BIS HEALTH AND ENVIRONMENTAL SCIENCE

Volume 2 2025 | DOI: 10.31603/bishes.240
6th Borobudur International Symposium on Science and Technology (BIS-STE) 2024

UNIMMA PRESS
Universitas Muhammadiyah Magelang

Comparative analysis of antioxidant activity in arabica coffee (*coffea arabica l.*) through various post-harvest processes: Luwak, honey, fullwash, natural

Ambar Pratiwi[1*], Afnan Syah H[1], Novi Febrianti[1], Eri Eryati[1]

[1] Universitas Ahmad Dahlan, Yogyakarta, Indonesia
[*]Corresponding author email: ambar@bio.uad.ac.id

Abstract

Arabica coffee beans exhibit high antioxidant activity, measuring 128.8±18.7 µg TE/mg. Post-harvest processing of coffee beans can influence antioxidant activity, TFC (Total Flavonoid Content), and TPC (Total Phenolic Content) due to the fermentation processes involved. This study aims, firstly, to determine whether there are differences in antioxidant activity across various post-harvest processes of Arabica coffee. Secondly, it seeks to identify the process that yields the highest antioxidant activity in Arabica coffee. Thirdly, it aims to determine the highest TFC in Arabica coffee, and fourthly, to identify the highest TPC in Arabica coffee. The research utilized an experimental method with three replications. The independent variable was the post-harvest processing methods of coffee, while antioxidant activity was measured using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method, TFC was measured using the aluminum chloride ($AlCl_3$) method, and TPC was measured using the Folin-Ciocalteu method. The results showed significant differences in antioxidant activity. Arabica coffee processed using the honey method exhibited the highest antioxidant activity, with an IC_{50} value of 76.31 ppm, categorized as very strong. Post-harvest processing was found to influence antioxidant activity in honey and civet (luwak) coffee. Civet coffee had the highest TFC, measuring 1.40 mg QE/g extract, while Arabica coffee processed using the full-wash method had the highest TPC, measuring 83.47 mg GAE/g extract. In conclusion, post-harvest processes such as honey and civet significantly affect antioxidant activity, with values of 76.31 ppm and 164.05 ppm, respectively. The honey process produced coffee with the highest antioxidant activity (IC_{50} 76.31 ppm). The post-harvest process for civet coffee resulted in the highest TFC, measuring 1.40 mg QE/g extract.

Keywords

Arabica coffee, Luwak, Honey, Fullwash, Antioxidants

Published:
May 26, 2025

Selection and Peer-review under the responsibility of the 6th BIS-STE 2024 Committee

Introduction

Arabica coffee (*Coffea arabica L.*) is one of the most sought-after coffee varieties worldwide, mainly due to its distinctive flavor and high content of bioactive compounds. It is also one of Indonesia's key commodities. However, only about 13% of the total coffee production in Indonesia is Arabica coffee, with major production areas located in Sumatra and Java [1]. A major research concern today is how post-harvest processes influence coffee quality, particularly in terms of antioxidant, flavonoid, and phenolic compound content, which provide significant health benefits [2].

Various post-harvest methods, such as Luwak, Honey, Fullwash, and Natural, have been extensively used to enhance the flavor profile of coffee. However, these methods also significantly affect the chemical composition of coffee, particularly its antioxidant compounds [3]. The antioxidant activity in coffee, which protects body cells from damage caused by free radicals, is crucial for health [4]. Similarly, the total flavonoid content (TFC) and total phenolic content (TPC) play essential roles as natural antioxidant compounds [5].

Previous studies have shown that the fermentation process involved in the Luwak method can reduce chlorogenic acid and phenolic compounds, potentially decreasing antioxidant activity [6]. On the other hand, the Honey method, which involves drying coffee beans with part of the fruit mucilage still attached, is known to enhance the coffee's natural sweetness and may increase its antioxidant content [7]. However, research directly comparing the effects of different post-harvest methods on antioxidant content, TFC, and TPC in Arabica coffee remains limited.

This study aims to provide new scientific insights into the effects of post-harvest processes on antioxidant activity in Arabica coffee. Through the measurement of antioxidant activity, TFC, and TPC, this research seeks to offer new information that could help coffee producers select the most effective post-harvest methods to enhance the nutritional value of coffee.

The study focuses on three main objectives: (1) analyzing the differences in antioxidant activity in Arabica coffee processed using Luwak, Honey, Fullwash, and Natural methods, (2) identifying the post-harvest method that yields the highest TFC and TPC, and (3) providing recommendations for the coffee industry regarding optimal post-harvest methods to enhance bioactive compound content in coffee. The methods employed in this research include the extraction of bioactive compounds using methanol as a solvent, followed by the measurement of antioxidant activity using the DPPH method, TFC determination using the aluminum chloride method, and TPC measurement with the Folin-Ciocalteu reagent [8], [9].

Methods

Tools and Materials

The tools used in this research include a blender, porcelain crucibles, red propipette, dark jars, funnels, stirring rods, UV-Vis spectrophotometer, analytical balance, rotary evaporator, cuvettes, test tubes, Durham bottles, 10 ml pipette, 100 µl micropipette, and 1000 µl micropipette.

