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TOTAL PHENOLIC CONTENT ANALYSIS IN PALM WASTE EXTRACTS PREPARED BY ETHANOL- AND WATER-BASED MACERATION METHODS

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Abstract:

This study investigates the comparative analysis of total phenolic content (TPC) in palm waste extracts—empty fruit bunches (EFB), palm fronds (PF), and palm kernel shells (PKS)—using ethanol- and water-based maceration methods. Palm waste, a byproduct of the palm oil industry, represents an abundant but underutilized biomass with significant potential for phenolic compound extraction. Phenolic compounds are known for their antioxidant, antimicrobial, and reducing properties, making them valuable in green chemistry and industrial applications. The extraction solvents, ethanol and water, were selected for their distinct abilities to dissolve phenolic compounds of varying polarity. Ethanol effectively extracts medium-polarity phenolics, while water targets highly polar compounds. Results showed notable differences in TPC among the three palm waste types and between the solvents used. For ethanolic extraction, PF exhibited the highest TPC (19.96 mg GAE/g), followed by PKS (5.63 mg GAE/g), and EFB (1.18 mg GAE/g), indicating the selective solubility of phenolic compounds in ethanol. Conversely, water extraction yielded higher TPC values across all samples, with EFB achieving the highest (26.31 mg GAE/g), followed by PF (22.32 mg GAE/g) and PKS (12.58 mg GAE/g), highlighting the abundance of hydrophilic phenolics in EFB and PF. These findings emphasize the influence of solvent polarity on phenolic recovery and underscore the potential of palm waste as a sustainable source of bioactive compounds.

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Keywords:

Total Phenolic Content; Palm Waste Extract; Empty Fruit Bunch; Palm Frond; Palm Kernel Shell

Introduction

Plant extracts, derived from a wide range of biomass such as leaves, roots, peels, seeds, husks, and bark (Bhushan et al., 2024), have garnered significant attention due to their functional compounds like phenolics, flavonoids, alkaloids, and tannins, enabling diverse applications in food, cosmetics, pharmaceuticals, and sustainable materials (Dias et al., 2021). Recently, palm waste extracts, a specific type of plant extract, have gained prominence, particularly in palm oil-producing countries like Indonesia and Malaysia (Papilo et al., 2022), due to the abundant availability of palm wastes, including empty fruit bunches (EFB), palm fronds (PF), and palm kernel shells (PKS). Among the functional compounds in palm waste extracts, phenolics stand out for their various properties, such as antioxidant, antimicrobial, and reducing capabilities. These properties not only make palm waste extracts valuable in multiple industrial applications, such as food preservation (Dias et al., 2021), cosmetics (Chaiwut et al., 2022), and pharmaceuticals (Chaiwut et al., 2022) but also in green chemistry, where they serve as natural reductants and stabilizers in sustainable processes like nanoparticle synthesis (Aswathi et al., 2023) and wastewater treatment (Baskaran et al., 2024).

The extraction of phenolics from palm waste largely depends on the type of palm waste, the extraction method used, and the choice of extraction solvent (Osorio-tobo, 2020). Various extraction techniques, including Soxhlet extraction, ultrasonic-assisted extraction, and maceration, have been employed to extract phenolic compounds from palm waste (Jha & Sit, 2022). Among these, maceration is particularly advantageous due to its simplicity, low-cost operation, and compatibility with a wide range of solvents(Gori et al., 2021). Ethanol and water are two commonly used solvents for phenolic extraction due to their differing polarities and ability to selectively dissolve phenolic compounds. Ethanol is particularly effective for extracting medium-polarity phenolics, while water is more suitable for highly polar phenolic compounds (Osorio-Tobón, 2020). However, the efficiency of these solvents can vary significantly based on the biomass being extracted, making it essential to evaluate their performance across different types of palm waste.

