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Antihypercholesterolemic Potential of Ethanolic Leaf Extracts of *Santalum album* L., *Calotropis gigantea, Ziziphus spina*-christi L.

Khoirul Ngibad[1*], Elis Dwi Nuryani[1], Tarisatus Syahlum Mukarromah[1], Nurisma Fadhila[1]

[1] Medical Laboratory Technology Program, Universitas Maarif Hasyim Latif, Sidoarjo, Indonesia

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Corresponding Author:
Khoirul Ngibad
khoirul_ngibad@dosen.umaha.ac.id

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Abstract: Hyperlipidemia, especially elevated Low-Density Lipoprotein (LDL) cholesterol, is a global health problem that increases the risk of cardiovascular disease. Conventional treatment with statins is effective, but it often causes side effects. This study aims to evaluate the potential of sandalwood (*Santalum album* L.) leaf, biduri (*Calotropis gigantea*) leaf, and arabic bidara (*Ziziphus spina*-christi L.) leaf as an antihypercholesterolemia agent using ethanol extract to lower cholesterol levels in mice. Extraction is carried out through maceration with 96% ethanol for 3 x 24 hours, then evaporated to produce a thick extract. The samples used in the antihyperocholesterolterol test were extracts of *Santalum album* L., *Calotropis gigantea*, and *Ziziphus spina*-christi L. Six groups, six mice each, consisted of: negative control (I), positive control (II), simvastatin drug control (III), and three test dose groups (IV: 3.5 mg/20 g BW, V: 7 mg/20 g BW, VI: 14 mg/20 g BW). Cholesterol levels were measured by the Point of Care Testing (POCT) Method using a cholesterol strip test after a blood draw. The results showed that simvastatin can lower cholesterol by 59 mg/dl. Moreover, *Santalum album* L. leaf extracts provided the most significant reduction in cholesterol (33 mg/dl), followed by *Ziziphus spina*-christi L. (31 mg/dl) and *Calotropis gigantea* (28 mg/dl). Although simvastatin showed a greater decrease, the plant extract still exerted significant effects as an alternative to antihypercholesterolemia therapy. This decrease in cholesterol is related to the content of active compounds, such as flavonoids and phenolics, that reduce LDL oxidation. These findings suggest that *Santalum album* L. has promising potential as an herbal antihypercholesterolemic agent.

Keywords: Antihypercholesterolemic; *Calotropis gigantea*; Leaf Extract; *Santalum album* L., *Ziziphus spina*-christi L.

Introduction

Hyperlipidemia, a condition characterized by elevated blood fat levels, has become a significant health issue, particularly among urban populations. Increased cholesterol levels, especially Low-Density Lipoprotein (LDL) cholesterol, can cause atherosclerosis in the blood vessels and are at high risk of causing cardiovascular disease, which is the leading cause of death in the world (Packard et al., 2021).

The instantaneous modern lifestyle, coupled with the consumption of high-cholesterol, low-nutrient fast food, exacerbates the prevalence of this condition. Hypercholesterolemia, as part of hyperlipidemia, increases the risk of atherosclerosis and coronary heart disease (Simonen et al., 2023). Amid this trend, the search for safer, more effective, and affordable treatment solutions is crucial, both for health scientists and the broader community that requires more natural therapeutic alternatives (Bhattacharjee et al., 2023). Given the profound impact that this disease poses, it is important to explore alternative therapies, both through pharmacological approaches and the use of medicinal plants that have potential as anti-hyperlipidemia, which

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are believed to be safer and have fewer side effects compared to synthetic drugs (Rachitha et al., 2023).