The materials used in this research include roasted Arabica Luwak coffee, Arabica Honey coffee, Arabica Fullwash coffee, Arabica Natural coffee, filter paper, methanol (pa), aluminum foil, labels, distilled water, DPPH (2,2-diphenyl-1-picrylhydrazyl), Folin-Ciocalteu reagent, quercetin, $AlCl_3$, Na_2CO_3, gallic acid, 70% alcohol, sample containers, and micropipette tips (100 µl and 1000 µl).

Research Variables

In this study, the independent variables include various types of Arabica coffee processed with different post-harvest treatments: Arabica Luwak coffee, Arabica Fullwash coffee, Arabica Honey coffee, and Arabica Natural coffee. The dependent variables measured are antioxidant activity, total phenolic content (TPC), and total flavonoid content (TFC), with each measurement performed in triplicate.

This study using an experimental method to evaluate the effects of various post-harvest treatments. The experimental design enables systematic and controlled analysis of the variables, allowing the research to provide a clear understanding of differences in active compound content among the coffee types and post-harvest treatments.

Procedures

The procedure is divided into the preparation stage and the sample testing stage, as detailed below:

1. Preparation Stage:
    a. Arabica Luwak, Honey, Fullwash, and Natural coffee (250 g each) were sorted to separate intact coffee beans from small or broken beans [10].
    b. The samples were ground using a blender to produce simplicia powder, followed by maceration.
2. Maceration Process:
    a. The coffee powder (250 g) was placed in a dark jar and added with methanol (pa) in a 1:2 ratio, then covered with aluminum foil [10].
    b. The coffee powder was macerated for three days [11].
    c. The macerated samples were filtered using filter paper and concentrated using a rotary evaporator at 50°C [10].
3. Testing Stage:
    a. Antioxidant activity measurement was conducted using the DPPH method [3].

b. A 50 µg/ml DPPH solution was prepared.
c. Coffee extract concentrations were varied, and their absorbance was measured using a UV-Vis spectrophotometer.

Data Analysis

Data analysis was performed using non-parametric tests, including the Kruskal-Wallis test and post hoc analysis. Non-parametric tests were applied to assess the significance and relevance of data that did not follow a normal distribution.

The Kruskal-Wallis test, a non-parametric test for two or more datasets, was used to analyze IC50 data from antioxidant tests on Arabica coffee processed with various post-harvest methods. Post hoc analysis was then conducted to determine whether there were differences between two or more groups based on the results of the Kruskal-Wallis test.

Results and Discussion

Result

The antioxidant activity testing using the DPPH method revealed significant differences based on the post-harvest methods applied to Arabica coffee. The results showed that coffee processed using the Honey method exhibited the highest antioxidant activity, with an IC50 value of 77.05 ppm, categorized as strong antioxidant activity. Conversely, coffee processed with the Luwak method had the lowest antioxidant activity, with an IC50 value of 160.78 ppm, categorized as weak, as shown in Table 1.

The Honey post-harvest method retains the mucilage layer during the drying process, which serves as a protective barrier for antioxidant compounds against oxidation. This process minimizes direct exposure of coffee beans to oxidation, resulting in higher antioxidant activity. In contrast, the Luwak process involves fermentation in the civet's digestive system, leading to a reduction in flavonoid and phenolic compounds, which lowers antioxidant activity.

Table 1. Effect of Post-Harvest Methods on Antioxidant Activity, TFC, and TPC in Arabica Coffee.

Post-harvest methods	Antioxidant activity (IC50, ppm)	TFC (mg QE/g extract)	TPC (mg GAE/g extract)
Luwak	164.05	1.40	75.23
Honey	76.31	1.30	81.47
Fullwash	105.45	1.15	83.47
Natural	89.20	1.20	79.22

Table 1 highlights that differences in post-harvest methods result in significant variations across the three key research parameters. The highest antioxidant activity was observed in Honey coffee, while Luwak coffee had the highest TFC, and Fullwash coffee exhibited the highest TPC. A lower IC50 value indicates higher antioxidant activity, making Honey coffee, with an IC50 of 76.31 ppm, the coffee with the strongest antioxidant activity. In

contrast, Luwak coffee, with a higher IC50 value of 164.05 ppm, displayed weaker antioxidant activity compared to the other methods.

Discussion

The results indicate that post-harvest methods significantly affect antioxidant activity, TFC, and TPC in Arabica coffee. Coffee processed using the Honey method exhibited the highest antioxidant activity. This can be attributed to the drying process, during which part of the fruit mucilage remains on the coffee beans, preserving high levels of phenolic and flavonoid compounds. These findings align with previous research suggesting that the Honey process enhances the concentration of bioactive compounds through partial fermentation [4].

Meanwhile, the Luwak method yielded the highest TFC, although its antioxidant activity was lower than that of other methods. The natural fermentation occurring in the civet's digestive tract increases flavonoid content despite a reduction in chlorogenic acid levels. This is consistent with studies reporting that fermentation affects secondary metabolites in coffee, including flavonoids and phenolics [3].