Despite the growing interest in utilizing palm waste as a source of phenolic compounds, comparative studies on total phenolic content (TPC) in EFB, PF, and PKS are limited. Furthermore, there is a lack of comprehensive data on how solvent polarity influences the recovery of phenolics from these materials. Addressing these gaps is crucial for optimizing extraction methods and unlocking the full potential of palm waste as a sustainable source of phenolic compounds.

This study aims to investigate the TPC in EFB, PF, and PKS, using ethanol and water as extraction solvents. By comparing the TPC across different palm waste types and solvents, this research seeks to highlight the influence of solvent polarity on phenolic recovery and to identify the most promising sources of phenolics within palm waste. The findings contribute to the

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growing knowledge of sustainable biomass utilization and support the development of value-added applications for palm wastes.

Materials, Equipment and Methods

Materials
Palm waste materials, i.e., EFB, PKS, and PF, were collected from United Oil Palm Industries Sdn. Bhd., located in Nibong Tebal, Penang, Malaysia. Analytical-grade chemicals, including 70% ethanol, 15% sodium carbonate solution, and Folin-Ciocalteu reagent, were procured from Bellamy Precision, Malaysia. All chemicals were used as received, without further modification.

Equipment
The equipment used for the study included a laboratory grinder to process palm waste into powder size 63-45 µm, and Whatman No. 1 filter paper for filtration. A rotary evaporator was employed for solvent removal and concentration of the extracts. The TPC measurements were performed using a UV-Vis spectrophotometer capable of detecting absorbance at 765 nm. Standard laboratory glassware such as conical flasks, pipettes, and test tubes were also utilized.

Preparation Of Palm Waste Powder
The collected palm waste materials (EFB, PKS, and PF) were washed thoroughly with distilled water to remove dirt and other impurities. After washing, the materials were air-dried for 24 hours and subsequently ground into fine particles using a laboratory grinder. The ground samples were sieved to achieve a uniform particle size range of 45–63 µm and stored in airtight containers until further analysis. Figure 1 shows the palm waste before and after sieve for PKS, PF and EFB.

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Figure 1: Palm Wastes Powder Prepared For Extraction; a) PKS, b) PF, c) EFB

Preparation Of Palm Waste Extracts

Distilled water and 70% ethanol were the two solvents employed for extraction. In the water extraction process, 4 g of each palm waste extracts sample was mixed with 100 mL of distilled water in a conical flask, sealed, and stored at room temperature for 3 days with periodic shaking. Similarly, for ethanol extraction, 4 g of each palm wastes extracts was macerated in 100 mL of 70% ethanol under similar circumstances. After three days of maceration, the mixtures were filtered through Whatman No. 1 filter paper to remove solid residues, and the filtrates were collected (Ayoub et al., 2020). Figure 2 shows the palm waste powder that have been extracted.

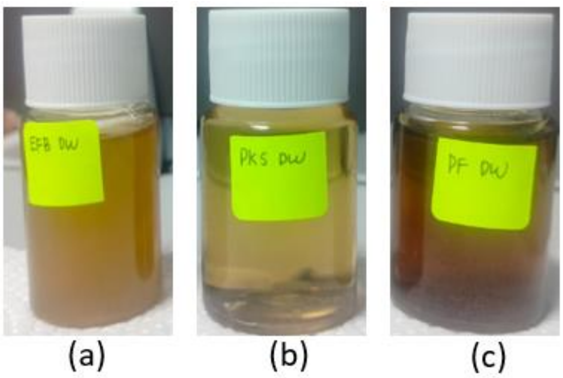

Figure 2: Palm Waste Extracts Derived From EFB (a), PKS (b), and PF (c)

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Total Phenolic Content (TPC) Analysis

The TPC of these extracts was then measured using the Folin-Ciocalteu method. A 1 mL aliquot of each extract was combined with 5 mL of diluted Folin-Ciocalteu reagent. After 3 minutes, 4 mL of 7.5% sodium carbonate solution was added to the mixture, which was then incubated at room temperature for 30 minutes in the dark. Absorbance readings were recorded at 765 nm using a UV-Vis spectrophotometer, and TPC was expressed as milligrams of gallic acid equivalent (mg GAE) per gram of dry weight of the extract (Siddiqui et al., 2017).

