Pharmaceutical and Biomedical Sciences Journal
Volume 8(1), June 2026, 137-145

Antioxidant and Cytotoxic Evaluation of *Garcinia dioica* Blume Stem Bark Extracts

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Received: 21 April 2026; Accepted: 24 June 2026

Abstract: *Garcinia dioica* Blume, locally known as asam kandis, is a member of the Garcinia genus, which is recognized as an important source of xanthones, a class of polyphenolic compounds associated with diverse biological activities. Previous studies have demonstrated that xanthones possess antioxidant, anti-inflammatory, antimicrobial, and cytotoxic properties. The present study aimed to evaluate the antioxidant and cytotoxic activities of *G. dioica* stem bark extracts. The antioxidant analyzes with DPPH method and the cytotoxic activities with BSLT method. Asam kandis stems were extracted in stages with hexane, ethyl acetate, and ethanol. All extracts exhibited very strong antioxidant activity compared to vitamin C, with an IC_{50} of 3.86. The 96% ethanol extract showed the highest activity (IC_{50} 10.59 ppm; AAI 1.89), followed by *n*-hexane and ethyl acetate extracts with IC_{50} of 12.96 and 20.04 ppm. The cytotoxic activity of ethyl acetate was proven to provide significant results, followed by ethanol and hexane extracts with LC_{50} of 30.50 ppm, 37.68 ppm, and 59.10 ppm, respectively. These results indicate that the bark of *Garcinia dioica* exhibits significant antioxidant and cytotoxic activity, suggesting its potential for further research as a source of anticancer compounds.

Keywords: antioxidant, cytotoxic, stem bark, *Garcinia dioica*

Abstrak: *Garcinia dioica* Blume, yang secara lokal dikenal sebagai asam kandis, merupakan anggota genus Garcinia, yang diakui sebagai sumber penting xanton, suatu kelas senyawa polifenol yang dikaitkan dengan beragam aktivitas biologis. Penelitian sebelumnya telah menunjukkan bahwa xanton memiliki sifat antioksidan, antiinflamasi, antimikroba, dan sitotoksik. Penelitian ini bertujuan untuk mengevaluasi aktivitas antioksidan dan sitotoksik ekstrak kulit batang *G. dioica*. Uji antioksidan dianalisa dengan metode DPPH dan uji sitotoksik dengan metode BSLT. Batang asam kandis diekstraksi secara bertingkat dengan heksan, etil asetat dan etanol. Semua ekstrak menunjukkan aktivitas antioksidan yang sangat kuat dibandingkan dengan vitamin C dengan IC_{50} sebesar 3,86. Ekstrak etanol 96% menunjukkan aktivitas tertinggi (IC_{50} 10,59 ppm; AAI 1,89), diikuti oleh ekstrak n-heksana dan etil asetat dengan IC_{50} masing-masing 12,96 dan 20,04 ppm. Aktivitas sitotoksik etil asetat terbukti memberikan hasil yang signifikan diikuti oleh etanol dan heksan dengan LC_{50} berturut-turut yaitu 30,50 ppm, 37,68 dan 59,10 ppm. Hasil-hasil ini menunjukkan bahwa kulit batang *Garcinia dioica* memiliki aktivitas yang signifikan pada uji antioksidan dan sitotokik sehingga berpeluang untuk diteliti lebih lanjut sebagai sumber senyawa aktif antikanker.

Keywords: antioksidan, asam kandis, sitotoksik, *Garcinia dioica*

DOI: https://doi.org/10.15408/pbsj.v8i1.50813

1. INTRODUCTION

Garcinia is a genus in the Clusiaceae family, which comprises 400 species; 77 of these are found in Indonesia and other tropical regions. This group is rich in secondary metabolites, namely phenolic compounds such as flavonoids, xanthones, and benzophenones (Putri et al., 2017). These compounds exhibit biological activities such as antimicrobial, antioxidant, antimalarial, and cytotoxic effects (Darwati et al., 2019). The stems, leaves, fruits, and flowers are also reported to possess biological activities such as anti-inflammatory and antibacterial properties (Putri et al., 2017; Syamsudin et al.,

2008).

Asam kandis (*Garcinia dioica* Blume.), one of the species of the Garcinia group, which is rich in xanthone compounds and is widely distributed in tropical areas. This plant is found in various regions in Indonesia, such as Kalimantan, Sumatra, Java, and Bali. This plant has various names in different regions, such as asam kandih in West Sumatra; kunyi talerang in Lampung; and buran in Kalimantan. Asam kandis is a cooking spice widely used as a substitute for tamarind (Cahyani et al., 2021). Beyond its culinary uses, the rich chemical profile of this genus, particularly its xanthone content, contributes significantly to its diverse biological activities, making it highly valuable in ethnomedicine(Espirito Santo et al., 2020a; Ritthiwigrom et al., 2013).

