

Antidiabetic activity test of mangrove leaf extract (*Rhizophora mucronata*) from west lombok regency using the oral glucose tolerance test method

Amran Halim¹, Raisya Hasina¹, Lina Permatasari^{1*}

¹ Department of Pharmacy, Faculty of Medicine and Health Sciences, University of Mataram, Mataram, West Nusa Tenggara, Indonesia

DOI: <https://doi.org/10.29303/sjp.v7i1.641>

Article Info

Received : 2025-11-10

Revised : 2026-05-07

Accepted : 2026-06-04

Abstract: Black mangrove (*Rhizophora mucronata*) is recognized as a natural ingredient with potential antidiabetic properties due to the presence of active compounds such as flavonoids, alkaloids, and tannins. Conventional antidiabetic drugs like metformin often cause side effects, highlighting the need for safer, natural alternatives. The safety of *Rhizophora mucronata* leaves has been demonstrated through acute toxicological studies. This study aimed to evaluate the antidiabetic activity of *Rhizophora mucronata* leaf ethanol extract and determine the most effective dose. Unlike previous studies that used maceration and methanol as solvent, this research employed a sonication method with 96% ethanol solvent and collected leaf samples from the Cemare area, West Lombok, to reflect local conditions. Twenty-five mice were divided into five groups: negative control (0.5% Na CMC), positive control (metformin 500 mg/kg body weight), and three test groups receiving extract doses of 62.5; 125; and 250 mg/kg body weight. The first blood sample was taken to measure fasting blood glucose, followed by induction with a 50% glucose solution, and another blood sample was taken after 30 minutes. Then, the test solutions were administered, and blood glucose levels were measured at 30, 45, 60, 90, and 120 minutes post-administration. Blood glucose data were analyzed using SPSS version 25 with One Way ANOVA, Post Hoc Tukey, and Paired Sample T-Test. The results showed that doses of 125 mg/kg and 250 mg/kg body weight significantly reduced blood glucose levels ($p < 0.05$), identifying these as the optimal doses. These findings support the potential of *Rhizophora mucronata* as a safe, natural antidiabetic therapy.

Keywords: antidiabetic; *rhizophora mucronata*; OGTT.

Citation: Halim, A., Hasina, R. & Permatasari, L. (2026). Antidiabetic activity test of mangrove leaf extract (*Rhizophora mucronata*) from west lombok regency using the oral glucose tolerance test method. *Sasambo Journal of Pharmacy*, 7(1), 52-58. doi: <https://doi.org/10.29303/sjp.v7i1.641>

Introduction

Diabetes Mellitus represents a chronic metabolic condition characterized by elevated blood glucose levels, primarily resulting from impaired insulin production, reduced cellular response to insulin, or a combination of these factors (Tandra, 2020). Global diabetes prevalence has risen dramatically over the past three decades, with WHO reports indicating a more than fourfold increase from approximately 200 million cases

in 1990 to over 830 million by 2022. This epidemic shows disproportionate growth patterns, with low- and middle-income nations experiencing accelerated rates of increase compared to their high-income counterparts (WHO, 2024). The results of the 2023 Indonesian Health Survey (SKI) show that the prevalence of diabetes in Indonesia is 11.7% out of 270 million people (BKPK, 2023). West Lombok Regency is the district with the fourth highest number of diabetes cases in NTB, with

Email: lina.permatasari@unram.ac.id (*Corresponding Author)

3,588 patients from 10 existing districts (Dinas Kesehatan NTB, 2022).

Conventional treatment of diabetes generally uses antihyperglycemic drugs such as sulfonylurea, metformin, thiazolidinedione, and others. However, these drugs are inseparable from side effects that can limit their use. Previous studies have found the risk of hypoglycemia in the use of sulfonylurea, indigestion due to metformin, and potential liver damage related to thiazolidinedione (Anisya et al., 2019; Nisa et al., 2018; Pramanik et al., 2018). These side effects encourage the search for safer, more natural, and affordable therapeutic alternatives, especially in the midst of the phenomenon of people's return to the use of herbal medicines related to the economic crisis and concerns about the side effects of modern medicine (Kinanti et al., 2023; Kurniawan et al., 2022).

