CURRENT BIOCHEMISTRY

Article

Effect of Solvent Polarity on Total Flavonoid and Phenolic Contents and Antioxidant Activity of Sweet Corn Cob (*Zea mays* L.) Waste Extracts

Theresia Eunike Margaretha Pontoh [1], Mega Safithri [1,*], and Dimas Andrianto[1]

[1] Department of Biochemistry, IPB University, Bogor, 16680, Indonesia
* Correspondence: safithri@apps.ipb.ac.id

Abstract: *Corn cob waste is an agricultural by-product that has not been optimally utilized. This study aims to determine the flavonoid, phenolic, and antioxidant levels in corn cob extract obtained by maceration with n-hexane, ethyl acetate, and 70% ethanol. The test was carried out using the colorimetric method, where* Folin-*Ciocalteu reagent acted as a phenolic-detecting agent. The results showed that corn cob extract using 70% ethanol as the solvent had the highest total phenolic content, at 455.09 ± 16.97 mg GAE/g extract. The flavonoid content of the 70% ethanol extract also showed the highest result of 179.38 ± 0.95 mg GAE/g extract. The highest antioxidant capacity was observed in the extract using ethyl acetate solvent at 71.36 ± 0.18 µmol/g extract. Statistical analysis showed a significant difference. In conclusion, the type of solvent plays an important role in determining the levels of bioactive compounds extracted. Corn cobs have the potential to be a source of natural antioxidants that can be utilized in the cosmetics industry.*

Keywords: Antioxidants, extraction, corn cob, flavonoids, phenolic

Abstrak: Limbah bonggol jagung merupakan salah satu hasil sampingan pertanian yang masih belum dimanfaatkan secara optimal. Penelitian ini bertujuan untuk menentukan kadar flavonoid, fenolik, dan antioksidan dari ekstrak bonggol jagung yang diekstraksi menggunakan metode maserasi dengan pelarut *n*-heksana, etil asetat, dan etanol 70%. Pengujian dilakukan menggunakan metode kolorimetri, Folin-Ciocalteu berperan sebagai reagen fenolik. Hasil penelitian menunjukkan bahwa ekstrak bonggol jagung dengan pelarut etanol 70% memiliki kadar total fenolik tertinggi sebesar 455,09 ± 16,97 mg GAE/g ekstrak. Kadar flavonoid dari ekstrak etanol 70% juga menunjukkan hasil tertinggi sebesar 179,38 ± 0,95 mg GAE/g ekstrak. Kapasitas antioksidan tertinggi diperoleh pada ekstrak dengan pelarut etil asetat sebesar 71,36 ± 0,18 µmol/g ekstrak, dan analisis statistik menunjukkan adanya perbedaan signifikan. Simpulan penelitian ini adalah jenis pelarut berperan penting dalam menentukan kadar senyawa bioaktif yang diekstraksi. Bonggol jagung memiliki potensi sebagai sumber antioksidan alami yang bisa dimanfaatkan dalam industri kosmetik.

Kata kunci: : Antioksidan, ekstraksi, bonggol jagung, flavonoid, fenolik

Citation: Pontoh TEM, Safithri M, Andrianto D. 2026. Effect of solvent polarity on total flavonoid and phenolic contents and antioxidant activity of sweet corn cob (*Zea mays* L.) waste extracts. *Current Biochemistry*. 13(2): 22-27.

Received: June 23rd, 2026
Revised: November 13rd, 2026
Accepted: November 13rd, 2026
Published: November 15th, 2026

Copyright: © 2026 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution-ShareAlike 4.0 International License (http://creativecommons.org/licenses/by-sa/4.0/).

pISSN: 2355-7877
eISSN: 2355-7931

1. Introduction

Antioxidants are essential compounds that mitigate cellular damage caused by free radicals (Sari, 2017). Excessive exposure to ultraviolet (UV) radiation serves as a primary source of these reactive species, often leading to significant cutaneous complications. Consequently, antioxidants are increasingly incorporated into cosmetic formulations and sunscreen products to enhance protective efficacy. Naturally occurring chemical constituents, specifically flavonoids and phenolic compounds found in various botanical sources, have demonstrated potent antioxidant properties.