Consequently, various parts of this plant have been widely integrated into traditional medicine. For instance, the fruits and leaves are traditionally used to improve blood circulation, as well as serving as an expectorant and a laxative. The fruit besides being a popular spice in Sumatran cuisine, has also been reported to possess anti-cholesterol properties. Furthermore, the roots are traditionally utilized to reduce fever, while the bark has demonstrated potential as an antipyretic, antimicrobial, and anticancer agent (Dwi Cahya et al., 2025; Mayanti, 2019; Pathak et al., 2026; Praman et al., 2024). Jhofi et al. (2021) reported that the ethanol extract of *Garcinia cowa* had antioxidant activity with IC_{50} of 41.36 ± 1.25 µg/ml. This antioxidant capacity is highly relevant, as oxidative stress induced by free radicals is closely linked to cellular damage and carcinogenesis. Therefore, evaluating both antioxidant and cytotoxic activities is a crucial step in discovering novel therapeutic agents from the *Garcinia* genus.
To bridge traditional knowledge with laboratory evidence, cytotoxicity assays serve as an initial screening method for its anticancer potential. Cytotoxic tests on plant extracts are carried out to detect the presence of anticancer activity of a compound. *The Brine Shrimp Lethality Test* (BSLT) is a method frequently used to determine toxic effects and to screen new anticancer compounds from plant extracts (Pangow et al., 2018; Sukkum et al., 2025). Based on the plant's traditional use as an anticancer agent and its potential chemical profile, the bark of *asam kandis* serves as a promising candidate to be developed as a source of active compounds. Therefore, this study examined the antioxidant activity and cytotoxic activity of ethyl acetate, n-hexane, and 96% ethanol extracts of *asam kandis* bark as a preliminary screening to discover its potential as a natural antioxidant and anticancer agent.

2. MATERIAL AND METHODS

2.1 Material

Garcinia dioica stem bark (*Garcinia dioica* Blume) was obtained from Padang known by local people as *asam kandih* (asam kandis), West Sumatra in August 2020. The chemicals used were n-hexane, ethyl acetate, methanol, ethanol 96%, distilled water, 10% H_2SO_4, $FeCl_3$, NaOH, silica gel Merck 60 GF_{254} (0.063-0.2 mm), 1,1-diphenyl-2-picrylhydrazyl (DPPH), and methanol p.a. from Merck.

2.2 Method

a. Determination of Plant

Plant determination was identified at the Herbarium Bogoriense, Botany Division, Biology Research Center, Badan Riset dan Inovasi Nasional (BRIN) Cibinong Bogor, West Java with number B-408/IV/DI.01/3/2021

b. Extraction

One kg of *G. dioica* stem bark powder was extracted using a multistep maceration method using three solvents: n-hexane, ethyl acetate, and ethanol. The extraction was carried out for 3x24 hours, with the bottle occasionally shaken. Each extract was evaporated and then concentrated using rotary evaporation at 50-60^{o}C until thick extract was obtained (Rindita et al., 2020).

2.2.1 Determination of Antioxidant Activity of Extracts with the DPPH Method

The antioxidant activity of the extract was analyzed using the method carried out by Baliyan et al. (2022). The DPPH solution was prepared by dissolving 2 mg of DPPH in 100 mL of ethanol p.a to obtain a 0.05 mM solution. A mixture of 2 mL DPPH solution and 1 mL ethanol p.a was homogenized and incubated in the dark for 30 minutes, after which the absorbance was measured using a UV–Vis spectrophotometer at 400–600 nm to determine the maximum wavelength, with measurements conducted in triplicate (Baliyan et al., 2022a). The crude extracts were prepared in a series of concentrations (12.5, 25, 50, 100, and 200 ppm). Vitamin C is used as a reference, with test concentrations of 2, 4, 6, 8, and 10 ppm. Each test sample was then mixed with the DPPH solution at a 1:1 ratio, and the absorbance was recorded at the maximum wavelength after 30 minutes. The IC_{50} value was calculated using a logarithmic regression equation, and the Antioxidant Activity Index (AAI) was determined by dividing the DPPH concentration by the IC_{50} value.