One promising natural source is the black mangrove, *Rhizophora mucronata*, containing bioactive compounds such as flavonoids, tannins, and alkaloids, known to possess antidiabetic properties (Ridlo et al., 2017; Usman et al., 2022). Flavonoids improve insulin sensitivity by protecting pancreatic β -cells (Prawitasari, 2019), mimicking the mechanism of metformin, which enhances insulin sensitivity and glucose uptake (Lina et al., 2022). Quercetin was identified as the predominant flavonoid in *Rhizophora mucronata* leaves (Saputri et al., 2025). It has been reported to exhibit antidiabetic activity by inhibiting α -amylase and α -glucosidase, thereby reducing the breakdown of carbohydrates into glucose (Günel-Köroğlu et al., 2025). Tannins exert antidiabetic effects by promoting cell recovery and inhibiting carbohydrate-digesting enzymes, while alkaloids stimulate glucose uptake and reduce insulin resistance (Rohdiana, 2022).

Previous studies by Usman et al. (2019) tested antidiabetic activity of *Rhizophora mucronata* leaf extract using oral glucose tolerance test (OGTT) method. The previous study showed the extract extract of *R. mucronata* effective to decrease the blood glucose of mice. The previous study was extracting *R. mucronata* using maceration method. Meanwhile, this study employs sonication method, a faster, simpler, and lower temperature method that improves bioactive compound yield (Inggarwati et al., 2020; Putri et al., 2024). Furthermore, differences in extraction techniques can influence the composition of secondary metabolites obtained. The sonication method has been reported to be more effective than maceration for extracting quercetin (Raditya et al., 2025; Sharifi et al., 2017). In addition, leaf samples were collected from Cemare, West Lombok, untested before and potentially exhibiting different metabolite profiles due to environmental factors (Utomo et al., 2020). However, the main objectives of this research are to analyze the antidiabetic effects of ethanol

extract derived from the leaves of *Rhizophora mucronata* on white mice (*Mus musculus*) using the OGTT method, and to determine the optimal dosage of this extract in producing a significant antidiabetic effect. These goals aim to provide foundational data supporting the potential of *Rhizophora mucronata* as a natural and affordable alternative treatment for diabetes mellitus.

Materials and Methods

Material

This study utilized black mangrove (*Rhizophora mucronata*) leaves, which were collected from the coastal area of Cemare Village, Lembar Subdistrict, West Lombok, Nusa Tenggara Barat. Botanical identification and confirmation of the plant materials were conducted at the Advanced Biology Laboratory, Faculty of Mathematics and Natural Sciences, University of Mataram, with Determination Certificate No. 49/UN18 F7/LBL/2024. The experimental animals used were 25 healthy white mice (*Mus musculus*), aged 2–3 months and weighing between 20 and 30 grams. Other essential materials included 96% ethanol, 50% glucose solution, metformin 500 mg tablets (used as a positive control), 0.5% sodium carboxymethyl cellulose (Na-CMC), and distilled water (aquadest). The equipment used in this study comprised beakers (Iwaki), measuring cylinders (Iwaki), scissors, hotplates (Ika), watch glasses (Iwaki), Erlenmeyer flasks (Iwaki), volumetric flasks (Iwaki), dropper pipettes (Iwaki), filter paper, rotary evaporators (Heidolph), ovens (Mettler), blenders (Philips), spoons, oral gavage probes, spatulas, syringes, gloves, test strips (EasyTouch GCU), and glucometers (EasyTouch GCU meters).

Method

Mangrove Sample Collection

The samples of *Rhizophora mucronata* mangrove were collected from the Lembar sub-district, West Lombok Regency, West Nusa Tenggara Province. The leaves selected for sampling were fresh and green in color

Preparation of Simplisia Powder

The mangrove leaf samples were first subjected to wet sorting to remove damaged or unsuitable leaves, then thoroughly washed three times with running water. After draining, the leaves were air-dried in a shaded, well-ventilated area. Once completely dry, the leaves underwent dry sorting before being ground using a blender. The resulting powder was then sieved through a mesh size 40 screen to obtain a uniform particle size (Robbiyan et al., 2021; Sammanta et al., 2023).