The Fullwash method resulted in the highest TPC. This can be explained by the thorough washing process, which helps retain phenolic compounds during drying. While removing unwanted substances from the coffee beans, this method preserves compounds beneficial to health. These findings align with [3], who found that full-washing was more effective at maintaining phenolic content compared to fermentation methods.

The comparison of these post-harvest methods reveals that each has distinct advantages in enhancing specific bioactive compounds. For instance, the Honey method is more effective in increasing antioxidant activity, while the Luwak method boosts flavonoid content, and the Fullwash method retains phenolic compounds.

Conclusion

This study demonstrates that post-harvest methods significantly influence antioxidant activity, TFC (total flavonoid content), and TPC (total phenolic content) in Arabica coffee. Coffee processed using the Honey method exhibited the highest antioxidant activity, with an IC50 value of 77.05 ppm, categorized as strong. Conversely, Luwak coffee showed the lowest antioxidant activity, with an IC50 value of 160.78 ppm, categorized as weak. The Honey process proved effective in protecting antioxidant compounds from oxidation, while fermentation in the Luwak process tended to reduce antioxidant levels despite increasing flavonoid content. The highest flavonoid content was found in Luwak coffee at 1.40 mg QE/g extract, and the highest phenolic content was observed in Fullwash coffee at 83.47 mg GAE/g extract. The variability in antioxidant, flavonoid, and phenolic content across different processes underscores the importance of selecting appropriate methods for maximizing the health benefits of coffee. Coffee with high antioxidant activity, like that produced through the Honey method, could be promoted for its functional and nutraceutical value.

Acknowledgement

The authors thank the Universitas Ahmad Dahlan's Research and Community Service Center (LPPM UAD) for funding this study through the basic research scheme.

References

[1] A. Wibowo, "Produksi dan kualitas kopi arabika di Indonesia," *J. Agribisnis dan Teknol. Pertan.*, vol. 32, no. 1, pp. 12–19, 2019.

[2] R. N. V Antezana and G. I. L. Mercado, "Effect of processing methods (washed, honey, natural, anaerobic) of catimor coffee on physical and sensory quality in Alto Inambari, Peru," *Coffee Sci.*, vol. 18, no. 182111, pp. 1–10, 2023.

[3] L. Febrina, N. Happyana, and Y. M. Syah, "Metabolite profiles and antidiabetic activity of the green beans of Luwak (civet) coffees," *Food Chem.*, vol. 355, pp. 1–9, 2021.

[4] E. I. Wigati, E. Pratiwi, T. F. Nissa, and N. F. Utami, "Uji karakteristik fitokimia dan aktivitas antioksidan biji kopi robusta (Coffea canephora Pierre) dari Bogor, Bandung, dan Garut dengan metode DPPH (1,1-diphenyl-2-picrylhydrazyl)," *FITOFARMAKA J. Ilm. Farm.*, vol. 8, no. 1, pp. 53–59, 2019.

[5] C. E. Dhurhania and A. Novianto, "Uji kandungan fenolik total dan pengaruhnya terhadap aktivitas antioksidan dari berbagai bentuk sediaan sarang semut (Myrmecodia pendens)," *J. Farm. dan Ilmu Kefarmasian Indones.*, vol. 5, no. 2, pp. 62–68, 2018.

[6] A. Farah and C. M. Donangelo, "Phenolic compounds in coffee," *Brazilian J. Plant Physiol.*, vol. 18, no. 1, pp. 23–36, 2006.

[7] Y. Wibowo and C. B. Palupi, "Analisis nilai tambah pengolahan biji kopi arabika (studi kasus: Rumah Kopi Banjarsengon, Jember)," *J. Agroteknologi*, vol. 16, no. 1, pp. 37–48, 2022.

[8] L. Gobbi, L. Maddaloni, S. A. Prencipe, and G. Vinci, "Bioactive compounds in different coffee beverages for quality and sustainability assessment," *Beverages*, vol. 9, no. 1, pp. 1–18, 2023.

[9] M. Haile, H. M. Bae, and W. H. Kang, "Comparison of the antioxidant activities and volatile compounds of coffee beans obtained using digestive bio-processing (elephant dung coffee) and commonly known processing methods," *Antioxidants*, vol. 9, no. 5, pp. 1–21, 2020.

[10] I. W. Pebriati and A. N. Diana, "Uji antioksidan ekstrak etanol biji kopi arabika (Coffea arabica L.) lereng Gunung Argopura Kabupaten Jember pada berbagai kondisi penyangraian," *J. Ris. Kefarmasian Indones.*, vol. 5, no. 2, pp. 284–298, 2023.

[11] Y. P. Utami, Imrawati, and J. A. Barrang, "Studi aktivitas antioksidan ekstrak etanol biji kopi robusta (Coffea canephora var. robusta) dan biji kopi arabika (Coffea arabica L.) dengan metode DPPH," *J. FARBAL*, vol. 7, no. 1, pp. 19–28, 2019.