2.2.2 Cytotoxicity Test of Extracts with Brine Shrimp Lethality Test (BSLT)

This test measures the toxicity of an extract to *Artemia salina* larvae. *A. salina* is a shrimp species that is highly sensitive to environmental changes, both biotic and abiotic. The shrimp larvae used for testing were 48 hours old after hatching. A total of 10 mg of each extract (ethyl acetate, n-hexane, and 96% ethanol) from the asam kandis stem bark was weighed and dissolved in 10 mL of DMSO to prepare a 1000 ppm stock solution. To achieve a concentration of 100 ppm, a 10 mL aliquot of this stock solution was further diluted with saline solution to a total volume of 100 mL. Subsequently, a series of dilutions was prepared by further diluting the 100 ppm solution with saline, resulting in a concentration series of 100, 50, 25, 12.5, and 6.25 ppm. For the negative control, a 10% DMSO solution in saline was prepared without the addition of any extract.

A total of 10 *A. salina* Leach shrimp larvae were pipetted into each test solution and the negative control. The tops of the measuring flasks were then covered with aluminum foil and slightly perforated to allow airflow. Afterward, the flasks were placed in a well-lit area and left for 24 hours. The test was conducted in triplicate for each concentration and negative control. After 24 hours, the number of surviving larvae in each test solution was counted. The standard criterion for measuring larval mortality was the absence of movement during observation. Observations were conducted by calculating the percentage of larval mortality (Ala et al., 2018; Surya et al., 2022). The data were analyzed using the probit method to determine the LC_{50} value. Probit analysis was used to describe the relationship between the biological response, larval mortality, and the concentration of the test sample. Subsequently, the data were processed using Microsoft Excel by plotting a linear regression curve between the probit values and the log concentrations. The resulting regression equation is expressed as ($y = ax + b$), where (y) is the probit value and (X) is the log concentration.

3. RESULTS AND DISCUSSION

Plant determination was carried out to ensure the identity of the plant. Based on botanical identification, the sample was authenticated as *Garcinia dioica* Blume (locally known as asam kandis). The antioxidant activity of asam kandis stem bark extract was evaluated using the DPPH radical scavenging assay (Kamal-Eldin & Pokorny, 2020). This method was selected due to its simplicity, high sensitivity, minimal sample requirement, rapid execution, and reliable reproducibility. DPPH is also highly soluble and, when stored dry under stable storage conditions (Kedare & Singh, 2011; Shahidi & Zhong, 2015). DPPH is a stable free radical. The reaction between an antioxidant and the stable DPPH free radical involves hydrogen donation, leading to the reduction of the radical form. This chemical transition reduces the solution's absorbance, visibly characterized by a color change from purple to yellow as the picryl chromophore group is neutralized (Chandra Shekhar & Anju, 2014).

The DPPH control solution, prepared in methanol, serves to determine the initial absorbance of the stable free radicals before the addition of any test compound. This control value is used as the baseline

absorbance to calculate the percentage of inhibition, reflecting the radical scavenging activity of the extracts (Baliyan et al., 2022b; Salsabila et al., 2025). The maximum wavelength of 0.1 mM DPPH was 515 nm and the absorbance was 0.685. This indicates that the wavelength and absorbance values are in accordance with the literature, namely a wavelength of around 515-520 nm and an absorbance value of around 0.4-0.9 (Wulandari L et al., 2021).

This antioxidant activity test uses varying concentrations in the test solution of each extract, aiming to provide an overview of the antioxidant activity of the tested compound. A decrease in DPPH absorbance will occur after the addition of the test compound and indicates a reduction in the concentration of DPPH free radicals. This occurs due to a reaction with the antioxidant compound, resulting in the reduction of DPPH molecules and a decrease in the intensity of the purple color in the DPPH solution (Baliyan et al., 2022b). The results of the antioxidant activity of each sample tested are provided in table 1 and figure 1.

Table 1. Results of Antioxidant Tests Using the DPPH Method of *Garcinia dioica* Stem Bark Extract and Vitamin C

Sample tested	Conct.	Log Conct.	%Inhibition	Regreation Equation	Nilai IC_{50} (ppm)	AAI (ppm)
n-hexane	12.5	2.526	48.22	$y = 16.637 \ln x + 7.377$	12.96	1.54
	25	3.219	58.88			
	50	3.912	74.48	$R^2 = 0.9780$		
	100	4.605	90.17			
	200	5.298	91.66			
Ethyl Acetate	12.5	2.526	32.75	$y = 21.037 \ln x - 13.064$	20.04	1.00
	25	3.219	60.58			
	50	3.912	87.53	$R^2 = 0.9043$		
	100	4.605	88.48			
	200	5.298	89.76			
Ethanol 96%	12.5	2.526	48.38	$y = 12.112 \ln x + 21.417$	10.59	1.89
	25	3.219	66.41			
	50	3.912	74.33	$R^2 = 0.9634$		
	100	4.605	78.18			
	200	5.298	82.45			
Vitamin C	2	0.693	37.58	$y = 26.568 \ln x + 14.125$	3.86	5.18
	4	1.386	47.23			
	6	1.792	59.53	$R^2 = 0.9634$		
	8	2.079	68.07			
	10	2.303	80.16			