Preparation of Mangrove Leaf Extract

Two hundred grams of *Rhizophora mucronata* leaf powder were extracted using the sonication method with a solid-to-solvent ratio of 1:5 (w/v). One hundred grams of the powder were placed in a 1L Erlenmeyer flask, added with 500 mL of 96% ethanol, covered with aluminum foil, and sonicated at 35°C for 30 minutes. The process included two solvent renewals with the same volume. The filtrate was then filtered and concentrated using a rotary evaporator at 40°C. The resulting thick extract was weighed to calculate the extraction yield (Sammanta et al., 2023).

Antidiabetic activity test

Preparation of 0.5% Na-CMC Solution

A 0.5% Na-CMC solution was prepared as a negative control by weighing 0.5 grams of Na-CMC powder, which was then dissolved in 10 mL of hot water and ground until uniform. The mixture was transferred into a 100mL volumetric flask and diluted with distilled water up to the 100mL mark to obtain a homogeneous 0.5% solution¹¹.

Preparation of 50% Glucose Solution

Weighed 50 grams of glucose powder and dissolved it in distilled water in a 100 mL volumetric flask to produce a 50% glucose solution¹¹.

Preparation of Metformin Solution

The oral volume of mice was 0.2 mL. The dose of metformin was 65 mg/kgBB. One tablet of metformin 500 mg was ground into a fine powder using a mortar. From this powder, exactly 32.5 mg was weighed and then mixed with 5 mL of 0.5% Na-CMC solution. The mixture was ground together thoroughly until a homogeneous suspension was obtained. Finally, the prepared metformin suspension was transferred into a beaker for use in the experiment.

Preparation of Mangrove Leaf Extract Solutions (*Rhizophora mucronata*)

Rhizophora mucronata leaf extract solutions were prepared by dissolving 31.25 mg, 62.5 mg, and 125 mg of concentrated extract separately in 5 mL of 0.5% Na-CMC to obtain homogeneous solutions with concentrations of 6.25 mg/mL; 12.5 mg/mL; and 25.0 mg/mL. Each extract was administered orally at a dose of 1 mL/100 g BW. The doses of sample administrated to each group of mice were 62.5 mg/kg, 125 mg/kg, and 250 mg/kgBB.

Oral Glucose Tolerance Test (OGTT)

This study used the Oral Glucose Tolerance Test (OGTT) to measure blood glucose levels in mice (Figure 1). The animals were acclimated and fasted for 18 hours

with water provided. Mice were divided into five groups.

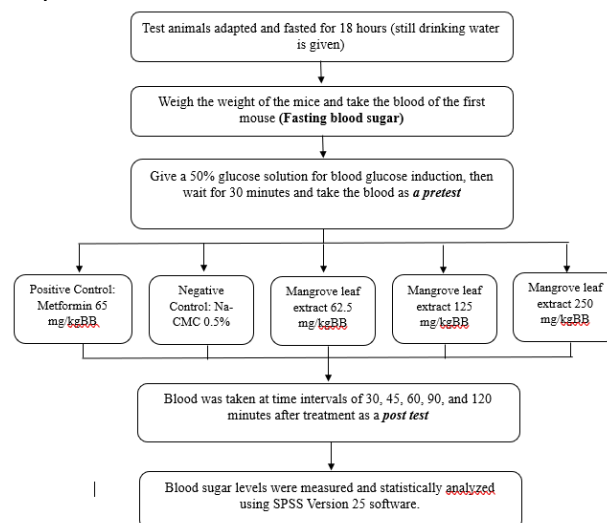


Figure 1. research flow scheme OGTT

Initially, fasting blood glucose (FBG) was measured, then mice were given 0.2 mL of glucose solution to raise blood glucose. Blood was collected again after 30 minutes to determine glucose-induced blood glucose (GIBG). Each group then received their respective treatments, as presented in Table 1. Blood samples were taken by tail nicking at 30, 45, 60, 90, and 120 minutes post-treatment for glucose measurement using a glucometer.

