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Research Article

Liver protective effect of Indonesian bay leaf on liver injury in alloxan-induced diabetic Wistar rats

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Abstract
Prolonged hyperglycemia can cause microvascular damage and lead to various microvascular complications. One of these complications is liver injury. Various natural products have been investigated for the treatment and prevention of this condition. One of these natural products is Indonesia bay leaf. Due to this reason, this study was conducted to investigate the liver-protective effect of Indonesian bay leaf extract against liver injury in alloxan-induced diabetic rats. This experimental study used thirty-two diabetic male Wistar rats that were grouped into four groups: Group I as control (distilled water), II as normal (non-diabetic), III as Indonesia bay leaf -1 (100 mg/ kg BW), and IV as Indonesia bay leaf -2 (200 mg/ kg BW). The diabetic condition was induced by intraperitoneal injection of 150 mg/ kg BW 5% Alloxan solution. This study evaluated some parameters, including blood glucose levels on the 7th and 14th days, as well as liver tissue histology. Administration of Indonesia bay leaf extract significantly decreased blood glucose levels on the 7th and 14th days (P-Value < 0.05). On the other hand, the histological study of liver tissue showed that the increase in Indonesian bay leaf significantly improved diabetic-induced liver injury, as demonstrated by the improvement in hepatocyte structure and size, a decrease in necrosis, and reduced inflammatory cell infiltration. Thus, it can be concluded that both Indonesian bay leaf extract doses can significantly improve liver tissue injury by keeping the blood glucose level within the normal range.

Keywords: Alloxan, Diabetic, Indonesian Bay leaf, Liver Injury

INTRODUCTION

Diabetes mellitus is a metabolic disease characterised by chronic hyperglycaemia and impairment of carbohydrate, lipid, and protein metabolism. It triggers either impaired insulin secretion or dysfunction of insulin hormone (Riduan and Mustofa 2017). The number of patients suffering from diabetic mellitus is relatively high, and Indonesia has the fourth-highest number of diabetic patients in the world. The Local Health Ministry on Basic Health Research (*Riset Kesehetan Dasar/ Riskesdas*) in 2018 reported that the rate of diabetic patients increased from 6.9% in 2013 to 8.5% in 2018, and it also predicted to increase 21.3 million diabetic patients every year. The high rate of diabetic patients is caused by the changes in the demographic and lifestyles of these patients. It is observed in normal-weight patients who become obese due to a change in lifestyle from a healthy, low-calorie diet to a high-calorie diet, often characterised by fast-food consumption (American Diabetes Association, 2020; International Diabetes Federation).

Diabetes can lead to both microvascular and macrovascular complications, affecting various organs in the body. Liver tissue is vulnerable to damage due to prolonged hyperglycemia. In Non-Insulin-Dependent Diabetes Mellitus (NIDDM), insulin resistance disrupts both lipid and glucose metabolism in certain tissues, including the liver. During insulin-resistant states, impaired glucose uptake and enhanced lipolysis in white adipose tissue lead to an increased influx of free fatty acids into the liver. This influx promotes hepatic de novo lipogenesis, resulting in the accumulation of lipids within hepatocytes, either as lipid droplets or systemic lipoproteins, ultimately leading to hepatic steatosis (fatty liver). Fatty liver contributes to the release of pro-inflammatory, pro-oxidative, and pro-fibrogenic mediators, which further aggravate insulin resistance and may contribute to myocardial damage. At advanced stages, persistent insulin resistance within the vasculature facilitates the development of atherogenic plaques and worsens glycemic control, leading to both macrovascular and microvascular complications. (Mantovani *et al*. 2022; Nogueira and Cusi 2024)

Several treatment approaches for diabetes, including dietary modifications, physical activity, and antidiabetic medications, have been developed. However, adverse drug reactions associated with conventional therapies have led some patients to look for any alternative treatments, particularly herb. One such herb that has attracted significant attention is the Indonesian bay leaf (*Syzygium polyanthum*). Prambudi *et al*. (2022) reported that the ethyl acetate fraction of Indonesian bay leaf significantly reduced blood glucose levels in alloxan-induced diabetic rats after 14 days of treatment. Similarly, Kurniawati *et al*. (2025) and Pratama (2024) found that both the infusion and decoction forms of Indonesian bay leaf exhibited notable antidiabetic effects. Despite these promising findings, previous studies have not investigated the liver-protective effects of Indonesian bay leaf in the context of diabetes, when the diabetic condition can potentially cause fatty liver. However, Handayani *et al*. (2023) demonstrated that the ethanol extract of Indonesian bay leaf, at doses ranging from 75 to 300 mg/kg body weight (BW), showed liver-protective effects in rats induced with rifampicin and isoniazid. A similar protective effect was also observed by Awwalia *et al*. (2024) in a study using potassium oxonate-induced liver injury in mice. These findings highlight the potential of Indonesian bay leaf not only as an antidiabetic agent but also as a candidate for mitigating diabetes-associated fatty liver.

