matrices [15]. Comparative work shows that genetic–environment interactions and climate variables influence mass, density, and biochemical composition, explaining why size alone does not guarantee superior cup quality. In our data, the predominance of larger fractions (Figure 1) coincided with favourable defect scores in green cherry treatments; however, sensory advantages were distributed across treatments rather than confined to the single largest screen category.

Beyond morphology, environmental drivers such as altitude, rainfall regularity, and soil fertility shape bean development. High-elevation cultivation favours slower cherry maturation and a tendency toward larger seeds with enhanced flavour complexity. Agronomic practices—particularly balanced potassium fertilization—also improve physical quality metrics and can shift size distributions [9]. Post harvest processing, including the decision to implement controlled soaking, then interacts with these pre harvest factors. Here, the soaking step likely mitigated mechanical impacts during pulping, supporting the retention of intact, larger beans and contributing to a lower prevalence of size-related defects. Drying kinetics are another determinant: excessive airflow or rapid drying can cause differential shrinkage, disproportionately affecting smaller seeds and elevating breakage. Our moisture trajectories (Figure 3) suggest that all treatments reached safe endpoints; however, the lowest moisture in A1B1 implies faster water removal for riper cherries, which merits careful control to avoid internal fissuring in future scale-ups.

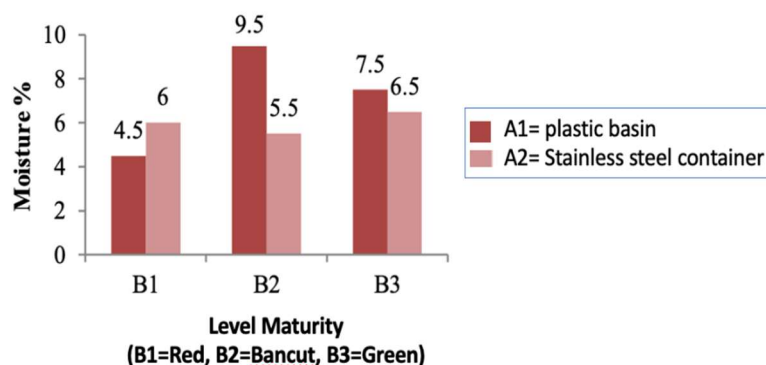


Fig. 3. Graph of moisture content.

3.3 Defects and compliance with grading standards

Defects remained the central discriminator among treatments, directly informing SNI-based grade outcomes (Figure 2). The superior performance of A1B3 (Grade 1) and A2B3 (Grade 2) demonstrates that pairing soaking with green cherries is an effective strategy for defect reduction. Mechanistically, hot-water soaking facilitates mucilage loosening, improving pulper throughput and minimizing parchment tearing or seed chipping—defects that otherwise lower market grade. These observations align with evidence that controlled hydration diminishes mechanical injury and mitigates the risk of secondary fungal colonization during drying. In practice, cleaner parchment removal reduces the reservoir of fermentable substrates on seed surfaces, indirectly discouraging microbial growth.

Adherence to grading systems such as SNI is contingent on meeting composite thresholds that include physical cleanliness, moisture limits, and defect counts. Treatments meeting low-defect thresholds advance to higher grades, improve lot uniformity, and signal better risk management to buyers. Literature further supports the notion that the choice of processing method—washed, honey, or natural—modulates defect profiles and flavour chemistry; combining method optimisation with standardised soaking can yield additive benefits. Our outcomes suggest that targeted, low-cost interventions—here, the pre-pulp soak—can significantly impact compliance with speciality-oriented standards, even without substantial capital investment.

3.4 Acidity, organic acid composition, and consumer relevance

Titrateable acidity analysis revealed modest variation among the assessed treatments, consistent with the notion that soaking before pulping has a limited direct influence on bulk acid content under otherwise controlled processing conditions. Nevertheless, fermentation dynamics and drying trajectories remain capable of shifting organic acid profiles in ways that shape sensory perception. Chlorogenic, quinic, and caffeic acids are particularly salient in Arabica; changes in their relative abundance can alter perceived brightness and aftertaste. Brewing variables modulate acid extraction efficiency, yet multiple studies report that overall titrateable acidity varies only modestly across typical brewing temperature ranges. Within this context, the moisture results (Figure 3) and the acidity graph (Figure 4) suggest that the soaking step neither inflated nor depressed acid levels beyond typical experimental noise.