Table 1. Research treatment group

No.	Group	Treatment
1	Positive Control	Metformin 65 mg/kgBB + Na-CMC 0,5%
2	Negative Control	Na-CMC 0,5%
3	Test group I	Mangrove leaf extract dose 62.5 mg/kgBB + Na-CMC 0.5%
4	Test group II	Mangrove leaf extract dose 125 mg/kgBB + Na-CMC 0.5%
5	Test group III	Mangrove leaf extract dose 250 mg/kgBB + Na-CMC 0.5%

Data analysis

Data analysis involved measuring blood glucose levels at 30, 45, 60, 90, and 120 minutes after extract administration. Blood samples were collected via tail nick and tested using a glucometer. The glucose data were analyzed with SPSS version 25. Paired Sample T-Test was used for normally distributed the data

analyzed was the pretest, namely blood sugar and glucose induction with each test time interval and homogeneous data ($P < 0.05$), while the Wilcoxon test was applied if data were non-normal or non-homogeneous ($P > 0.05$).

Result and Discussion

The antidiabetic activity of Mangrove leaf (*Rhizophora mucronata*) is attributed to its secondary metabolites, which share a similar mechanism of action with the drug metformin, particularly flavonoids. The antidiabetic mechanism of flavonoids involves increasing insulin secretion from pancreatic beta cells, enhancing glucose uptake in tissues, and improving tissue sensitivity to insulin.

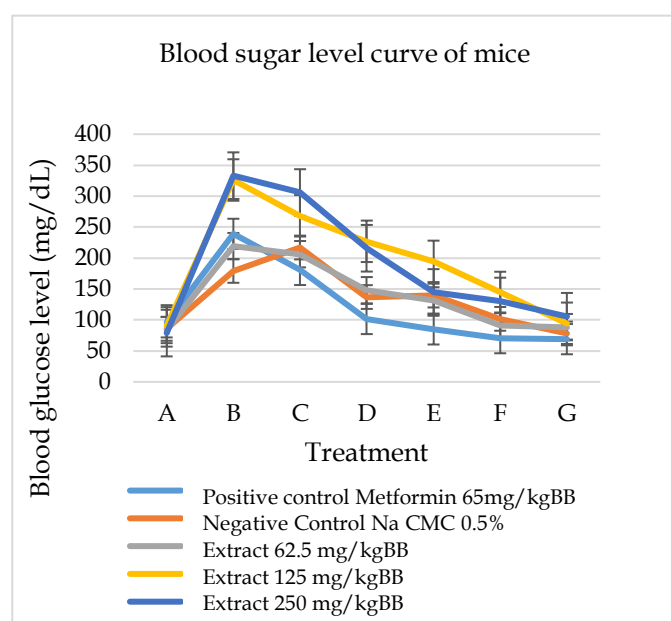


Figure 2. Blood sugar level curve of mice for each treatment. (A) fasting blood sugar level of mice, (B) blood sugar level of mice after 50% glucose induction, (C) blood sugar level of mice 30 after test treatment (D) blood sugar level of mice 45 after test treatment, (E) blood sugar level of mice 60 after test treatment, (F) blood sugar level of mice 90 after test treatment, (G) blood sugar level of mice 120 after test treatment Blood sugar levels were tested using 3 replications.

In **Figure 2A**, the fasting blood glucose levels are shown with an average range of 78.8–96.2 mg/dL, indicating that the fasting glucose levels in the mice are within the normal range. According to PERKENI (2021), the normal fasting blood glucose range is below 100 mg/dL. **Figure 2B** illustrates that after administration of a 50% glucose solution, blood glucose levels increased significantly to a range of 179.2–333 mg/dL, indicating diabetes since the glucose level in mice is ≥ 126 mg/Dl

(PERKENI, 2021). **Figure 2C–G** show blood glucose levels at 30, 45, 60, 90, and 120 minutes, demonstrating a significant reduction in blood glucose in all test groups, with effects comparable to the positive control group treated with 500 mg metformin. Meanwhile, the negative control group showed little to no decrease in blood glucose levels; although some reduction was observed, glucose levels remained high, indicating no significant decrease. This is because the administration of Na-CMC has no significant antihyperglycemic effect and therefore does not significant to reduce blood glucose levels (Ramatillah & Yanti, 2018).