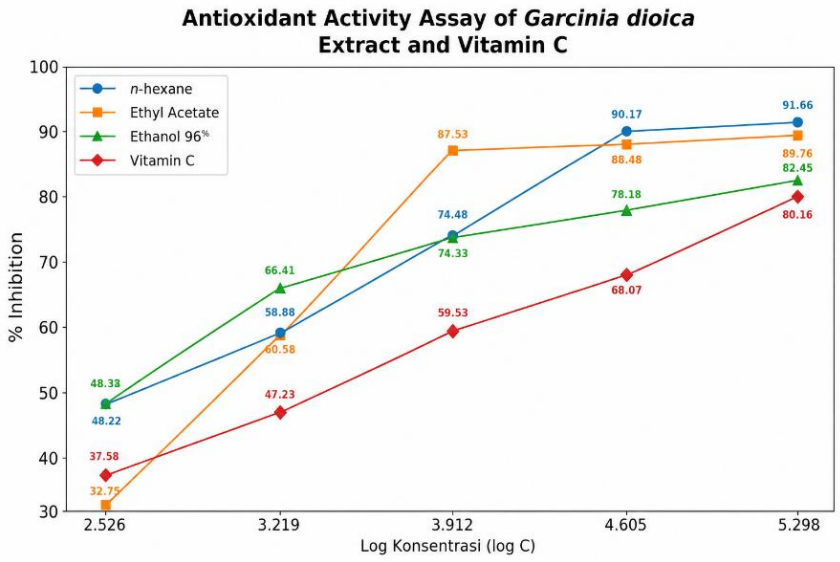

Figure 1. Linear Regression Curve of Antioxidant Activity Test of *G. dioica* Extract

The results are shown in Table 1. The results of the study show that all Garcinia dioica bark extracts exhibit increased free radical scavenging activity as the extract concentration increases. The n-hexane extract showed an increase in the inhibition percentage from 48.22% at a concentration of 12.5 ppm to 91.66% at a concentration of 200 ppm. A similar increase was also observed in ethyl acetate and 96% ethanol extracts. This indicates a dose-dependent relationship, wherein the higher the extract concentration, the greater the ability of the bioactive compounds it contains to donate electrons or hydrogen atoms to stabilize DPPH free radicals. These findings align with the fundamental principles of the DPPH assay as described by Molyneux (2004). Based on the results of the logarithmic regression analysis, the IC_{50} values for the hexane, ethyl acetate, 96% ethanol, and vitamin C extracts were 12.96, 20.04, 10.59, and 3.86 ppm, respectively. The IC_{50} value represents the concentration of the sample required to scavenge 50% of DPPH free radicals. It is one of the most commonly used parameters for evaluating antioxidant potency in DPPH assays. Lower IC_{50} values indicate stronger antioxidant activity because a smaller amount of the sample is needed to neutralize half of the DPPH radicals present in the reaction system (Gulcin & Alwasel, 2023; Rana et al., 2024). Therefore, among the tested extracts, the 96% ethanol extract exhibited the highest antioxidant activity, followed by the hexane and ethyl acetate extracts, while vitamin C showed the strongest radical scavenging activity overall due to its substantially lower IC_{50} value. Based on a widely used classification of antioxidant activity, extracts with an IC_{50} < 50 ppm are categorized as very potent antioxidants (Phongpaichit et al., 2007). Therefore, all extracts tested in this study fall into the category of very potent antioxidants. Phenolic compounds and flavonoids exert antioxidant effects primarily through hydrogen atom transfer and single-electron transfer mechanisms, enabling them to stabilize reactive oxygen species and other free radicals. Similarly, xanthones possess phenolic hydroxyl groups that contribute to their radical scavenging activity and reducing power (Kazmierczak et al., 2023; Murthy et al., 2020).

The strong antioxidant activity exhibited by *G. dioica* stem bark extracts in the present study may therefore be associated with the presence of these classes of compounds. This assumption is further supported by phytochemical screening studies reporting the occurrence of phenolics and flavonoids in *G. dioica* extracts (A Hidayat et al., 2018). The strong antioxidant activity observed in *G. dioica* is consistent with previous reports on members of the genus *Garcinia*, which are recognized as rich sources of phenolic compounds, flavonoids, benzophenones, and xanthone derivatives. These metabolites have attracted considerable attention because of their diverse biological activities, particularly their antioxidant properties (Aravind et al., 2017; Espirito Santo et al., 2020a).