Result and Discussion

TPC Of Palm Waste Extracts From Ethanolic Extraction

Figure 3 shows the TPC of palm waste extracts analysed using UV-Vis. TPC of ethanolic extraction varied considerably between PKS, EFB, and PF. PF had the highest TPC 19.96 mg GAE/g, indicating the presence of phenolic compounds with medium to low polarity that are ideal for ethanol extraction. PKS has a moderate TPC 5.63 mg GAE/g, indicating the presence of moderately ethanol-soluble phenolic components such flavonoids and tannins (Abdullah et al., 2018). In contrast, EFB had the lowest TPC 1.18 mg GAE/g, indicating that its phenolic content is primarily hydrophilic and less compatible with ethanol extraction (Plaskova & Mlcek, 2023). Ethanol is effective for extracting medium-polarity phenolic chemicals but less efficient for highly hydrophilic ones(Abdullah & Ramu, 2020). The results demonstrate ethanol's selectivity as a solvent, making it perfect for PF and fairly successful for PKS. Meanwhile for EFB has low extraction efficiency indicates that predominantly hydrophilic and less soluble in ethanol.

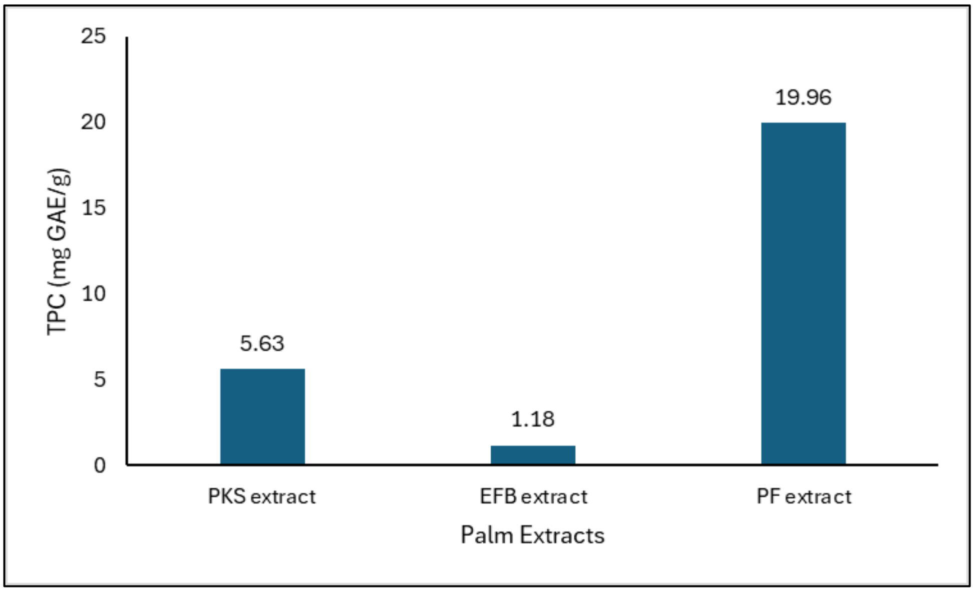

Figure 3: TPC for 3 Palm Extracts Using Ethanol As Solvent; PKS Extract, EFB Extract And PF Extract

TPC Of Palm Waste Extracts From Water Extraction

Figure 4 shows TPC of palm waste extracts extracted through water extraction. EFB had the greatest TPC at 26.31 mg GAE/g, followed by palm fronds (PF) at 22.32 mg GAE/g, while palm kernel shells (PKS) had the lowest TPC at 12.58 mg GAE/g. These data show that EFB and PF contain more water-soluble phenolic compounds than PKS. EFB's higher phenolic content may be due to its greater availability of free phenolics or more accessible cellular structure, which enables extraction. In contrast, PKS thick lignocellulosic structure can hinder phenolic chemical release(Abdullah et al., 2018).