Table 2. Percentage Data on Blood Sugar Level Reduction

Group	% Blood Sugar Level Reduction				
	30 minute	45 minute	60 minute	90 minute	120 minute
Positive group	26,475 ± 20,748 ^b	55,808 ± 18,143 ^a	62,753 ± 14,108 ^a	69,341 ± 8,855 ^a	70,253 ± 5,393 ^a
Negative group	-27,295 ± 36,462 ^a	17,180 ± 39,150 ^a	16,861 ± 37,082 ^a	40,779 ± 20,709 ^a	54,716 ± 11,873 ^a
Extract 62,5mg/kgBB	2,2094 ± 19,608 ^{ab}	27,118 ± 28,656 ^a	33,986 ± 30,362 ^a	54,369 ± 19,480 ^a	56,244 ± 16,109 ^a
Extract 125mg/k	16,472 ± 20,958 ^b	31,795 ± 20,085 ^a	42,462 ± 23,132 ^a	56,535 ± 16,293 ^a	70,912 ± 8,416 ^a
Extract 250mg/k	7,5526 ± 4,8568 ^{ab}	34,460 ± 11,583 ^a	55,969 ± 11,972 ^a	60,193 ± 12,512 ^a	66,603 ± 10,899 ^a

Description: Treatment groups that have different superscripts (a, b, ab) in 1 column have significant differences analyzed using the Tukey post hoc test with SPSS software version 25.

Based on **Table 2**, Post Hoc Tukey analysis revealed significant differences among treatment groups following ANOVA. The negative control group (Na CMC 0.5%) showed a significant difference ($p < 0.05$) compared to the positive control and all extract groups (62.5, 125, and 250 mg/kgBB). At 30 minutes, the 125 mg/kgBB extract dose demonstrated a glucose-lowering effect comparable to the positive control ($p > 0.05$), suggesting similar antidiabetic potency to metformin 500 mg. The 62.5 mg/kgBB and 250 mg/kgBB doses showed no significant difference between each other ($p > 0.05$), reflecting similar but less potent effects than the 125 mg/kgBB dose. Overall, the 125 mg/kgBB dose was identified as the optimal dose due to its comparable efficacy to the positive control. Previous research by Usman et al. (2019) also reported the greatest glucose reduction at this dose (28.89%)(Usman et al., 2022).

Based on the Paired Sample T-test analysis shown in **Table 3**, significant reductions in glucose-induced blood glucose (GDIG) levels were observed across

treatment groups over time. The positive control group treated with metformin 500 mg exhibited a significant decrease ($p < 0.05$) in GDIG from 30 minutes (180.8 ± 76.75 mg/dL) through 120 minutes (69 ± 6.93 mg/dL), confirming metformin's effective onset at 30 minutes and sustained effect. The negative control (Na-CMC 0.5%) showed no significant change until 90 and 120 minutes ($p < 0.05$), reflecting normal pancreatic β -cell function maintaining glucose homeostasis due to no β -cell damage by the oral glucose tolerance test (OGTT) method (Cheng et al., 2018).