Research related to the treatment of high cholesterol has been conducted using modern medications, particularly statins, which have been proven effective in lowering cholesterol levels (Christyaningsih et al., 2024). Continued use of statin drugs can cause side effects, such as myopathy, indigestion, skin rashes, and insomnia (Cheung et al., 2023). Alternatively, numerous studies have led to the use of herbal plants, such as sandalwood (*Santalum album* L.), which has been shown to exhibit anti-hyperglycemic (Phung et al., 2025), antibacterial (Sharmila et al., 2017), and anticancer properties (Pullaiah et al., 2021). However, research on the potential of sandalwood leaves as an anti-hyperlipidemia in mice has not been widely conducted. In addition, several studies have been conducted on the benefits of biduri (*Calotropis gigantea*) leaves, focusing on their anti-inflammatory (Kumar et al., 2022) and antibacterial (Rengarajan et al., 2024), antimicrobial (Pattnaik et al., 2017), and antioxidant properties (Ahmad Nejhad et al., 2023). Ethanol extract of 70% biduri leaves is reported to contain flavonoids, phenols, tannins, saponins, terpenoids, and alkaloids (Alibasyah et al., 2023) which may have the potential to lower cholesterol levels. Furthermore, the leaves of bidara arabic (*Ziziphus spina-christi* L) have also been researched as antioxidants (Rialdi et al., 2023), antidiabetics (Nasution et al., 2024) and antibacterial (Muzayyidah et al., 2023). Bidara arabic leaves have also been reported to contain alkaloids, flavonoids, saponins, steroids, and tannins (Hastiana et al., 2022).

There are shortcomings in existing research, particularly in testing the effectiveness of *Santalum album* L., *Calotropis gigantea*, *Ziziphus spina-christi* L. leaves extracts in lowering cholesterol levels or functioning as anti-hyperlipidemic agents. Most previous studies have focused more on the antioxidant or antimicrobial activity of the three plants and no one has specifically studied the effect of the extracts of the three leaves on cholesterol levels in the blood, especially in test animal models such as mice. Thus, this deficiency needs to be complemented to verify the potential of *Santalum album* L., *Calotropis gigantea*, *Ziziphus spina-christi* L. leaves as an alternative treatment for hyperlipidemia.

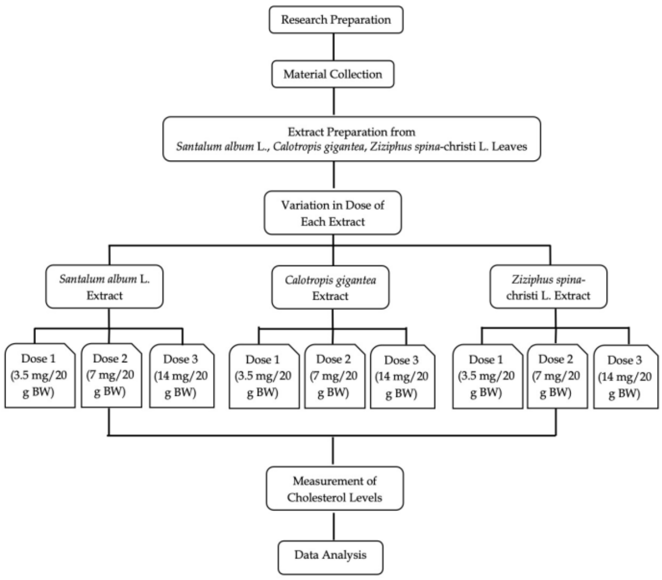
This study aims to investigate the potential of *Santalum album* L., *Calotropis gigantea*, *Ziziphus spina-christi* L. leaves as antihypercholesterolemic agents by utilizing ethanol extracts of these plants to reduce cholesterol levels in mice. This research is expected to make a significant contribution to the pharmaceutical field, particularly in the development of safer and more effective herbal medicines to address the issue of high cholesterol, as well as provide more affordable treatment options for the community.

Method

Tools and Materials

The tools used in this study include rotary evaporators, water baths, stirring rods, glassware, sondes, syringes, scissors, analytical balances, cholesterol test strips, and cholesterol automatic testing tools (Easy Touch GCU). Meanwhile, the ingredients used consist of *Santalum album* L., *Calotropis gigantea*, *Ziziphus spina-christi* L. leaves powder, 96% ethanol, simvastatin, propylthiouracil, aquadest, alcohol swabs, and aquadest.