Sweet corn (*Zea mays* L.) represents a major food commodity in Indonesia with production increasing consistently. Data from the Ministry of Agriculture of the Republic of Indonesia (2019) indicated that national corn production reached 30.06 million tons in 2018, reflecting a 3.91% increase from the previous year. However, this high production volume generates a proportional amount of agricultural byproducts, such as corn cobs. Currently,

these cobs are frequently discarded as waste or limited to low-value applications such as animal feed and traditional fuel.

The corn cob constitutes the largest physical component of the plant, suggesting that industrial reliance on corn kernels alone leads to substantial underutilization of biomass. Preliminary studies (Suryanto and Momuat, 2017) have identified significant antioxidant activity and phenolic content within the ethyl acetate fraction of corn cobs, reaching levels as high as 87.57%. Given this potential, exploring corn cob extract as a functional ingredient is vital for waste reduction and the development of sustainable bioactive sources. This study aims to evaluate the efficacy of these extracts within a broader pharmacological framework to justify their application in high-value products.

2. Materials and Methods

2.1. Materials

Sweet corn cob waste was sourced from farmers in Ciapus, Bogor, Indonesia. Chemical reagents of analytical grade included ethanol (70%), *n*-hexane, ethyl acetate, Folin-Ciocalteu reagent, 2,2-diphenyl-1-picrylhydrazyl (DPPH), quercetin, and gallic acid.

2.2. Sample Preparation and Extraction (Kursia et al. 2016; Simanjuntak 2023)

Corn cobs were washed, dried, and pulverized into a fine powder. The moisture content was determined according to the gravimetric method according to the method described by Simanjuntak (2023). Sequential maceration was performed using *n*-hexane, ethyl acetate, and 70% ethanol to obtain fractions of varying polarity.

2.3. Maceration Protocol (Modified from Simanjuntak 2023)

Extraction was executed in triplicate using a solid-to-solvent ratio of 1:10 (w/v). Briefly, 10 g of powder was homogenized in 100 mL of solvent via a rotary shaker at 92 rpm for 24 hours at room temperature. The process included three rinsing cycles. Extracts were filtered and concentrated using a rotary evaporator at 50°C to yield the crude extract. The yield percentage was calculated as follows:

$$Extract\ Yield\ (\%) = \frac{Weight\ of\ concentrated\ extract}{Weight\ of\ initial\ dry\ powder\ (1 - moisture\ content)} \times 100\%$$

2.4. Total Phenolic Content (TPC) Analysis (Modified from Putri 2022)

TPC was determined using a microplate-adapted Folin-Ciocalteu assay. A 20 µL aliquot of the extract was mixed with 120 µL of 10% Folin-Ciocalteu reagent in a 96-well microplate and sequestered in the dark for 5 minutes. Subsequently, 80 µL of 7.5% Na_2CO_3 was added, followed by a 30-minute incubation. Absorbance was measured at 750 nm using a microplate reader. Results were expressed as mg Gallic Acid Equivalents (GAE) per gram of dry weight (DW) using the equation:

$$TPC\ (mg\ GAE/g\ DW)\} = \frac{C \times V}{m} \times\ DF$$

Where C is the concentration from the gallic acid calibration curve ($R^2 > 0.99$), V is the sample volume (L), m is the sample mass (g), and DF is the dilution factor.

2.5. Total Flavonoid Content (TFC) Assay (Modified from Simanjuntak 2023)

TFC was quantified by mixing 10 µL of extract with 110 µL of distilled water, 10 µL of 10% $AlCl_3$, 10 µL of 1 M potassium acetate, and 60 µL of ethanol. After 30 minutes of incubation at room temperature, absorbance was recorded at 432 nm. TFC was expressed as mg Quercetin Equivalent (QE) per gram of extract (mg QE/g) based on a quercetin standard curve.

2.6. DPPH Radical Scavenging Activity (Modified from Putri 2022)

Antioxidant capacity was evaluated across a concentration gradient (100, 200, 400, 600, and 800 ppm). A 100 µL sample aliquot was reacted with 100 µL of 100 µM DPPH solution in a microplate. Following a 30-minute dark incubation, absorbance was measured at 517 nm. The inhibition percentage was calculated as:

$$Inhibition\ (\%)\ = \frac{A_{control} - A_{sample}}{A_{control}} \times 100\%$$

2.7. Statistical Analysis

Quantitative data were subjected to One-Way Analysis of Variance (ANOVA) followed by Tukey's post-hoc test for mean separation. All statistical procedures were performed using SPSS software, with significance defined at $p < 0.05$.