Table 3. Average Blood Sugar Levels

Group	GDIG	Blood Sugar Levels (mg/dL)				
		30 min	45 min	60 min	90 min	120 min
Positive group	$239 \pm 53,11$	$180,8 \pm 76,75^*$	$101,6 \pm 36,43^*$	$84,8 \pm 22,64^*$	$70,6 \pm 15,06^*$	$69 \pm 6,93^*$
Negative group	$179,2 \pm 41,47$	$217 \pm 28,28$	$137 \pm 29,10$	$139,4 \pm 35,997$	$101,8 \pm 31,47^*$	$78,2 \pm 18,45^*$
Extract 62,5mg/kgBB	$219,2 \pm 60,98$	$206,2 \pm 26,75$	$148 \pm 29,73$	$131,6 \pm 31,56$	$90,8 \pm 23,11^*$	$88,4 \pm 18,45^*$
Extract 125mg/kgBB	$326 \pm 62,66$	$268,2 \pm 69,93$	$227 \pm 89,95^*$	$194,6 \pm 98,597^*$	$144,4 \pm 66,11^*$	$94,6 \pm 33,34^*$
Extract 250mg/kgBB	$333 \pm 96,67$	$305,8 \pm 77,86$	$215,8 \pm 63,89^*$	$144,4 \pm 50,62^*$	$130,6 \pm 50,46^*$	$106 \pm 24,67^*$

Note: *) indicates a significant difference ($P < 0.05$) in blood sugar levels after glucose induction (GDIG) and after treatment at each time interval after glucose induction. This was tested using a Paired T-test with SPSS version 25 software.

The extract at 62.5 mg/kgBB dose showed non-significant reductions until 90 and 120 minutes ($p < 0.05$), suggesting this lowest dose has a delayed onset of antidiabetic effect. The 125 mg/kgBB dose resulted in significant GDIG decreases starting from 45 minutes (227 ± 89.95 mg/dL) to 120 minutes (94.6 ± 33.34 mg/dL; $p < 0.05$), demonstrating strong and stable antidiabetic activity nearing that of the positive control. The 250 mg/kgBB dose also significantly reduced GDIG from 45 to 120 minutes ($p < 0.05$), though with higher variability than the 125 mg/kgBB dose, possibly due to dose-response differences.

Overall, the extract's hypoglycemic effect was dose-dependent, with 125 and 250 mg/kgBB doses showing significant glucose reductions beginning at 45 minutes and lasting until 120 minutes, while the 62.5 mg/kgBB dose showed a later onset at 90 minutes ($p < 0.05$). These results indicate that *R. mucronata* ethanol leaf extract effectively lowers blood glucose levels in a time- and dose-dependent manner.

Conclusion

The hypoglycemic properties of *Rhizophora mucronata* leaf ethanol extract were clearly evidenced through dose-responsive reductions in blood glucose concentrations. Administration of 125 mg/kg and 250 mg/kg dosages produced substantial glycemic control within 45-120 minutes post-treatment, while the 62.5 mg/kg dose displayed delayed onset of activity, achieving significance only after 90 minutes. Comparative analysis revealed that both medium and high extract doses exhibited therapeutic efficacy statistically equivalent to metformin treatment ($p > 0.05$). These results position *R. mucronata* as a promising botanical candidate for diabetes intervention, warranting expanded investigation into its phytochemical mechanisms and clinical potential as a complementary antidiabetic agent.

Acknowledgements

First and foremost, I would like to sincerely thank all the lecturers, especially my supervisors and examiners, for their invaluable guidance, constructive feedback, and continuous support throughout the course of this research. Your expertise and encouragement have been fundamental in the successful completion of this study. I also extend my deepest appreciation to the laboratory staff who generously provided assistance, technical support, and facilities that enabled the smooth progress of the experiments. Lastly, I am profoundly grateful to my parents for their unwavering support, patience, and motivation. Their encouragement has been a constant source of strength that helped me overcome challenges and complete this research successfully. Thank you all for your contributions and support.

References

- Anisya, K., Robiyanto, R., & Nurmainah, N. (2019). Profil Penggunaan Antidiabetik pada Pasien Diabetes Melitus Gestasional di Puskesmas Wilayah Kecamatan Pontianak Kota. *Indonesian Journal of Clinical Pharmacy*, 8(1). <https://doi.org/10.15416/ijcp.2019.8.1.72>
- Badan Kebijakan Pembangunan Kesehatan. (2023). Prevalensi, Dampak, serta Upaya Pengendalian Hipertensi & Diabetes di Indonesia. *Kementerian Kesehatan*, 1-2. <https://drive.google.com/file/d/1RGiLjySxNy4gvJLWG1gPTXs7QQRnkS--/view>
- Cheng, K., Li, Y., & Cheng, J. (2018). Limitations of oral glucose tolerance test in animal studies. *J Diabetes Treat.* <https://doi.org/10.29011/2574-7568.000046>