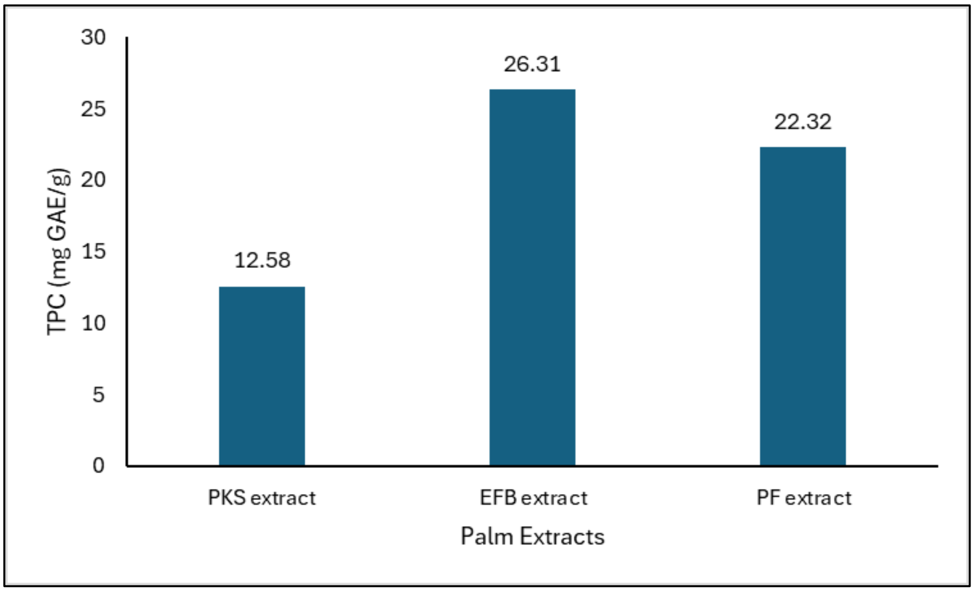

Figure 4: TPC For 3 Palm Extracts Using Water As Solvent; PKS Extract, EFB Extract And PF Extract

Conclusions

It can be concluded that water extraction yielded significantly higher TPC values compared to ethanol, with EFB recording the highest TPC (26.31 mg GAE/g), followed by PF (22.32 mg GAE/g), and PKS (12.58 mg GAE/g). This indicates that EFB and PF are rich in water-soluble phenolic compounds, potentially due to their higher availability of free phenolics and more accessible cellular structure. In contrast, PKS's lower TPC could be attributed to its dense lignocellulosic structure, which limits phenolic release. Ethanolic extraction, however, showed selectivity for phenolic compounds with medium to low polarity. PF had the highest TPC (19.96 mg GAE/g), followed by PKS (5.63 mg GAE/g), while EFB exhibited the lowest TPC (1.18 mg GAE/g). This suggests that ethanol is effective for extracting moderately polar phenolics, such as flavonoids and tannins, while less suitable for highly hydrophilic compounds. These findings emphasize the importance of solvent selection in phenolic compound recovery. Water extraction is ideal for maximizing phenolic yield from EFB and PF, while ethanol is better suited for selectively extracting medium-polarity phenolics, particularly from PF.

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References

Abdullah, F., Ismail, R., Ghazali, R., & Idris, Z. (2018). Total phenolic contents and antioxidant activity of palm oils and palm kernel oils at various refining processes. *Journal of Oil Palm Research*, *30*(DECEMBER), 682–692. https://doi.org/10.21894/jopr.2018.0058

Abdullah, F., & Ramu, N. A. S. (2020). Identification of hydrophilic phenolic compounds derived from palm oil products. *Journal of Oil Palm Research*, *32*(2), 258–270. https://doi.org/10.21894/jopr.2020.0020

Aswathi, V. P., Meera, S., Maria, C. G. A., & Nidhin, M. (2023). Green synthesis of nanoparticles from biodegradable waste extracts and their applications: a critical review. *Nanotechnology for Environmental Engineering*, *8*(2), 377–397. https://doi.org/10.1007/s41204-022-00276-8