3. Results

3.1. Water Content and Extract Yield

The gravimetric determination of the moisture content in corn cob powder was conducted in triplicate. Extraction via maceration with triple rinsing yielded varying results based on solvent polarity. The 70% ethanol extract produced the highest yield at 8.61±0.40%, whereas the *n*-hexane extract resulted in the lowest yield at 7.84±0.06% (Table 1).

Table 1. Moisture content and extraction yield of corn cob extracts.

Parameters	Yield (% w/w)
Moisture content:	0,54±0,01
Extraction yield:	
n-hexane	7,84±0,06
Ethyl acetate	8,57±0,17
Ethanol 70%	8,61±0,40

3.2. Total Phenolic Content (TPC)

The TPC was quantified using a gallic acid standard curve ($y = 0.0048x + 0.0789$; $R^2 = 0.9952$). At a sample concentration of 1000 ppm, the 70% ethanol extract exhibited the highest phenolic concentration at 467.80±0.73 mg GAE/g extract (Figure 1), which was not significantly different from the ethyl acetate extract (333.42±1.15 mg GAE/g extract; $p > 0.05$). In contrast, the *n*-hexane extract yielded a markedly lower value, recording 40.51±3.23 mg GAE/g extract. Tukey's post-hoc analysis confirmed significant differences ($p < 0.05$) among the *n*-hexane extract, the positive control, and the ethyl acetate and 70% ethanol extracts, whereas the latter two did not differ significantly (Figure 1).

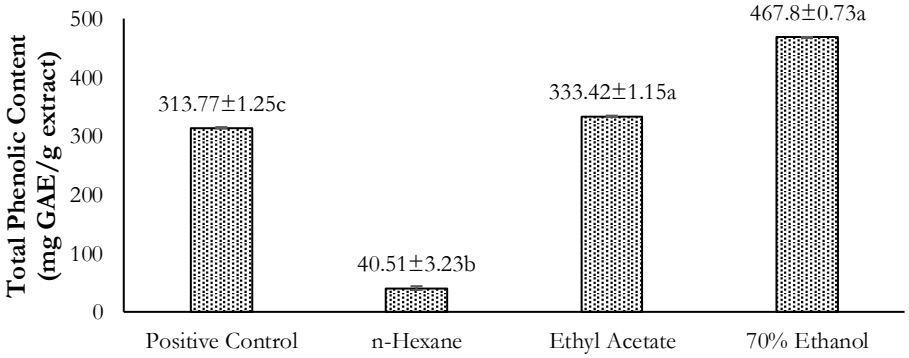


Figure 1. Total phenolic content of corn cob extracts using different solvents. Values followed by different letters indicate significant statistical differences ($p < 0.05$).

3.3. Total Flavonoid Content (TFC)

Flavonoid quantification was based on the quercetin standard equation ($y = 0.0021x - 0.0977$; $R^2 = 0.9616$). Similar to the phenolic profile, the 70% ethanol extract at 1000 ppm contained the highest flavonoid level at 179.38±0.95 mg QE/g extract (Figure 2). The *n*-hexane extract showed the minimum concentration at 125.10±1.43 mg QE/g extract. Statistical analysis via Tukey's HSD indicated that these variations across solvents were significant ($p < 0.05$).

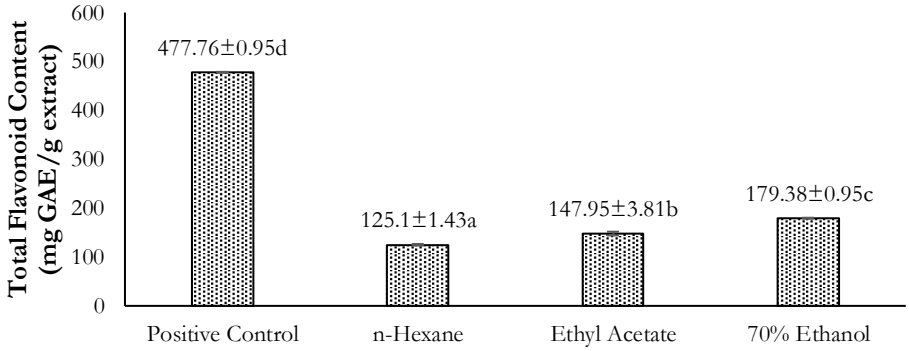


Figure 2. Total flavonoid content of corn cob extracts. Values followed by different letters indicate significant statistical differences ($p < 0.05$).