Table 2. The Effect of Extracts Concentration on the Mortality of *A. salina* Leach Larvae.

Extracts	Conct. (ppm)	Mortality (%)	Probit
Hexane	100	63.33	5.341
	50	43.33	4.832
	25	33.33	4.569
	12.5	26.67	4.377
	6.25	23.30	4.271
Ethyl Acetate	100	70.00	5.524
	50	63.33	5.341
	25	40.00	4.747
	12.5	36.67	4.659
	6.25	23.33	4.272
Ethanol	100	66.67	5.431
	50	56.67	5.168
	25	43.33	4.832
	12.5	26.67	4.377
	6.25	23.33	4.272

Cytotoxic assays of ethyl acetate, *n*-hexane, and 96% ethanol extracts of stem bark were carried out using the BSLT method. The BSLT method is often used to determine the toxic ability of a compound produced by plant extracts to cells (cytotoxic) because it is simple to carry out, fast to carry out, cheaper, and does not require special equipment. Besides that, the BSLT method serves as an initial step in evaluating the toxicity of an extract or compound, and it is also used to assess the bioactivity of compounds derived from natural products. It is commonly applied as a preliminary screening tool to

identify active compounds in plant extracts and exhibits a broad range of pharmacological activities (Nhamussua et al., 2026; Sari et al., 2024). Each extract solution was prepared in five concentrations: 6.25, 12.5, 25, 50, and 100 ppm. Negative controls were prepared, consisting of only salt water and shrimp larvae without the addition of extract. The test was carried out in triplicate at each extract concentration to obtain reliable and accurate data. The results of the cytotoxic activity test are presented in Table 2.

Table 3. Results of the Probit Analysis of *Garcinia dioica* Fractions

Extracts	Linear Regression Equation	R^2	LC_{50}
Hexane	y = 0.862x + 3.473	0.921	59.10
Ethyl Acetate	y = 1.058x + 3.429	0.958	30.50
Ethanol	y = 1.033x + 3.372	0.975	37.68

Based on the results, all extracts showed an increase in larval mortality rates as the extract concentration increased. For the hexane extract, the larval mortality rate increased from 23.30% at a concentration of 6.25 ppm to 63.33% at a concentration of 100 ppm. Similarly, the ethyl acetate and ethanol extracts showed a trend of increased mortality at higher concentrations. These results indicate a dose-response relationship, meaning that the higher the concentration of the extract administered, the greater the toxic effect on *A. salina* larvae (Meyer B N et al., 1982). The probit analysis in this study yielded LC_{50} values for the hexane, ethyl acetate, and ethanol extracts of 59.25, 30.54, and 37.82 ppm, respectively as shown in Table 3. The lowest LC_{50} value was obtained for the ethyl acetate extract, indicating that this extract exhibits the strongest cytotoxic activity compared to the other extracts. Conversely, the hexane extract had the highest LC_{50} value, indicating relatively lower cytotoxic activity.

The cytotoxicity assay using the BSLT is one of the most widely used preliminary screening methods for evaluating the potential toxicity of plant extracts and natural compounds. This method utilizes *A. salina* Leach larvae as test organisms to detect biological activity related to cytotoxic properties. The BSLT method was chosen because it is simple, rapid, economical, requires relatively small sample sizes, and has good correlation with various pharmacological activities, including antitumor and anticancer activities (da Cunha Demenciano et al., 2020).

The differences in cytotoxic activity among the extracts are thought to be influenced by the types of secondary metabolites extracted, based on the polarity of the solvents used. Ethyl acetate is a semi-polar solvent and is therefore capable of dissolving various bioactive compounds such as aglycone flavonoids, certain alkaloids, quinones, and specific terpenoids known to possess cytotoxic activity. Meanwhile, hexane tends to extract nonpolar compounds such as lipids and steroids, whereas ethanol is more effective at dissolving polar compounds such as flavonoid glycosides, tannins, and other phenolic compounds (Ojong et al., 2026). The content of these secondary metabolites is thought to contribute to the toxic activity observed in *A. salina* larvae. Phytochemical investigations have demonstrated that both the species and genus *Garcinia* contain a variety of bioactive secondary metabolites, including phenolic constituents particularly xanthones along with benzophenones and bioflavonoids. In addition, a number of metabolites isolated from the *Garcinia* have been reported to possess anticancer activity. For example, garcinol, a polyisoprenylated benzophenone derived from Garcinia, has been studied in both in vitro and in vivo studies against cancer cells and has been found to inhibit activity through several mechanisms, including inducing apoptosis and cell cycle arrest, inhibiting angiogenesis, and modulating gene expression in cancer cells (Aggarwal et al., 2020; Pochana et al., 2025). These findings provide an initial indication of the potential of metabolites derived from the bark of asam kandis as a source of anticancer bioactive compounds. However, further comprehensive research is needed, including investigations into the mechanisms of action, toxicity evaluations, and identification of the active compounds, in order to elucidate their therapeutic potential and support the development of this plant.