Based on the information above, Indonesia's bay leaf is widely reported to have antidiabetic effects potentially decreasing blood glucose levels and prevents macrovascular or microvascular damage, especially glucose-induced liver injury. Due to these reasons, this study aimed to investigate the liver-protective effect of Indonesian bay leaf extract against liver injury in alloxan-induced diabetic rats.

MATERIALS AND METHODS

Study design

This experimental study was conducted in the Laboratory of the Pharmacy Faculty, Universitas Sumatera Utara, Medan, from March to June 2021, using a pretest-posttest randomised control group design. This study used 32 Wistar rats as trial animals, each weighing 150-200 grams, and aged 8-12 weeks. All rats were male rats.

These Wistar rats were grouped into four groups: normal groups, including Group I as the control (distilled water), II as the normal (non-diabetic), III as Indonesia bay leaf -1 (100 mg/kg BW), and IV as Indonesia bay leaf -2 (200 mg/kg BW). Thus, each group consisted of eight Wistar rats.

Animal ethical approval

This study was approved by the Health Research Ethics Committee of Universitas Prima Indonesia with letter number 018/KEPK/UNPRI/XII/2022.

Materials

This study utilised various materials, including Indonesian bay leaf, 96% ethanol, filter paper, pellets, distilled water, 70% alcohol, 10% formalin buffer solution, alloxan, normal saline, glucometer strips, and hematoxylin and eosin staining powder.

Extraction process

The extraction process was performed using the maceration method. Indonesian bay leaves were collected from the local market in Medan City. This leaf was then cleaned and dried into Indonesia bay leaf simplicial powder. The amount of 500 grams of Indonesian bay leaf simplicial powder was soaked in 3.75 litres of 96% ethanol for 3-5 days and was regularly stirred. After that, it was filtered, and the residue was soaked again in one-third of 96% ethanol (1.25 liters) for 3-5 days, then filtered it. The first and second maceration filtrates were collected and evaporated by rotary evaporator at 40 °C, forming a concentrated Indonesian bay leaf extract. This concentrated extract was stored at 20 °C until use (Chiuman *et al*., 2022; Gulo *et al*., 2021; Suhartomi *et al*., 2020).

Alloxan-induced diabetes

Diabetic induction was performed by alloxan injection. Initially, 1.25 grams of alloxan powder was dissolved in

25 millilitres of cool normal saline solution to obtain a 5% alloxan solution. After that, this solution was injected intraperitoneally in a 150 mg/ kg BW dose for diabetic induction. All rats had been fasted for 12 hours before the injection. The diabetic condition was evaluated 48 hours after the alloxan injection. A blood glucose level of≥ 200 mg/dL was defined as diabetic in rats. All groups underwent diabetic induction, except the normal group (Chiuman *et al*., 2021; Chiuman, Ginting, and Yulizal, 2022; Mutia and Suhartomi, 2022).

Treatment

All groups received treatment for 14 days. Group I and II freely accessed to pellets and distilled water but did not receive any extracts or drugs. Group I consisted of non-diabetic Wistar rats, whereas Group II consisted of diabetic Wistar rats. Meanwhile, Groups III and V received 150 mg/kg body weight (BW) and 200 mg/kg BW of Indonesian bay leaf extract, respectively, orally.

Blood glucose level monitoring

All rats were monitored for blood glucose levels before and after induction on the 7th day and 14th day. Blood glucose levels were measured using a glucometer with vein tail blood, expressed in mg/dL (Chiuman *et al*., 2021; Chiuman, Ginting, and Yulizal, 2022; Mutia and Suhartomi, 2022).