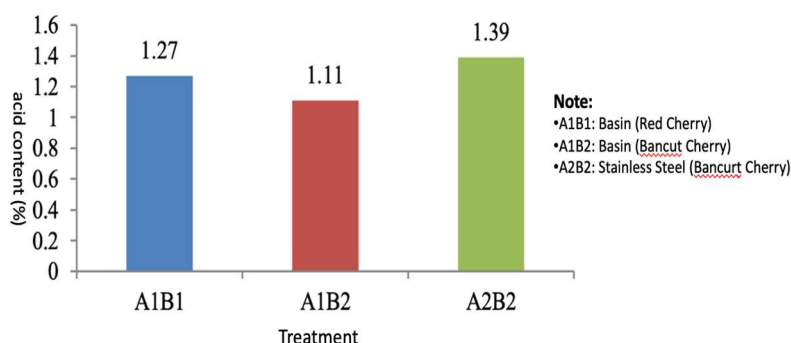


Fig. 4. Titrateable acidity (%) across selected treatments.

From a consumer perspective, preferences for acidity are segmented. Enthusiast segments often equate higher, well-integrated acidity with freshness and flavor complexity, while other consumers prefer rounder profiles with moderated sourness. The cupping data reported below reflect this balance: treatments with disciplined physical integrity and clean processing achieved high scores in uniformity, clean cup, and sweetness, indicating that whatever minor shifts occurred in acid composition did not translate into penalties in holistic liking.

3.5 Organoleptic outcomes: fragrance, flavor, and overall quality

Sensory evaluation, conducted under SCAA protocol, provided a holistic view of treatment performance. All samples achieved high auxiliary scores for uniformity, clean cup, and sweetness, indicating consistent processing and low contamination. Fragrance and flavor attributes varied more distinctly across treatments. Green-cherry treatments exhibited

elevated fragrance scores and notes that included caramel, sugar cane, nutty, chocolate, and citrus tones, consistent with the balanced development of volatile compounds under controlled hydration and drying conditions. These aromatic signatures align with literature indicating that pre-pulp hydration and careful post-harvest control enhance volatile retention and complexity, particularly when combined with gentle drying regimes.

Aftertaste, acidity, body, balance, and overall impression showed modest but meaningful differentiation among treatments. Samples from the plastic-basin × green cherry condition presented clean, lingering aftertastes and a medium body, with acidity integrated into a sweet matrix—attributes that cuppers frequently associate with high speciality potential. Stainless steel × green cherry presented a slightly leaner body but maintained desirable citrus-nutty combinations, suggesting that container heat transfer may subtly modulate volatile evolution and mouthfeel. Treatments involving red and semi-ripe cherries tended toward rounder profiles with lower aromatic intensity but preserved high cleanliness and sweetness, which often translates to consumer acceptance in broader markets.

The conjunction of low defect counts and strong organoleptic performance in green-cherry treatments underscores the operational value of incorporating a standardised soak before pulping. While the industry commonly prioritises harvesting at full ripeness for cup complexity, our results show that, under disciplined soaking and processing, less mature cherries can still produce beans that meet stringent physical criteria and deliver appealing flavour profiles. This aligns with recent evidence that processing innovations can partly compensate for pre-harvest variability, enabling producers to stabilize quality across uneven harvests. Importantly, the high scores for uniformity and clean cup across all treatments confirm that the soaking intervention did not introduce off-flavours or hygiene risks; rather, it supported consistent cup profiles within the speciality threshold.

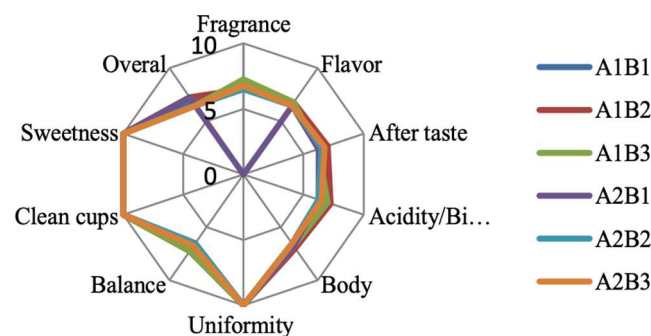


Fig. 5. Sensory performance by attribute under SCAA protocol across soaking × ripeness treatments.

4 Conclusion

This study demonstrates that hot water soaking before pulping can significantly enhance the physical and sensory quality of Arabica coffee, particularly when processing mixed maturity cherries. Key findings reveal that soaking improves grade outcomes, especially for green cherries, reduces defect counts, and preserves desirable chemical attributes such as balanced titratable acidity. Sensory evaluations consistently showed high scores for uniformity, clean cup, and sweetness, indicating that soaking supports clean fermentation trajectories without introducing off-tastes. The results underscore the method’s potential as a low-cost, high-impact intervention for smallholder farmers seeking to enhance product quality and marketability. Beyond the immediate quality gains, the technique offers economic benefits

by enabling access to speciality markets and reducing losses from downgraded beans. However, scaling requires attention to environmental sustainability, water use efficiency, and farmer training to ensure consistent outcomes. Integrating soaking into broader post harvest workflows can strengthen quality management systems and contribute to climate resilience strategies in coffee production. Future research should explore optimal soaking parameters under diverse environmental conditions, investigate interactions with downstream processing stages, and speciality coffee quality.