4. CONCLUSION

The results of the antioxidant assays demonstrated that the ethanol extract of asam kandis stem bark showed highest activity while ethyl acetate extract showed the highest cytotoxic activity. These results indicate the presence of bioactive constituents in asam kandis and support further studies aimed at identifying its secondary metabolites and evaluating their biological activities, including potential anticancer effects.

5. ACKNOWLEDGMENT

The authors would like to acknowledge the Research and Publishing Center of Syarif Hidayatullah Islamic University Jakarta for funding this work with a number B-302/LP2M-PUSLITPEN/TL.03/2022.

6. REFERENCES

A Hidayat, W Ardiningsih, P Jayuska, & Afghani. (2018). Aktivitas Antioksidan dan Antibakteri Fraksi Etil Asetat Buah Asam Kandis (Garcinia dioica Blume) Terenkapsulasi Gelatin. *Jurnal Kimia Khatulistiwa*, *7*(2), 33–40.

Aggarwal, V., Tuli, H. S., Kaur, J., Aggarwal, D., Parashar, G., Parashar, N. C., Kulkarni, S., Kaur, G., Sak, K., Kumar, M., & Ahn, K. S. (2020). Garcinol exhibits anti-neoplastic effects by targeting diverse oncogenic factors in tumor cells. *Biomedicines*, *8*(5). https://doi.org/10.3390/BIOMEDICINES8050103

Ala, A. A., Olotu, B. B., & Ohia, C. M. D. (2018). *Assessment of cytotoxicity of leaf extracts of Andrographis paniculata and Aspilia africana on murine cells in vitro*.

Aravind, A. P. A., Menon, L. N., & Rameshkumar, K. B. (2017). Structural diversity of secondary metabolites in Garcinia species. In *JNTBGRI*.

Baliyan, S., Mukherjee, R., Priyadarshini, A., Vibhuti, A., Gupta, A., Pandey, R. P., & Chang, C. M. (2022a). Determination of Antioxidants by DPPH Radical Scavenging Activity and Quantitative Phytochemical Analysis of Ficus religiosa. *Molecules*, *27*(4). https://doi.org/10.3390/molecules27041326

Baliyan, S., Mukherjee, R., Priyadarshini, A., Vibhuti, A., Gupta, A., Pandey, R. P., & Chang, C. M. (2022b). Determination of Antioxidants by DPPH Radical Scavenging Activity and Quantitative Phytochemical Analysis of Ficus religiosa. *Molecules*, *27*(4). https://doi.org/10.3390/molecules27041326

Cahyani, W. U., Darmawan, A., & Suci, D. margi. (2021). Suplementasi Ekstrak Asam Kandis (Garcinia xanthochymus) dalam Air Minum terhadap Kadar Malondialdehid Kuning Telur dan Komposisi Kimia Daging dan Telur Puyuh. *Jurnal Ilmu Nutrisi Dan Teknologi Pakan*, *19*(1), 24–29. https://doi.org/10.29244/jintp.19.1.24-29

Chandra Shekhar, T., & Anju, G. (2014). Antioxidant Activity by DPPH Radical Scavenging Method of Ageratum conyzoides Linn. Leaves. In *American Journal of Ethnomedicine* (Vol. 1, Number 4). www.ajethno.comhttp://www.ajethno.com

da Cunha Demenciano, S., Lima e Silva, M. C. B., Farias Alexandrino, C. A., Kato, W. H., de Oliveira Figueiredo, P., Garcez, W. S., Campos, R. P., de Cássia Avellaneda Guimarães, R., Sarmento, U. C., & Bogo, D. (2020). Antiproliferative activity and antioxidant potential of extracts of garcinia gardneriana. *Molecules*, *25*(14). https://doi.org/10.3390/molecules25143201

Dwi Cahya, M., Andriani, Y., Adharyan Islamy, R., & Masriah, A. (2025). Exploring the Potential of Garcinia cowa as a Phytogenic Feed Additive for Fish. *Egyptian Journal of Aquatic Biology & Fisheries*, *29*(6), 159–174. www.ejabf.journals.ekb.eg