Histology study

All rats were sacrificed on the 15th day after treatment by ketamine injection. After that, the abdomen was vertically incised for liver resection. The resected liver was washed with normal saline and then collected into the 10% buffer formalin solution. Finally, the cleaned liver tissue was sliced and stained with hematoxylin and eosin in the Pathology Anatomy Laboratory, Faculty of Medicine, Universitas Sumatera Utara. The stained liver tissue was then observed under a light microscope at 40x and 100x magnification (Chiuman *et al*., 2021; Duan *et al*., 2018; Shakya, 2020).

This study also analysed liver histology in all groups on the 15th day, and the liver tissue was stained with hematoxylin and eosin.

Pathological changes were evaluated in liver tissue, including hepatocyte and sinusoidal structure, inflammation, degeneration, and necrosis.

Data analysis

All data were analyzed by descriptive statistics. All blood glucose levels were expressed as Mean and Standard Deviation. After that, these data were analysed using One-Way ANOVA and a Post Hoc Test (Tukey HSD). Meanwhile, the histology investigation of liver tissue was narratively described.

RESULTS AND DISCUSSION

Comparison of blood glucose level

All rats' blood glucose levels after alloxan-induced diabetes and seven to fourteen days after treatment are described in Table 1.

Table 1 shows a significant difference (P-Value < 0.05) in fasting blood glucose between the control (Group I) (77.17 ± 8.33 mg/dL) and normal (Group II) (116.50 ± 12.37 mg/dL) groups; both Indonesia bay leaf groups (Group III and IV) did not show any significant blood glucose level against both control (Group I) and normal (Group II) group. All blood glucose levels were lower than 200 mg/dL, indicating non-diabetic conditions. After that, all groups except the normal group were induced, and the blood glucose levels increased by more than 200 mg/dL, ranging between 452.17 and 558.93 mg/dL. After 7 days of treatment, both Indonesia bay leaf groups (Group III and IV) showed a significantly decreased blood glucose level compared to the control group (Group I) (530.83 ± 27.32 mg/dL). The 7th day's blood glucose levels of Indonesia bay leaf-1 and 2 (Group III and IV) were 362.33 ± 84.53 mg/dL and 262.00 ± 83.04 mg/dL, respectively. However, it did not decrease as low as the normal group (Group II), which was the normal control (Group II) (81.33 ± 2.58 mg/dL). Interestingly, both Indonesian bay leaf groups' (Group III and IV) blood glucose levels continued to decrease on the 14th day of treatment, close to the normal

Table 1. Showing blood glucose levels in all the groups

Group	Blood Glucose Level, mg/ dl			
	Before Induction	**After Induction**	**7th day**	**14th day**
Group I (Control)	116.50±12.37^{b}	558.93±40.39^{b}	530.83±27.32^{b}	298.00±48.90^{b}
Group II (Normal)	77.17±8.33^{a}	80.33±6.41^{a}	81.33±2.58^{a}	83.17±3.49^{a}
Group III (Indonesia bay leaf-1)	93.17±16.82^{ab}	452.17±101.95^{b}	362.33±84.53^{c}	109.17±45.86^{a}
Group IV (Indonesia bay leaf-2)	98.17±25.26^{ab}	509.00±80.96^{b}	262.00±83.04^{d}	79.83±19.78^{a}
P-Value	0.006	0.000	0.000	0.000

Data expressed as Mean ± SD; P-Value was obtained from One Way ANOVA; Difference superscript in the same column indicated a significant difference.