3.4. Antioxidant Capacity via DPPH Assay

The antioxidant capacity, measured at 1000 ppm, peaked in the ethyl acetate extract at 71.36±0.18 μmol/g, followed by the ethanol extract at 66.94±0.18 μmol/g and the *n*-hexane extract at 61.11±3.49 μmol/g (Figure 3). Inhibition percentages followed a corresponding trend, with ethyl acetate, 70% ethanol, and *n*-hexane reaching 67.32%, 63.28%, and 57.94%, respectively (Table 2). Tukey's HSD test revealed a significant difference between *n*-hexane and ethyl acetate ($p < 0.05$); however, no significant differences were observed between *n*-hexane and 70% ethanol, nor between ethyl acetate and 70% ethanol ($p > 0.05$).

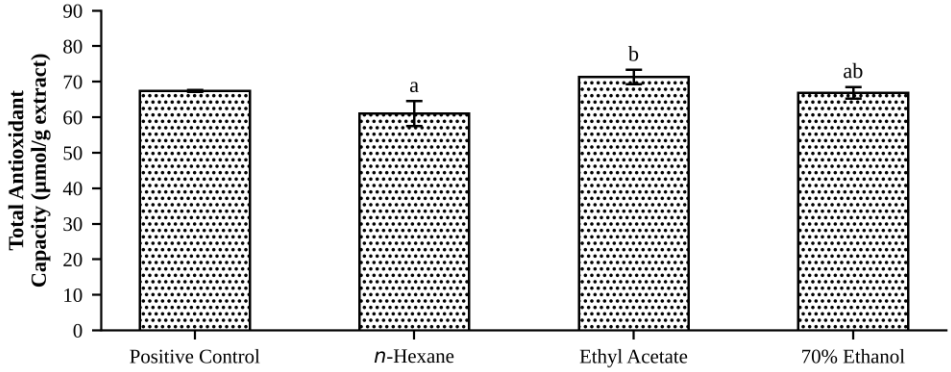


Figure 3. Comparative antioxidant capacity of corn cob extracts. Values followed by different letters indicate significant statistical differences ($p < 0.05$).

Table 2. DPPH radical inhibition percentage of corn cob extracts.

Corn cob extracts	Inhibition (%)
n-hexane	57,94 ±3,19
Ethyl acetate	67,32 ±2,02
Ethanol 70%	63,28 ±1,64

Note: Data are presented as mean ± standard deviation.

4. Discussion

4.1 Physicochemical Evaluation and Extraction Yield Efficiency

The moisture content of the corn cob extract, recorded at 0.54±0.01%, aligns with the quality standards established by the Indonesian National Agency of Drug and Food Control (2023), which stipulate a maximum threshold of 10%. Maintaining moisture levels below this limit is critical for preventing microbial proliferation and enzymatic degradation, thereby ensuring the long-term stability of the bioactive constituents (Atma, 2018). The observed value suggests that the drying process successfully eliminated moisture, which is vital for preserving the chemical integrity of the material. Furthermore, the high degree of reproducibility across replicates indicates that the extraction and measurement protocols are highly reliable, resulting in a homogeneous and high-quality sample. Excessive moisture is

known to compromise the quality of crude drugs by increasing contamination risks and damaging physical texture (Handayani *et al.*, 2017).

The extraction yield varied significantly depending on the solvent utilized. Ethanol demonstrated a superior ability to dissolve a wide array of compounds, ranging from polar to no*n*-polar, thereby maximizing the recovery of active components. This efficiency is attributed to ethanol's ability to penetrate cellular boundaries, facilitating rapid diffusion and attracting bioactive molecules (Prayitno & Rahim, 2020). Conversely, ethyl acetate yielded a lower recovery (8.57±0.17%), as its semi-polar nature is more selective, failing to extract all components with equal efficiency. The lowest yield was observed with *n*-hexane (7.84±0.06%), a no*n*-polar solvent capable only of dissolving hydrophobic substances. Consequently, polar and semi-polar constituents remain largely unextracted in *n*-hexane media (Pratiwi et al., 2016).