Espirito Santo, B. L. S. do, Santana, L. F., Kato Junior, W. H., de Araújo, F. de O., Bogo, D., Freitas, K. de C., Guimarães, R. de C. A., Hiane, P. A., Pott, A., Filiú, W. F. de O., Arakaki Asato, M., Figueiredo, P. de O., & Bastos, P. R. H. de O. (2020a). Medicinal Potential of Garcinia Species and Their Compounds. *Molecules (Basel, Switzerland)*, *25*(19). https://doi.org/10.3390/molecules25194513

Espirito Santo, B. L. S. do, Santana, L. F., Kato Junior, W. H., de Araújo, F. de O., Bogo, D., Freitas, K. de C., Guimarães, R. de C. A., Hiane, P. A., Pott, A., Filiú, W. F. de O., Arakaki Asato, M., Figueiredo, P. de O., & Bastos, P. R. H. de O. (2020b). Medicinal Potential of Garcinia Species and Their Compounds. In *Molecules (Basel, Switzerland)* (Vol. 25, Number 19). NLM (Medline). https://doi.org/10.3390/molecules25194513

Gulcin, İ., & Alwasel, S. H. (2023). DPPH Radical Scavenging Assay. *Processes*, *11*(8). https://doi.org/10.3390/pr11082248

Kamal-Eldin, A., & Pokorny, J. (2020). Antioxidants in Food Preservation. In *Handbook of Food Preservation*. https://doi.org/10.1201/9780429091483-22

Kazmierczak, E., Magalhães, C. G., & Pereira, R. P. (2023). Antioxidant property of secondary metabolites from Garcinia genus: A short review. In *Ecletica Quimica* (Vol. 48, Number 1, pp. 41–54). Atlantis Livros Ltda. https://doi.org/10.26850/1678-4618eqj.v48.1.2023.p41-54

Kedare, S. B., & Singh, R. P. (2011). Genesis and development of DPPH method of antioxidant assay. In *Journal of Food Science and Technology* (Vol. 48, Number 4, pp. 412–422). https://doi.org/10.1007/s13197-011-0251-1

Mayanti, T. (2019). Steroid Compounds from Root Plant of Garcinia cowa Roxb. ex DC for Fever Relief. *Jurnal Penelitian Hasil Hutan*, *37*(1). https://doi.org/10.20886/jphh.2019.37.1.51-58

Meyer B N, Ferrigni N R, Putnamm J E, Jacobsen L B, Nichols D E, & McLaughlin J L. (1982). Brine Shrimp: A Convenient General Bioassay for Active Plant Constituents. *Journal of Medicinal Plant Research*, *45*.

Murthy, H. N., Dalawai, D., Dewir, Y. H., & Ibrahim, A. (2020). Phytochemicals and biological activities of Garcinia morella (Gaertn.) desr.: A review. *Molecules*, *25*(23). https://doi.org/10.3390/molecules25235690

Nhamussua, R. L., Mabiki, F. P., Mwakalesi, A. J., & McGaw, L. J. (2026). Screening anticancer activity by Brine shrimp lethality test of extracts of Annona stenophylla (Engl. & Diels), Strophanthus petersianus (Klotzsch) and Synadenium glaucescens (Pax). *PloS One*, *21*(1), e0336636. https://doi.org/10.1371/journal.pone.0336636

Ojong, C., Besong, S. A., & Aryee, A. N. A. (2026). Solvent-Based Extraction Recovers Phytochemicals from Medicinal Plants Demonstrating Anticancer and Chemopreventive Potential: A Review. *Molecules*, *31*(7). https://doi.org/10.3390/molecules31071202

Pangow, M. E., Bodhi, W., & De Queljoe, E. (2018). Skrining Fitokimia dan Uji Toksisitas Ekstrak Etanol Daun Manggis (Garcinia mangostana L.) dengan Metode Brine Shrimp Lethality test (BSLT). *PHARMACON*, *7*(3).

Pathak, K., Das, A., Das, M., Saikia, R., Ahmad, M. Z., Sahariah, J. J., Pathak, M. P., Islam, M. A., Pramanik, P., & Sonowal, S. (2026). From tradition to therapeutics: antioxidant, anti-inflammatory, and antidiabetic activities of Garcinia cowa Roxb. leaf extracts. *Phytomedicine Plus*, *6*(1). https://doi.org/10.1016/j.phyplu.2026.100955

Phongpaichit, S., Nikom, J., Rungjindamai, N., Sakayaroj, J., Hutadilok-Towatana, N., Rukachaisirikul, V., & Kirtikara, K. (2007). Biological activities of extracts from endophytic fungi isolated from Garcinia plants. *FEMS Immunology and Medical Microbiology*, *51*(3), 517–525. https://doi.org/10.1111/j.1574-695X.2007.00331.x