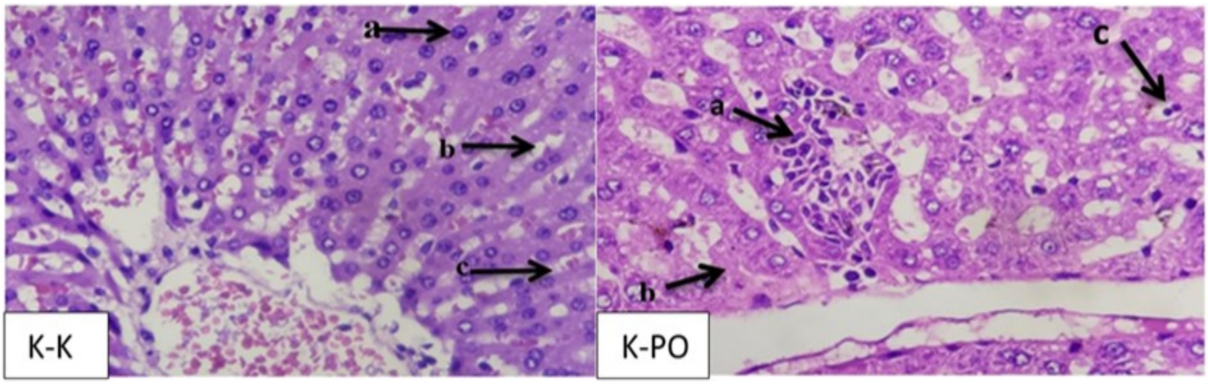

Fig. 1. *Liver tissue histology of control (Group I) (Right) and normal (Group II) (Left) Group. In the normal group, (a) indicating a normal hepatocyte, consisting of a round nucleus located in the center and regular nuclear membrane, (b) indicating sinusoidal, (c) indicating clear-appearance cytoplasmically. Whereas in the control (Right), (a) indicating abnormal hepatocytes with varied cell shapes and the nucleus (pleomorphic), (b) indicating necrotic cells, (c) indicating lymphocyte inflammatory cells; Stain: Haematoxylin and Eosin; Magnification: 400x*

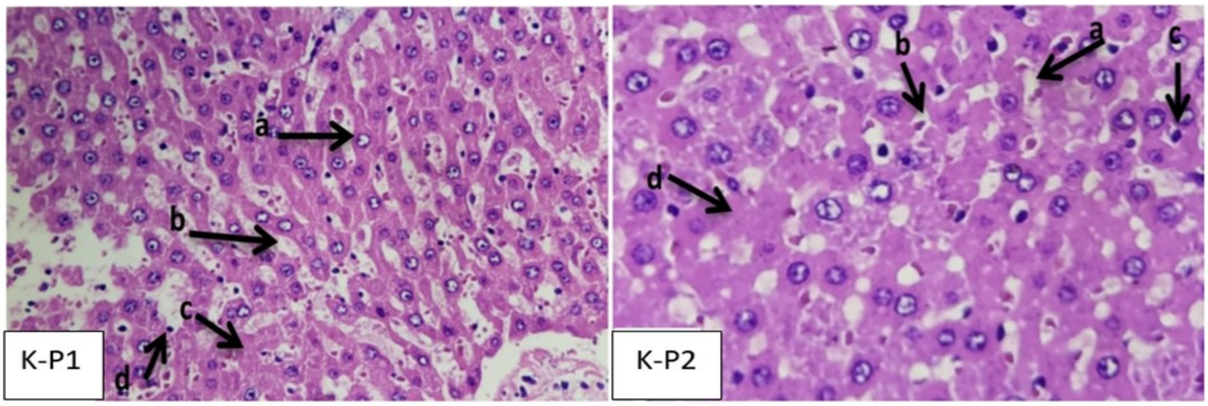

Fig. 2. *Liver tissue histology of Indonesian leaf bay-1 (Group III) (Left) and Indonesian leaf bay-2 (Group IV) (Right) Group. In the Indonesian leaf bay-1, (a) indicating monomorphic- hepatocyte with a round nucleus, (b) indicating slightly dilated sinusoids, (c) indicating necrosis, (d) indicating lymphocyte cells. Whereas in the Indonesian Leaf bay-2, (a) indicating normal sinusoidal size, (b) indicating normal hepatocyte with minimal variation of nuclear size, (c) indicating lymphocytes, (d) indicating necrosis; Stain: Haematoxylin and Eosin; Magnification: 400x*

group's blood glucose level (Group II). The 14th day's blood glucose levels in Indonesia Bay leaf-1 and 2 (Group III and IV) were 109.17 ± 45.86 mg/dL and 79.83 ± 19.78 mg/dL, respectively.

Liver histology study

Fig. 1 describes the liver histology features of both the control (Group I) and normal (Group II) groups.

This shows that normal liver tissue has some features, including normal hepatocyte cell shape and size, clear cytoplasm, and normal sinusoid and vein structure. Meanwhile, the control group (Group I) exhibited the most severe damage, characterised by abnormal and varying hepatocyte cell shapes and sizes, deranged radial hepatocyte construction, irregular sinusoid dilation, and the presence of necrotic cells. The cytoplasmic and nuclear cell changes indicated liver tissue necrosis, which was also found in the normal and control groups. These pathology changes may be associated with the prolonged hyperglycemia condition induced by alloxan injection. Meanwhile, both Indonesia bay leaf groups' (Group III and IV) liver histology are described in Fig. 2.