Research Flow Diagram



Extraction

Samples of *Santalum album* L., *Calotropis gigantea*, *Ziziphus spina-christi* L. leaves were separately placed in a maceration container, and then 96% ethanol solvent was added until the simplicia were submerged. The maceration container is closed and stored for 3 × 24 hours, with occasional stirring. After that, the sample is filtered and separated into the pulp and filtrate. The filtrate obtained is then evaporated for 40 minutes to get a thick extract.

Antihypercholesterolemia Activity Test

The Animal Research Ethics Committee of Universitas Nahdlatul Ulama Surabaya approved this research under approval number 0258/EC/KEPK/UNUSA/2022, 0260/EC/KEPK/UNUSA/2022, and 0267/EC/KEPK/UNUSA/2022.

Six groups of test animals, each containing six mice, were divided into group I (negative control), group II (positive control), group III (simvastatin drug control), group IV dose 1 (3.5 mg/20 g BW), group V dose 2 (7 mg/20 g BW), and group VI dose 3 (14 mg/20 g BW). The six groups were first adapted for 2 days and given CP511 concentrate feed to adjust to the new cage conditions. After adaptation, blood was taken from group I (negative control) for initial cholesterol examination. The next day, groups II, III, IV, V, VI, VII, VIII, IX, X, XI, and XII were given CP511 concentrate feed and propylthiouracil suspension as a cholesterol enhancer for 5 days. On the sixth day, blood was taken from group II (positive control) to determine the increase in cholesterol levels in mice. After administration of cholesterol enhancers, groups III, IV, V, VI, VII, VIII, IX, X, XI, and XII received therapy or treatment and continued to receive CP511 concentrate feed.

Group III (simvastatin drug control) was given propylthiouracil suspension and simvastatin suspension, group IV (dose 1) was given propylthiouracil suspension and *Santalum album* L. leaf extract at a dose of 3.5 mg/20 g BW, group V (dose 2) was given propylthiouracil suspension and *Santalum album* L. leaf extract at a dose of 7 mg/20 g BW, and group VI (dose 3) was given propylthiouracil suspension and *Santalum album* L. leaf extract at a dose of 14 mg/20 g BW, group VII (dose 1) was given propylthiouracil suspension and Calotropis gigantea leaf extract at a dose of 3.5 mg/20 g BW, group VIII (dose 2) was given propylthiouracil suspension and *Calotropis gigantea* leaf extract at a dose of 7 mg/20 g BW, and group IX (dose 3) was given propylthiouracil suspension and *Calotropis gigantea* leaf extract at a dose of 14 mg/20 g BW, group X (dose 1) was given propylthiouracil suspension and *Ziziphus spina*-christi L. leaf extract at a dose of 3.5 mg/20 g BW, group XI (dose 2) was given propylthiouracil suspension and *Ziziphus spina*-christi L. leaf extract at a dose of 7 mg/20 g BW, and group XII (dose 3) was given propylthiouracil suspension and *Ziziphus spina*-christi L. leaf extract at a dose of 14 mg/20 g BW. Treatment or therapy in groups III, IV, V, VI, VII, VIII, IX, X, XI, and XII was carried out simultaneously for 3 days. On the ninth day, blood samples were taken to determine the decrease in cholesterol levels in mice.

Measurement of Cholesterol Levels.

Cholesterol levels were measured in mice using the Point-of-Care Testing (POCT) Method with a cholesterol strip test tool (Easy Touch). The chip is inserted into the chip holder in the tool, and the code is adjusted to the test strip. The cholesterol test strip is placed on the designated spot on the device. Then, a "blood droplet" sign will appear, indicating that the device is ready for use. The tail of the mouse is disinfected, then cut about 1 mm. The first drop of blood that comes out is removed with a tissue or dry cotton swab, and the subsequent drop of blood is dripped at the end of the test strip until a beep is heard. After that, wait for 30 seconds; the results will appear on the tool screen.