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References

1. Leewellyn, V. S., & Palupi, S. (2020). Coffee Tourism: from Home Products to Attractions. *E-Journal of Tourism*, 88. <https://doi.org/10.24922/eot.v7i1.57861>
2. Yulia, M., Analiasari, A., Widodo, S., Kusumiyati, K., Naito, H., & Suhandy, D. (2023). The authentication of Gayo Arabica green coffee beans with different cherry processing methods using portable LED-based fluorescence spectroscopy and chemometrics analysis. *Foods*, 12(23), 4302. <https://doi.org/10.3390/foods12234302>
3. Rahardjo, B., Akbar, B. M. B., Iskandar, Y., & Shalehah, A. (2020). Analysis and strategy for improving Indonesian coffee competitiveness in the international market. *BISMA (Bisnis Dan Manajemen)*, 12(2), 154. <https://doi.org/10.26740/bisma.v12n2.p154-167>
4. Tampubolon, J., Ginting, A., Nainggolan, H., & Tarigan, J. (2023). Indonesian Coffee Development Path: Production and International Trade. *Asian Journal of Agricultural Extension, Economics & Sociology*, 41(12), 316-328. <https://doi.org/10.9734/ajaees/2023/v41i122335>
5. Cedeño, S., & Banchón, C. (2022). Influence of pre- and post-harvest factors on the organoleptic and physicochemical quality of coffee: a short review. *Journal of Food Science and Technology*, 60(10), 2526-2538. <https://doi.org/10.1007/s13197-022-05569-z>
6. Dias, R., Opitz, S., & Yeretian, C. (2023). Bioactive compounds in blends of coffee defects originating from the harvesting. *Coffee Science*, 17, 1-10. <https://doi.org/10.25186/v17i.2027>
7. Vegro, C. L. R., & Almeida, L. F. de. (2019). Global coffee market: Socio-economic and cultural dynamics. In Elsevier eBooks (p. 3). Elsevier BV. <https://doi.org/10.1016/b978-0-12-814721-4.00001-9>
8. Osorio, V., Matallana, L. G., Fernandez-Alduenda, M. R., Barreto, C. I. A., Gallego, C. P., & Restrepo, E. C. M. (2023). Chemical Composition and Sensory Quality of Coffee Fruits at Different Stages of Maturity. *Agronomy*, 13(2), 341. <https://doi.org/10.3390/agronomy13020341>

9. Calderon, N., Jiang, G., Gibney, P., & Dando, R. (2023). A consumer assessment of fermented green coffee beans with common beer/wine yeast strains for novel flavor properties. *Fermentation*, 9(10), 865. <https://doi.org/10.3390/fermentation9100865>
10. Nadaleti, D., Rezende, J., Malta, M., Santos, C., Pereira, A., & Carvalho, G. (2022). Influence of postharvest processing on the quality and sensory profile of groups of Arabica coffee genotypes. *Journal of the Science of Food and Agriculture*, 102(15), 6899-6906. <https://doi.org/10.1002/jsfa.12051>
11. Coelho, E., Bertarini, P., Gomes, M., Amaral, L., Zotarelli, M., Santos, L., ... & Santana, R. (2024). Physicochemical and sensory properties of arabica coffee beans of Arara cv. dried using different methods. *Foods*, 13(5), 642. <https://doi.org/10.3390/foods13050642>
12. Shen, X., Wang, Q., Zheng, T., Yuan, B., Yin, Z., Liu, K., ... & Yuan, W. (2024). Effect of fermentation duration on the chemical compounds of *Coffea arabica* during the washed processing. *Fermentation*, 10(11), 560. <https://doi.org/10.3390/fermentation10110560>
13. Suarez, W., Gamarra, A., Ponce-Rosas, F., Murillo-Baca, S., Buendía-Ponce, H., Huatay, J., ... & Díaz, M. (2024). La doble fermentación en la mejora de la calidad sensorial del café (*Coffea arábica*). *Manglar*, 21(2), 161-167. <https://doi.org/10.57188/manglar.2024.016>
14. Halagarda, M. (2023). Influence of post-harvest processing on functional properties of coffee (*Coffea arabica* L.). *Molecules*, 28(21), 7386. <https://doi.org/10.3390/molecules28217386>
15. Batali, M. E., Ristenpart, W. D., & Guinard, J. (2020). Brew temperature, at fixed brew strength and extraction, has little impact on the sensory profile of drip brew coffee. *Scientific Reports*, 10(1). <https://doi.org/10.1038/s41598-020-73341-4>