Fig. 2 illustrates the improvement of both Indonesian leaf bay groups (Groups III and IV). Indonesia leaf bay-1 group (Group III) showed a normal sinusoidal structure like the normal group (Group II), and the sinusoidal was slightly widened. However, some hepatocytes in this group exhibited hepatocyte injury, which was less severe than in the control group (Group I). The hepatocytes in Indonesia leaf bay-1 (Group III) were characterized by relatively monomorphic and minimal variation in size. Other pathology features in the Indonesia leaf bay -1 (Group III) group were lymphocyte cell infiltration and some necrosis. At the higher dose, Indonesia leaf bay-2 (Group IV) showed better liver tissue improvement than Indonesia leaf bay-1. This improvement was demonstrated by milder changes in hepatocyte size and structure, and a sinusoidal size approaching normal. However, the Indonesia leaf bay-2 group (Group IV) still had fewer lymphocyte infiltration and necrosis than the Indonesia leaf bay-1 group (Group III). This improvement may be due to the increase in the Indonesia bay leaf extract dose. Hence, Indonesia bay leaf extract prevented further liver tissue damage caused by prolonged hyperglycaemic conditions, which was better than the lower dose (Group III).

Administration of Indonesian bay leaf extract significantly reduced blood glucose levels in alloxan-induced diabetic rats, particularly at doses of 100–200 mg/kg body weight (BW) after 14 days of treatment. The antidiabetic effect was evident by the substantial decline in blood glucose levels toward the normal range (50–135 mg/dL). Histological analysis also revealed liver tissue regeneration, which was more pronounced in the group treated with 200 mg/kg body weight (BW) compared to the lower dose, indicating a dose-dependent hepatoprotective effect of the extract.

These findings are in line with a previous study by Prambudi *et al*. (2022), who reported that the ethyl acetate fraction of Indonesian bay leaf significantly decreased blood glucose levels at doses of 125–250 mg/kg body weight (BW) following 14 days of treatment ($p < 0.05$). The antidiabetic activity comes from the inhibition of the α-glucosidase enzyme. Furthermore, Indonesian bay leaf has been reported to enhance glucose uptake in abdominal muscle tissue while simultaneously reducing intestinal glucose absorption. The presence of phytochemicals such as flavonoids, saponins, and quinones is likely responsible for these effects. In particular, flavonoids are known for their antioxidant properties, including free radical scavenging and inhibition of aldose reductase in the polyol pathway, which may contribute to prevent diabetic complications such as fatty liver. Handayani *et al*. (2023) also demonstrated that Indonesian bay leaf extract significantly improved malondialdehyde (MDA) levels ($p < 0.05$), indicating a reduction in oxidative stress in liver tissue damaged by rifampicin and isoniazid. Thus, it becomes obvious that Indonesian bay leaf not only possesses antidiabetic properties but also offers potential liver-protective effects through antioxidant and metabolic modulation. (Handayani *et al*. 2023; Prambudi, Meles, and Widiyatno 2022; Widodo *et al*. 2023)

Indonesian Bay leaf extract, used in this study, not only decreased blood glucose levels but also improved liver tissue injury induced by a prolonged hyperglycemic condition. Flavonoids, specifically quercetin, are also reported to have liver-protective effects against liver injury, particularly induced by free radicals associated with diabetic conditions. Flavonoids neutralized various free radicals that affected both pancreas and liver tissue. Unnaturalized free radicals can directly disrupt membrane integrity by binding electrons from certain molecules in the membrane, inducing hepatocyte lysis and releasing various liver enzymes into the cytosol (Hardiningtyas *et al*., 2014; Mulya, 2015).

In addition to flavonoids, tannin has also been reported to have an antidiabetic effect. Tannin increases glucose (glycogenesis) and lipid serum uptake and metabolism rate and decreases blood glucose and lipid level. Furthermore, tannin also has antioxidant properties and inhibits glucose absorption in the small intestine, thereby decreasing blood glucose levels during the absorption phase. Indonesia bay leaf also has terpenoids that stimulate insulin secretion, and this compound has a similar structure to the insulin hormone. Other phytochemicals also increase insulin secretion in pancreatic tissue and decrease glucagon hormone secretion, such as alkaloids and saponins (Anggraini 2020; Lolok and Yuliastri 2020).