Data Analysis

The data analysis technique of mice cholesterol levels was processed using Microsoft Excel, which was then made into a table. The decrease in cholesterol levels was calculated by calculating the difference between the positive control and the simvastatin drug control, and each treatment group from the *Santalum album* L., *Calotropis gigantea*, and *Ziziphus spina*-christi L. leaf samples. The decrease in cholesterol levels indicates the presence of antihypercholesterolemic activity caused by the three extracts.

Result and Discussion

Yield, Flavonoid Content, and Phenolic Content

Table 1 shows the results of the measurement of yield, flavonoid content, and phenolic content of three leaf plant extracts, namely *Santalum album* L., *Calotropis gigantea*, and *Ziziphus spina*-christi L. These three parameters are measured to evaluate the potential phytochemicals present in the plant's leaves.

Table 1. Yield, flavonoid levels, and phenolic levels of 3 plant extracts

Types of Observations	*Santalum album* L.	*Calotropis gigantea*	*Ziziphus spina*-christi L.
Yield (%)	6.88	6	15.86
Flavonoid levels (mg QE/g extract)	4.16	2.62	2.55
Phenolic content (mg GAE/g extract)	14.98	16.58	38.14

Based on the data obtained, the data pattern showed a clear difference between the plant extracts tested in terms of yield, flavonoid content, and phenolic content. *Ziziphus spina*-christi L. yielded the highest amount (15.86%), indicating that this plant extract produces more ethanol-solvent-soluble ingredients compared to *Santalum album* L. (6.88%) and *Calotropis gigantea* (6%). In terms of flavonoid levels, *Santalum album* L. had higher levels (4.16 mg QE/g extract) compared to *Calotropis gigantea* (2.62 mg QE/g extract) and *Ziziphus spina*-christi L. (2.55 mg QE/g extract), which suggests that *Santalum album* L. extract is richer in flavonoid compounds. For phenolic levels, *Ziziphus spina*-christi L. had the highest phenolic levels (38.14 mg GAE/g extract), followed by *Calotropis gigantea* (16.58

mg GAE/g extract) *and Santalum album* L. (14.98 mg GAE/g extract). These data suggest that each plant has a distinct phytochemical content, which could potentially explain the variation in biological activity that each extract exhibits.

In this study, the sample used for all plants is the leaf part. The extraction method used is maceration with ethanol peelers. The differences in yield amount, flavonoid content, and phenolic content between plant extracts are influenced by the chemical composition of the plant. The higher yield of *Ziziphus spina*-christi L. (15.86%) compared to other plants, such as *Calotropis gigantea* (6%), may be influenced by the content of more easily extracted materials or the structure of the plant that contains more compounds soluble in ethanol solvents (Dewatisari, 2020) (Amaliah et al., 2019) (Purwanto, 2014). The higher flavonoid levels in *Santalum album* L. (4.16 mg QE/g extract) suggest that the plant is rich in flavonoid compounds.

In comparison, *Ziziphus spina*-christi L. has lower flavonoid levels (2.55 mg QE/g extract), which may be due to the chemical composition containing fewer flavonoids. The high phenolic levels in *Ziziphus spina*-christi L. (38.14 mg GAE/g extract) indicate that these two plants have a greater ability to produce phenolic compounds in response to environmental factors or stress (Hanin & Pratiwi, 2017; Wardani et al., 2020)**.** This difference highlights the significance of natural phytochemical characteristics and the impact of the extraction process on the resulting outcomes.

Antihypercholesterolemia Test

Table 2 presents the cholesterol levels of mice (in mg/dL) in the various treatment groups, including a negative control, a positive control, a drug control, and treatment with plant extracts of *Santalum album* L., *Calotropis gigantea*, and *Ziziphus spina*-christi L. at three different doses. Cholesterol levels were measured in six mice per group and averaged.