- Dinas Kesehatan NTB. (2022). Profil Kesehatan Provinsi NTB 2021. *Dinas Kesehatan NTB*, 1-101.
- Inggarwati, E. D., Istighfarini, V. N., & Prasetyo, A. (2020). Synthesis of Bi₄Ti₃O₁₂/TiO₂ Composite using Sonication Method Sonikasi. *Jurnal ILMU DASAR*, 21(2), 81-86. [https://doi.org/10.1002/\(sici\)1521-3862\(199812\)04:06<213::aid-cvde213>3.0.co;2-6](https://doi.org/10.1002/(sici)1521-3862(199812)04:06<213::aid-cvde213>3.0.co;2-6)
- Günel-Köroğlu, D., Catalkaya, G., Yusufoglu, B., Kezer, G., Esatbeyoglu, T., Abd El-Aty, A. M., & Capanoglu, E. (2025). Quercetin: Potential antidiabetic effects through enzyme inhibition and starch digestibility. *Food Safety and Health*, 3(1), 9-22. <https://doi.org/10.1002/fsh3.12066>
- Kinanti, A. P., Lestari, A., Nabilah, Z. M., Maulida, R., Widiastuti, T. C., & Kiromah, N. Z. W. (2023). Uji Aktivitas Antidiabetes Ekstrak Etanol Daun Ganitri (*Elaeocarpus ganitrus* Roxb.) Pada Tikus Wistar Jantan (*Rattus norvegicus*) Yang Diinduksi Streptozotocin. *JPSCR: Journal of Pharmaceutical Science and Clinical Research*, 8(1), 139. <https://doi.org/10.20961/jpscr.v8i1.64771>
- Kurniawan, D. W., Lestari, N. D., Sulisty, H., & Cacu, C. (2022). Pengaruh Pemberian Kombinasi Ekstrak Etanol Brotowali, Sambiloto, Meniran dan Kayu Manis Terhadap Histopatologi Glomerulus Tikus Model Hiperglikemia. *JPSCR: Journal of Pharmaceutical Science and Clinical Research*, 7(3), 294. <https://doi.org/10.20961/jpscr.v7i3.51501>
- Lina, R. N., Wijaya, H. M., & Fuadah, S. (2022). Aktivitas Infusa Daun Pisang Susu (*Musa Acuminata* Colla) Terhadap Kadar Glukosa Darah Mencit Jantan (*Mus Musculus*) Yang Diinduksi Aloksan. *Sains Medisina*, 1(1), 49-55.
- Nisa, N. R., Priatna, M., & Sukmawan, Y. P. (2018). Drug Use Evaluation on Type 2 Diabetes Mellitus and Diabetic Nephropathy Inpatients in One of Hospitals in Tasikmalaya. *Indonesian Journal of Clinical Pharmacy*, 7(4), 243. <https://doi.org/10.15416/ijcp.2018.7.4.243>
- PERKENI. (2021). Pedoman Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 Dewasa di Indonesia 2021. *Global Initiative for Asthma*, 46. www.ginasthma.org.
- Pramanik, G. S., Puspitasari, I. M., Rahayu, C., & Suwantika, A. A. (2018). Analisis Tingkat Kepuasan Pasien Rawat Inap Diabetes Melitus Tipe 2 dengan Komplikasi Ginjal di Fasilitas Kesehatan Tingkat Lanjut. *Indonesian Journal of Clinical Pharmacy*, 7(3), 217. <https://doi.org/10.15416/ijcp.2018.7.3.217>
- Prawitasari, D. S. (2019). Diabetes Melitus dan Antioksidan. *Jurnal Kesehatan Dan Kedokteran*, 1(1), 47-51.
- Putri, A. S., Sari, A. R., & Sidiq, A. W. (2024). Pengaruh Lama Maserasi Terhadap Senyawa Bioaktif Ekstrak Etanolik Teh Daun Daruju (*Achantus Illicifolius*). *Jurnal Teknologi Pangan Dan Hasil Pertanian*, 19(1), 37. <https://doi.org/10.26623/jtphp.v19i1.8987>
- Raditya, I. P. G. R., Susanti, N. M. P., & Dewi, L. P. M. K. (2025). Quercetin Isolation Methods from Various Plant Samples by Traditional Extraction Method, Microwave, and Ultrasonic Assisted Extraction Techniques: A Review. *Journal of Food and Pharmaceutical Sciences*, 249-263. <https://doi.org/10.22146/jfps.21157>
- Ramatillah, D. L., & Yanti, R. (2018). Uji Aktivitas Antidiabetes Ekstrak Etanol 70% Daun Taya (*Nauclea Subdita* (Korth) Steud) Terhadap Mencit Putih (*Mus Musculus* L.) Dengan Induksi Aloksan. 2(2), 79-87.
- Ridlo, A., Pramesti, R., Koesoemadji, K., Supriyantini, E., & Soenardjo, N. (2017). Antioxidant Activity of *Rhizophora mucronata* Mangrove Leaf Extract. *Buletin Oseanografi Marina*, 6(2), 110-116.
- Robbiyan, Pandapotan, M. M., & Apriani, R. (2021). Penentuan Kadar Flavonoid Dari Ekstrak Kulit Salak (*Salacca zalacca* Reinw). *Lantanida Journal*, 9(1), 1-92.
- Rohdiana, D. (2022). Aktivitas Antihiperglikemik Ekstrak Etanol Daun Cincau Hitam Pada Mencit Putih Jantan Yang Diinduksi Aloksan. *Pasundan Food Technology Journal*, 9(2), 58-61. <https://doi.org/10.23969/pftj.v9i2.5790>
- Sammanta, R. V., Muliasari, H., Rachmalia, N., & Mukhlisah, I. (2023). Penentuan Kadar Flavonoid Total Ekstrak dan Fraksi-Fraksi Daun Mangrove (*Rhizophora mucronata*). *Proceedings of the Institution of Mechanical Engineers, Part J: Journal of Engineering Tribology*, 1(1), 1-25.