Pochana, G., Karanam, T. S., Mack, S., & Karanam, B. (2025). Garcinol as an Epigenetic Modulator: Mechanisms of Anti-Cancer Activity and Therapeutic Potential. In *International Journal of Molecular Sciences* (Vol. 26, Number 22). Multidisciplinary Digital Publishing Institute (MDPI). https://doi.org/10.3390/ijms262210917

Praman, S., Teerapattarakan, N., & Hawiset, T. (2024). Garcinia cowa Leaf Ethanolic Extract Induces Vasorelaxation Through eNOS/NO/sGC Pathway, Potassium, and Calcium Channels in Isolated Rat Thoracic Aorta. *Pharmacognosy Journal* , *16*(4), 797–804. https://doi.org/10.5530/pj.2024.16.132

Putri, N. L., Elya, B., & Puspitasari, N. (2017). Antioxidant activity and lipoxygenase inhibition test with total flavonoid content from garcinia kydia roxburgh leaves extract. *Pharmacognosy Journal*, *9*(2), 280–284. https://doi.org/10.5530/pj.2017.2.48

Rana, M. S., Rayhan, N. M. A., Emon, M. S. H., Islam, M. T., Rathry, K., Hasan, M. M., Islam Mansur, M. M., Srijon, B. C., Islam, M. S., Ray, A., Rakib, M. A., Islam, A., Kudrat-E-Zahan, M., Hossen, M. F., & Asraf, M. A. (2024). Antioxidant activity of Schiff base ligands using the DPPH

scavenging assay: an updated review. In *RSC Advances* (Vol. 14, Number 45, pp. 33094–33123). Royal Society of Chemistry. https://doi.org/10.1039/d4ra04375h

Rindita, Anggia, V., Rahmaesa, E., Devi, R. K., & Alawiyah, L. F. (2020). Exploration, phenolic content determination, and antioxidant activity of dominant pteridophytes in gunung malang village, mount halimun salak national park, Indonesia. *Biodiversitas*, *21*(8), 3676–3682. https://doi.org/10.13057/biodiv/d210834

Ritthiwigrom, T., Laphookhieo, S., & Pyne, S. G. (2013). Chemical constituents and biological activities of Garcinia cowa Roxb. *Maejo Int. J. Sci. Technol*, *7*(02), 212–231. www.mijst.mju.ac.th

Salsabila, S., Pagarra, H., Muis, A., Naufal, M., & Haq, S. (2025). The Effect of Matoa (Pometia Pinnata) Leaf Ethanol Extract on Reducing Blood Sugar Level in Male Mice (Mus Musculus) Induced by Alloxan. In *Journal Bionature p* (Vol. 26, Number 1). http://ojs.unm.ac.id/bionature

Sari, F., Daulay, A. S., & Rani, Z. (2024). Cytotoxicity Test of Bandotan Herbal Ethanol Extract (Ageratum conyzoides L.) Using the Brine Shrimp Lethality Test (BSLT) Method. *Jurnal Akademika Kimia*, *13*(1), 14–19. https://doi.org/10.22487/j24775185.2024.v13.i1.pp14-19

Shahidi, F., & Zhong, Y. (2015). Measurement of antioxidant activity. In *Journal of Functional Foods* (Vol. 18, pp. 757–781). Elsevier Ltd. https://doi.org/10.1016/j.jff.2015.01.047

Sukkum, C., Lekklar, C., Chongsri, K., Deeying, S., Srisomsap, C., Surapanich, N., Kanjanasingh, P., & Hongthong, S. (2025). Anti-cancer activity and brine shrimp lethality assay of the extracts and isolated compounds from Garcinia schomburgkiana Pierre. *Journal of Applied Pharmaceutical Science*, *15*(3), 241–247. https://doi.org/10.7324/JAPS.2025.209800

Surya, A., Murwindra, R., & Syahrul Fiki, M. (2022). Uji Toksisitas Ekstrak Etanol Daun Kemangi (Ocinum Sanctum L.) Terhadap larva Udang (Artemia salina L.) Dengan Metode BSLT (Brine Shrimp Lethality Test). In *Journal Education and Chemistry* (Vol. 4, Number 1).

Syamsudin, Wahyuono S, Tjokrosonto S, & Mustofa. (2008). In vivo Antiplasmodial Activity and Acute Toxicity of the Fraction of the Garcinia parvifolia Miq. Stem Bark. *1*.

Wulandari L, Nugraha A S, & Himmah U A. (2021). In Vitro Determination of Antioxidant and Antidiabetic Activity of Matoa Leaf Extract(Pometia pinnataJ. R.Forst. & G. Forst.). *Jurnal Kefarmasian Indonesia*, (11).

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