Table 2. Mice's cholesterol levels (mg/dl) after administration of the extract

Test Animals	Mice Cholesterol Level (mg/dl)											
	Negative Control	Positive Control	Drug Control	*Santalum album* L.			*Calotropis gigantea*			*Ziziphus spina*-christi L.		
				Dose 1	Dose 2	Dose 3	Dose 1	Dose 2	Dose 3	Dose 1	Dose 2	Dose 3
1	129	185	129	157	148	159	157	146	158	169	148	139
2	130	179	123	152	170	140	162	148	139	156	158	157
3	139	170	119	171	161	131	153	140	162	182	139	149
4	130	181	117	164	151	162	162	170	142	159	163	147
5	129	172	108	178	164	143	175	158	149	149	149	136
6	137	182	120	142	159	132	178	168	153	167	160	154
Average	132	178	119	161	159	145	165	155	151	164	153	147

The cholesterol levels of the negative control group were the lowest, at 132 mg/dL. In contrast, the positive control had the highest levels (178 mg/dL), indicating an increase in cholesterol levels resulting from the administered treatment. The control group receiving the drug (simvastatin) showed a significant decrease, with an average cholesterol level of 119 mg/dL, indicating the effectiveness of the drug in lowering cholesterol. In the group given the plant extract, cholesterol levels varied depending on the type of plant and the dose given. In *Santalum album* L., cholesterol levels range from 145 to 161 mg/dL, whereas in *Calotropis gigantea*, they are slightly lower, ranging from 151 to 165 mg/dL. *Ziziphus spina*-christi L. showed slightly more stable cholesterol levels, ranging from 147 to 164 mg/dL at all doses. Thus, the three plant extracts have the potential to lower cholesterol levels, although the effects vary depending on the type of plant and the dosage used. Table 3 shows a decrease in mouse cholesterol levels (in mg/dL) after administration of plant extracts at a dose of 14 mg/20 g body weight (BW). A decrease in cholesterol levels was observed in both the control group treated with simvastatin and the treatment group receiving extracts of *Santalum album* L., *Calotropis gigantea*, and *Ziziphus spina*-christi L.

Table 3. Decreased cholesterol levels in mice (mg/dL) after administration of the extract at a dose of 14 mg/20 g BW

Treatment	Decreased cholesterol levels in mice (mg/dl)
Simvastatin Drug Control	59
Santalum album L.	33
Calotropis gigantea	28
Ziziphus spina-christi L.	31

The highest decrease in cholesterol levels occurred in the control group of the drug (simvastatin), with a reduction of 59 mg/dl. In the plant extract group, *Santalum album* L. showed a reduction of 33 mg/dL, followed by *Ziziphus spina*-christi L. with a decrease of 31 mg/dL, and *Calotropis gigantea* with a reduction of 27 mg/dL. These data show that simvastatin has a more substantial cholesterol-lowering effect than plant extracts; however, plant extracts still provide significant cholesterol reduction, albeit not as potent as simvastatin. This difference could be attributed to the content of active compounds in each plant, which play a role in lowering cholesterol levels. However, the effects vary depending on the type of plant being tested. Flavonoids are known to have antioxidant effects that can reduce the oxidation of Low-Density Lipoprotein (LDL), which plays a role in the formation of cholesterol plaques in blood vessels, thereby helping to lower harmful cholesterol levels (Emilia, 2023) (Muqowwiyah & Dewi, 2021) (Puger, 2024). There is a tendency for lower cholesterol levels to be associated with higher levels of flavonoids, although this relationship is not always linear. *Santalum album* L., which has the highest levels of flavonoids, shows the most significant reduction in cholesterol.

In contrast, *Ziziphus spina*-christi L., despite its slightly lower flavonoid levels, is still able to provide a significant reduction of cholesterol. This suggests that flavonoids play a role in lowering cholesterol; however, other factors, such as the content of phenolic compounds and the metabolism of each plant, also influence their effectiveness. Therefore, the reduction in cholesterol depends not only on the level of flavonoids, but also on the interaction between other active compounds in the extract of the plant.