4.2 Total Phenolic (TPC) and Flavonoid Content (TFC) Analysis

Phenolic compounds (encompassing flavonoids, tannins, tocopherols, and lignin) typically exist as esters, ethers, or glycosides and are recognized for their role as natural antioxidants (Dhurhania & Novianto, 2019). The results indicate that the choice of solvent significantly influenced the recovery of these compounds. The 70% ethanol extract achieved the highest phenolic concentration at 467.80±0.73 mg GAE/g, surpassing the positive control (313.77±1.25 mg GAE/g). This disparity suggests that 70% ethanol is exceptionally effective at liberating bioactive compounds, with a value that did not differ significantly from that of ethyl acetate, while *n*-hexane demonstrated a weak capacity for phenolic extraction. Statistical analysis via one-way ANOVA yielded a significance value below 0.05 ($P < 0.05$), confirming that the differences in TPC are statistically significant and driven by the varying polarities of the solvents (Gultom *et al.,* 2021). The results highlight the effectiveness of 70% ethanol and ethyl acetate in maintaining high phenolic concentrations.

Similarly, the 70% ethanol extract provided the highest Total Flavonoid Content (179.38±0.95 mg QE/g), whereas *n*-hexane yielded the lowest (125.10±1.43 mg QE/g). This trend is consistent with the semi-polar to polar nature of flavonoids, which facilitates better solubility in highly polar solvents such as 70% ethanol (Sulastri *et al.,* 2018). Tukey's post-hoc test results ($sig = 0.000 < 0.05$) further validate the significant differences in extraction capability among the solvents. Beyond their antioxidant roles, flavonoids serve as inhibitors for various enzymes, including xanthine oxidase and cyclooxygenase (Panche *et al.,* 2016). They neutralize free radicals by donating electrons or hydrogen atoms and act as co-antioxidants to regenerate essential vitamins, such as Vitamin E, thereby enhancing the overall biological defense system.

4.3 Radical Scavenging Capacity and Antioxidant Mechanisms

The antioxidant activity was evaluated through the DPPH assay, where a colorimetric shift from purple to yellow denotes the neutralization of radicals via proton donation. Ethyl acetate extracts exhibited the highest antioxidant capacity at 71.36±0.18 µmol TE/g. For comparison, Othman *et al.* (2020) reported that 95% ethanol extracts of cinnamon bark reached 817.89±9.03 µmol TE/g, illustrating how specific bioactive compounds are more efficiently isolated by solvents of compatible polarity. Statistical analysis via Tukey HSD revealed a significant difference between the *n*-hexane and ethyl acetate fractions ($p = 0.007$), underscoring the role of solvent selection in determining the quality of the antioxidant profile.

Furthermore, ethyl acetate achieved the highest inhibition percentage (67.32±2.02%), followed by 70% ethanol (63.28±1.64%) and *n*-hexane (57.94±3.19%). This suggests that ethyl acetate is more proficient at concentrating compounds with potent inhibitory effects. Semi-polar antioxidants, such as terpenoids and specific phenolic acids, dissolve readily in ethyl acetate, whereas the no*n*-polar *n*-hexane fails to capture these high-potential molecules. Spectrophotometric measurements showed that higher sample concentrations resulted in lower absorbance, reflecting a greater reduction of free radicals and higher inhibition. This mechanism relies on the ability of phenolic hydroxyl (-OH) groups to donate hydrogen, stabilizing radicals into no*n*-reactive forms and preventing oxidative chain reactions (Dhurhania & Novianto, 2019).

The results of this study conclusively demonstrate that the phytochemical profile and antioxidant potential of corn cob extracts are fundamentally governed by the polarity of the

extraction solvent. While 70% ethanol gave the highest total phenolics (467.80 mg GAE/g; not significantly different from ethyl acetate) and flavonoids (179.38 mg QE/g), ethyl acetate proves superior in isolating fractions with the highest specific antioxidant capacity (71.36 µmol TE/g) and inhibition percentage. The extremely low moisture content (0.54%) further validates the extract's stability and suitability for industrial processing. Consequently, corn cob that traditionally treated as agricultural waste, emerges as a high-value source of natural antioxidants, with significant potential for application as a functional ingredient in the cosmetic and nutraceutical sectors.