- Saputri, L. O., Permatasari, L., Harahap, H. S., Rosyidi, R. M., Rivarti, A. W., Prihatina, L. M., Rahayu, Z., & Azariani, W. (2025). Potential of rutin from *Rhizophora mucronata* leaves as a Inhibitor of Kelch-like ECH-associated protein 1/Nuclear factor erythroid 2 related factor 2 Keap1/Nrf2): An in silico study for Alzheimer's therapy. *Journal of Advanced Pharmaceutical Technology & Research*, 16(2), 73.
<https://doi.org/10.4103/JAPTR.JAPTR.313.24>
- Sharifi, N., Mahernia, S., & Amanlou, M. (2017). Comparison of Different Methods in Quercetin Extraction from Leaves of *Raphanus sativus* L. *Pharmaceutical Sciences*, 23, 59-65.
<https://doi.org/10.15171/PS.2017.09>
- Tandra, H. (2020). *Dari Diabetes Menuju Kaki*. Pt Gramedia Pustaka Utama Kompas.
- Usman, U., Fildzania, D., & Fauzi, I. (2022). Uji Aktivitas Antioksidan dan Antidiabetes Ekstrak Daun Mangrove *Rhizophora mucronata*. *Jurnal Sains Dan Kesehatan*, 4(1), 28-35.
<https://doi.org/10.25026/jsk.v4i1.724>
- Utomo, D. S., Kristiani, E. B. E., & Mahardika, A. (2020). The Effect of Growth Location on Flavonoid, Phenolic, Chlorophyll, Carotenoid and Antioxidant Activity Levels in Horse Whip (*Stachytarpheta Jamaicensis*). *Bioma*, 22(2), 143-149.
- WHO. (2024). Diabetes. *World Health Organization*, November, 1-18.