The relationship between phenolic levels and decreased cholesterol levels can be analyzed based on available data. Phenolic compounds have a special characteristic, namely the ability to oxidize, which makes them often used as antioxidants. Phenols are effective in reducing cholesterol oxidation, which can lead to LDL buildup in the blood, as well as preventing abnormal cell growth (Yunia et al., 2019). *Santalum album* L. had the highest phenolic content of 14.98 mg GAE/g extract and cholesterol reduction of 33 mg/dl, *Calotropis gigantea* had phenolic levels of 16.58 mg GAE/g extract with a cholesterol reduction of 28 mg/dl, and *Ziziphus spina*-christi L. had the highest phenolic content of 38.14 mg GAE/g extract and cholesterol reduction of 31 mg/dl. Although *Ziziphus spina*-christi L. has the highest phenolic levels, its cholesterol reduction is not as high as that of *Santalum album* L., which has lower phenolic levels. This suggests that although phenolic levels play a role in cholesterol reduction, other factors such as flavonoid levels and other bioactive components also affect the effectiveness of cholesterol lowering. Therefore, although higher phenolic levels tend to be associated with a decrease in cholesterol, this relationship is not entirely linear and is influenced by complex interactions between various active compounds in plant extracts.

Conclusion

This study evaluated the potential of *Santalum album* L., *Calotropis gigantea*, and *Ziziphus spina*-christi L. leaf extracts as antihypercholesterolemic agents in mice. The results showed that all three extracts were able to lower cholesterol levels, with *Santalum album* L. showing the greatest effect (33 mg/dL), followed by *Ziziphus spina*-christi L. (31 mg/dL) and *Calotropis gigantea* (28 mg/dL). Although the reductions were still not comparable to those achieved by the standard drug simvastatin (59 mg/dL), the extracts showed significant potential. They could serve as adjuvant therapy with conventional statins. This study provides preliminary evidence to support the use of these plant extracts as alternative plant-based options for managing hypercholesterolemia. Further studies are needed to explore the molecular mechanisms involved and to assess their efficacy in a wider range of animal models or human subjects.

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Author Contributions

Khoirul Ngibad: Conceptualization, Methodology, Supervision, Writing – review & editing. Elis Dwi Nuryani: Conceptualization, Methodology, Writing – original draft. Tarisatus Syahlum Mukarromah: Writing – review & editing. Tria Novitasari: Methodology, Validation. Nurisma Fadhila: Resources, Formal analysis, Data curation.

Conflicts of Interest

The authors reported no declarations of interest.

References

Ahmad Nejhad, A., Alizadeh Behbahani, B., Hojjati, M., Vasiee, A., & Mehrnia, M. A. (2023). Identification of phytochemical, antioxidant, anticancer and antimicrobial potential of *Calotropis procera* leaf aqueous extract. *Scientific Reports*, *13*(1), 14716. https://doi.org/10.1038/s41598-023-42086-1

Alibasyah, Z. M., Ningsih, D. S., & Sinda, M. P. (2023). Aktivitas antibakteri ekstrak etanol 70% daun biduri (*Calotropis gigantea*) terhadap *Aggregatibacter actinomycetemcomitans* ATCC 29523. *Cakradonya Dental Journal*, *12*(1), 56–63. https://doi.org/10.24815/cdj.v12i1.17076

Amaliah, A., Sobari, E., & Mukminah, N. (2019). Rendemen dan karakteristik fisik ekstrak oleoresin daun sirih hijau (*Piper betle* L.) dengan pelarut heksan. *Prosiding Industrial Research Workshop and National Seminar*, *10*(1), 273–278.

https://jurnal.polban.ac.id/proceeding/article/view/1399

Bhattacharjee, B., Sandhanam, K., Ghose, S., Barman, D., & Sahu, R. K. (2023). Market Overview of Herbal Medicines for Lifestyle Diseases. In *Role of Herbal Medicines* (pp. 597–614). Springer Nature Singapore. https://doi.org/10.1007/978-981-99-7703-1_30

Cheung, B., Sikand, G., Dineen, E. H., Malik, S., & Barseghian El-Farra, A. (2023). Lipid-lowering nutraceuticals for an integrative approach to dyslipidemia. *Journal of Clinical Medicine*, *12*(10), 3414. https://doi.org/10.3390/jcm12103414