References

1. Atma, Y. (2018). *Prinsip analisis komponen pangan: Makro & mikro nutrien*. Deepublish.
2. Badan Pengawas Obat dan Makanan Republik Indonesia [Indonesian National Agency of Drug and Food Control]. (2023). *Peraturan Kepala Badan Pengawas Obat dan Makanan Nomor 29 Tahun 2023 tentang Persyaratan Keamanan dan Mutu Obat Bahan Alam* [Regulation of the Head of the National Agency of Drug and Food Control Number 29 of 2023 concerning Safety and Quality Requirements for Natural Medicine]. BPOM RI.
3. Dhuharnia, C. E., & Novianto, A. (2018). Uji kandungan fenolik total dan pengaruhnya terhadap aktivitas antioksidan dari berbagai bentuk sediaan sarang semut (*Myrmecodia pendens*). *Jurnal Farmasi dan Ilmu Kefarmasian Indonesia, 5*(2), 62–68.
4. Gultom, D. K., Saraswati, I., & Sasikirana, W. (2021). Penetapan kandungan fenolik total dan uji aktivitas antioksidan fraksi etil asetat ekstrak etanolik kubis ungu (*Brassica oleraceae* var. *capitata* L.). *Generics: Journal of Research in Pharmacy, 1*(2), 79–87.
5. Handayani, S., Wirasutisna, K., & Insanu, M. (2017). Penapisan fitokimia dan karakterisasi simplisia daun jambu mawar (*Syzygium jambos* Alston). *JF FIK UINAM, 5*(3), 179–180.
6. Kementrian Pertanian Republik Indonesia [Ministry of Agriculture of the Republic of Indonesia]. (2019). *Laporan tahunan kementrian pertanian tahun 2018* [2018 Ministry of Agriculture annual report]. Biro Perencanaan Kementrian Pertanian.
7. Kursia, S., Lebang, J. S., & Nursamsiar. (2016). Uji aktivitas antibakteri ekstrak etilasetat daun sirih hijau (*Piper betle* L.) terhadap bakteri *Staphylococcus epidermidis*. *Indonesian Journal of Pharmaceutical Science and Technology, 3*(2), 72–77.
8. Othman, Z. S., Maskat, M. Y., & Hassan, N. H. (2020). Optimization of cinnamaldehyde extraction and antioxidant activity of Ceylon cinnamon extract. *Sains Malaysiana, 49*(5), 995–1002.
9. Panche, A. N., Diwan, A. D., & Chandra, S. R. (2016). Flavonoids: An overview. *Journal of Nutritional Science, 5*(e47), 1–15.
10. Pratiwi, L., Fudholi, A., Martien, R., & Pramono, S. (2016). Ekstrak etanol, ekstrak etil asetat, fraksi etil asetat, dan fraksi n-heksan kulit manggis (*Garcinia mangostana* L.) sebagai sumber zat bioaktif penangkal radikal bebas. *Journal of Pharmaceutical Science and Clinical Research, 1*, 71–82.
11. Prayitno, S. A., & Rahim, A. R. (2020). The comparison of extracts (ethanol and aquos solvents) *Muntingia calabura* leaves on total phenol, flavonid and antioxidant (IC_{50}) properties. *Kontribusia (Research Dissemination for Community Development), 3*(2), 319.
12. Putri, R. S. (2022). *Kajian in silico aktivator enzim Cu/Zn-SOD dan aktivitas antioksidan in vitro sirih merah (Piper crocatum Ruiz & Pav) asal berbagai daerah di Indonesia* [Undergraduate thesis]. Institut Pertanian Bogor.
13. Sari, A. N. (2017). Potensi antioksidan alami pada ekstrak daun jamblang (*Syzigium cumini* (L.) Skeels). *Eksakta, 18*(2).
14. Simanjuntak, P. R. (2023). *Kadar total fenolik, flavonoid, dan aktivitas inhibisi tirosinase fraksi ekstrak etanol daun sirih merah (Piper crocatum Ruiz & Pav) asal Solo* [Undergraduate thesis]. Institut Pertanian Bogor.
15. Sulastri, D., Hidayat, R., & Putri, M. (2018). Pengaruh jenis dan kepolaran pelarut terhadap ekstraksi flavonoid dari bonggol jagung. *Jurnal Teknologi Pangan, 20*(2), 145–152.
16. Suryanto, E., & Momuat, L. I. (2017). Isolasi dan aktivitas antioksidan fraksi dari ekstrak tongkol jagung (*Zea mays*). *Agritech, 37*(2), 139–147.