Ayoub, Z., Malik, S. B., & Mehta, A. (2020). In vitro and in vivo anticancer efficacy of Adiantum capillus-veneris L. against some selected human cancer cell lines and on EAC mouse model. *International Journal of Pharmaceutical Sciences and Drug Research*, *12*(3), 267–274. https://doi.org/10.25004/ijpsdr.2020.120309

Baskaran, D., Natarajan, A. P. A., & Byun, H. S. (2024). Potential of palm husk powder in the treatment of real tannery wastewater: Performance comparison between response surface methodology and artificial neural network-particle swarm optimization. *Journal of Water Process Engineering*, *67*(August), 106101. https://doi.org/10.1016/j.jwpe.2024.106101

Bhushan, D., Shoran, S., Kumar, R., & Gupta, R. (2024). Plant biomass-based nanoparticles for remediation of contaminants from water ecosystems: Recent trends, challenges, and future perspectives. *Chemosphere*, *365*(September), 143340. https://doi.org/10.1016/j.chemosphere.2024.143340

Chaiwut, P., Jirarat, A., Tiensri, N., Sangthong, S., & Pintathong, P. (2022). Green Synthesis Optimization of Glucose Palm Oleate and Its Potential Use as Natural Surfactant in Cosmetic Emulsion. *Cosmetics*, *9*(4). https://doi.org/10.3390/cosmetics9040076

Dias, R., Oliveira, H., Fernandes, I., Simal-Gandara, J., & Perez-Gregorio, R. (2021). Recent advances in extracting phenolic compounds from food and their use in disease prevention and as cosmetics. *Critical Reviews in Food Science and Nutrition*, *61*(7), 1130–1151. https://doi.org/10.1080/10408398.2020.1754162

Gori, A., Boucherle, B., Rey, A., Rome, M., Fuzzati, N., & Peuchmaur, M. (2021). Development of an innovative maceration technique to optimize extraction and phase partition of natural products. *Fitoterapia*, *148*(November 2020). https://doi.org/10.1016/j.fitote.2020.104798

Jha, A. K., & Sit, N. (2022). Extraction of bioactive compounds from plant materials using combination of various novel methods: A review. *Trends in Food Science and Technology*, *119*(November 2021), 579–591. https://doi.org/10.1016/j.tifs.2021.11.019

Osorio-tobo, J. F. (2020). *Recent advances and comparisons of conventional and alternative extraction techniques of phenolic compounds*. *57*(December), 4299–4315. https://doi.org/10.1007/s13197-020-04433-2

Osorio-Tobón, J. F. (2020). Recent advances and comparisons of conventional and alternative extraction techniques of phenolic compounds. *Journal of Food Science and Technology*, *57*(12), 4299–4315. https://doi.org/10.1007/s13197-020-04433-2

Papilo, P., Marimin, M., Hambali, E., Machfud, M., Yani, M., Asrol, M., Evanila, E., Prasetya, H., & Mahmud, J. (2022). Palm oil-based bioenergy sustainability and policy in Indonesia and Malaysia: A systematic review and future agendas. *Heliyon*, *8*(10), e10919. https://doi.org/10.1016/j.heliyon.2022.e10919

Volume 7 Issue 21 (June 2025) PP. 275-282
DOI 10.35631/IJIREV.721016
Plaskova, A., & Mlcek, J. (2023). New insights of the application of water or ethanol-water plant extract rich in active compounds in food. *Frontiers in Nutrition*, *10*(March). https://doi.org/10.3389/fnut.2023.1118761

Siddiqui, N., Rauf, A., Latif, A., & Mahmood, Z. (2017). Spectrophotometric determination of the total phenolic content, spectral and fluorescence study of the herbal Unani drug Gul-e-Zoofa (Nepeta bracteata Benth). *Journal of Taibah University Medical Sciences*, *12*(4), 360–363. https://doi.org/10.1016/j.jtumed.2016.11.006