Christyaningsih, J., Izza, F., Raiza, R., Nayla, A. A., Pristanti, D. A., Az-Zahra, F. P., & Salleh, M. N. (2024). Enhancing the therapeutic potential of purslane leaf extract (*Portulaca oleracea*) for cholesterol management. *International Journal of Advanced Health Science and Technology*, *4*(5), 273–279. https://doi.org/10.35882/ijahst.v4i5.418

Dewatisari, W. F. (2020). Perbandingan pelarut kloroform dan etanol terhadap rendemen ekstrak daun lidah mertua (*Sansevieria trifasciata*. Prain) menggunakan metode maserasi. *Prosiding Seminar Nasional Biologi*, *6*(1), 127–132. https://journal.uin-alauddin.ac.id/index.php/psb/article/view/15638

Emilia, E. (2023). Efektivitas pemberian rebusan daun salam terhadap kolesterol total dengan hiperkolesterolemia di wilayah kerja Puskesmas Desa Gedang Kota Sungai Penuh Provinsi Jambi Tahun 2022. *Jurnal Multidisiplin Dehasen (MUDE)*, *2*(2). https://doi.org/10.37676/mude.v2i2.3901

Hanin, N. N. F., & Pratiwi, R. (2017). Kandungan fenolik, flavonoid dan aktivitas antioksidan ekstrak daun paku laut (*Acrostichum aureum* L.) fertil dan steril di Kawasan Mangrove Kulon Progo, Yogyakarta. *Journal of Tropical Biodiversity and Biotechnology*, *2*(2), 51. https://doi.org/10.22146/jtbb.29819

Hastiana, Y., Handaiyani, S., & Agustin, I. (2022). Test of Phytocemical Levels of Bidara (*Ziziphus spina-christi* L.) potential as medicinal plants. *Mangifera Edu*, *6*(2), 182–196. https://doi.org/10.31943/mangiferaedu.v6i2.128

Kumar, V. L., Verma, S., & Das, P. (2022). Anti-inflammatory and antioxidant effect of methanol extract of latex of *Calotropis procera* in rat model of colorectal cancer. *Journal of Ethnopharmacology*, *296*, 115503. https://doi.org/10.1016/j.jep.2022.115503

Muqowwiyah, L. Z., & Dewi, R. K. (2021). Potensi ekstrak daun alpukat sebagai anti kolesterol. *Jurnal Tadris IPA Indonesia*, *1*(3), 403–412. https://doi.org/10.21154/jtii.v1i3.397

Muzayyidah, Asri SR, M., & Riska Safitri. (2023). Antibacterial activity test of anti-acne gel preparations containing ethanol extracts of bidara arab leaf (*Ziziphus spina*-christi (L.) Desf) againts *Propionibacterium acnes*. *PCJN: Pharmaceutical and Clinical Journal of Nusantara*, *2*(01), 19–29. https://doi.org/10.58549/pcjn.v2i01.61

Nasution, M., Nasution, A. N., & Mutia, M. S. (2024). Effect of bidara leaf extract (*Ziziphus mauritiana* L.) on the function of the pancreas of male wistar strain rats in reducing blood sugar levels. *Jurnal Teknologi Laboratorium*, *13*(1), 44–52. https://doi.org/10.29238/teknolabjournal.v13i1.476

Packard, C., Chapman, M. J., Sibartie, M., Laufs, U., & Masana, L. (2021). Intensive low-density lipoprotein cholesterol lowering in cardiovascular disease prevention: opportunities and challenges. *Heart*, *107*(17), 1369–1375. https://doi.org/10.1136/heartjnl-2020-318760

Pattnaik, P. K., Kar, D., Chhatoi, H., Shahbazi, S., Ghosh, G., & Kuanar, A. (2017). Chemometric profile & antimicrobial activities of leaf extract of *Calotropis procera* and *Calotropis gigantea*. *Natural Product Research*, *31*(16), 1954–1957. https://doi.org/10.1080/14786419.2016.1266349

Phung, P. T. K., Binh, D. N. L., Thu, N. T. A., Van Ha, N., Huyen, T. T., Hien, K. M., Nhu, M. H., Duc, N. K., & Minh Quan, L. (2025). Optimization of extraction parameters and anti-hyperglycemic assessment of standardized extract from *Santalum album* L. leaves. *Pharmacological Research - Modern Chinese Medicine*, *14*, 100577. https://doi.org/10.1016/j.prmcm.2025.100577

Puger, I. G. N. (2024). Manfaat daun kelor sebagai salah satu alternatif untuk menekan kadar low-density-lipoprotein (LDL). *Daiwi Widya*, *11*(1), 1–18. https://doi.org/10.37637/dw.v11i1.2010

Pullaiah, T., Ramulu, D. R., Murthy, K. S. R., Reddy, V. D., Saradamma, B., & Swamy, M. K. (2021). Phytochemistry and pharmacological properties of *Santalum album* L. in *Sandalwood: Silviculture, Conservation and Applications* (pp. 67–96). Springer Singapore. https://doi.org/10.1007/978-981-16-0780-6_5

Purwanto, A. (2014). Pengaruh jenis pelarut terhadap rendemen dan aktivitas antioksidan dalam ekstrak minyak bekatul padi (rice bran oil). *EKUILIBIUM*, *13*(1). https://doi.org/10.20961/ekuilibrium.v13i1.2152

Rachitha, P., Krishnaswamy, K., Lazar, R. A., Gupta, V. K., Inbaraj, B. S., Raghavendra, V. B., Sharma, M., & Sridhar, K. (2023). Attenuation of hyperlipidemia by medicinal formulations of emblica officinalis synergized with nanotechnological approaches. *Bioengineering*, *10*(1), 64. https://doi.org/10.3390/bioengineering10010064

Rengarajan, S., Sivalingam, A. M., Pandian, A., & Chaurasia, P. K. (2024). Nanomaterial (AgNPs) synthesis using calotropis gigantea extract, characterization and biological application in antioxidant and antibacterial activity. *Journal of Inorganic and Organometallic Polymers and Materials*, *34*(9), 4005–4021. https://doi.org/10.1007/s10904-024-03058-8

Rialdi, A. P., Prangdimurti, E., & Saraswati, S. (2023). Effect of different solvent on the antioxidant capacity of bidara leaves extract (*Ziziphus Spina-*Christi). *Devotion : Journal of Research and Community Service*, *4*(6), 1222–1233. https://doi.org/10.59188/devotion.v4i6.483

Sharmila, G., Haries, S., Farzana Fathima, M., Geetha, S., Manoj Kumar, N., & Muthukumaran, C. (2017). Enhanced catalytic and antibacterial activities of phytosynthesized palladium nanoparticles using *Santalum album* leaf extract. *Powder Technology*, *320*, 22–26. https://doi.org/10.1016/j.powtec.2017.07.026

Simonen, P., Öörni, K., Sinisalo, J., Strandberg, T. E., Wester, I., & Gylling, H. (2023). High cholesterol absorption: A risk factor of atherosclerotic cardiovascular diseases? *Atherosclerosis*, *376*, 53–62. https://doi.org/10.1016/j.atherosclerosis.2023.06.003

Wardani, Y. K., Kristiani, E. B. E., & Sucahyo, S. (2020). Korelasi antara aktivitas antioksidan dengan kandungan senyawa fenolik dan lokasi tumbuh tanaman *Celosia argentea* Linn. *Bioma: Berkala Ilmiah Biologi*, *22*(2), 136–142. https://ejournal.undip.ac.id/index.php/bioma/article/view/36614

Yunia, A., Suhariyanti, E., & Priyanto, S. (2019). Perbedaan efektivitas rebusan ketumbar dengan rebusan kunyit terhadap tekanan darah pada lansia hipertensi. *Prosiding University Research Colloquium*, 676–687. https://www.repository.urecol.org/index.php/proceeding/article/view/707/690