Conclusion

The administration of Indonesian bay leaf extract at doses of 100 mg/kg body weight (BW) and 200 mg/kg BW significantly reduced blood glucose levels on both the seventh and fourteenth days of treatment. Moreover, it demonstrated a hepatoprotective effect by alleviating liver tissue damage associated with prolonged hyperglycemia, as shown by decreased fatty degeneration, necrosis, and inflammatory cell infiltration. These findings highlight not only the antidiabetic potential of this traditional herbal remedy but also its dual action in mitigating diabetes-related liver complications. These findings warrant further in-depth studies on Indonesian bay leaf as a potential adjunctive therapy for diabetes, particularly given its accessibility and cost-effectiveness.

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Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

1. American Diabetes Association. 2020. St*andards of Medical Care in Diabetes Volume 43.* ed. Matthew C. Riddle. USA: American Diabetes Association.
2. Anggraini, A. (2020). Manfaat Antioksidan Daun Salam Terhadap Kadar Glukosa Darah dan Penurunan Apoptosis Neuron di Hippocampus Otak Tikus yang Mengalami Diabetes. *Jurnal Medika Hutama*, *2*(1), 349–355.
3. Awwalia, E. S., Salim, H. M., Riza M. F., and Mulyadi (2024). The Role of Bay Leaf Extract in Reducing Liver Inflammation in Mice (*Mus Musculus*) Induced by Potassium Oxonate. *Jurnal Ilmiah Kesehatan* 17(01), 85–90. https://doi.org/10.33086/jhs.v17i01.5613

4. Chiuman, L., Ginting, C. N., & Yulizal, O. (2022). Lemon Pepper Extract Improves Diabetic Nephropathy in Diabetic Rats. *Open Access Macedonian Journal of Medical Sciences* 10(A): 170–75. https://doi.org/10.3889/oamjms.2022.8226
5. Chiuman, L., Ginting, C. N., Yulizal, O., & Suhartomi. (2021). Improvement of Liver Function from Lemon Pepper Fruit Ethanol Extract in Streptozotocin-Induced Wistar Rats. In *2021 IEEE International Conference on Health, Instrumentation & Measurement, and Natural Sciences (InHeNce)*, Medan, Indonesia: IEEE. https://doi.org/10.1109/InHeNce52833.2021.9537284
6. Duan, Y., Duan J., Feng, Y., Huang, X., Fan W., Wang K., Ouyang, P., Deng, Y., Du, Z., Chen D., Geng, Y., & Yang, S. (2018). Hepatoprotective Activity of Vitamin E and Metallothionein in Cadmium-Induced Liver Injury in *Ctenopharyngodon Idellus*. *Oxidative Medicine and Cellular Longevity*. https://doi.org/10.1155/2018/9506543
7. Gulo, K. N., Suhartomi, Saragih, A. D., Raif, M. A., & Ikhtiari, R. (2021). Antioxidant Activity of Flavonoid Compounds in Ethanol and Ethyl Acetate Extract from *Citrus sinensis*. In *AIMS 2021 - International Conference on Artificial Intelligence and Mechatronics Systems*, IEEE, 1–6. https://doi.org/10.1109/AIMS52415.2021.9466078
8. Handayani, Puspitasari, R. N., Veterini, L., & Wulandari, D. D. (2023). Hepatoprotective Effect of Ethanolic Extract of *Syzygium Polyanthum* in Rats Induced by Rifampicin and Isoniazid. *Bali Medical Journal* 12(3): 3387–91. https://doi.org/10.15562/bmj.v12i3.4327
9. Hardiningtyas, S. D., Purwaningsih, S., & Handharyani, E. (2014). Aktivitas Antioksidan dan Efek Hepatoprotektif Daun Bakau Api-Api Putih. *Jurnal Pengolahan Hasil Perikanan Indonesia*, *17*(1), 80–91.
10. International Diabetes Federation. (2019). *IDF Diabetes Atlas* (9th ed.). Brussels, Belgium: International Diabetes Federation. Retrieved from https://www.diabetesatlas.org
11. Kurniawati, E. Y., Muhlida, V. I., Dewi, M. M., and Margiyati. (2025). Efficacy of Bay Leaf (*Syzygium Polyanthum*) Decoction in Improving Glycaemic Control in Type 2 Diabetes Mellitus Patients: A Randomized Controlled Trial. *Journal of Rural Community Nursing Practice* 3(1): 150–73. https://doi.org/10.58545/jrcnp.v3i1.462.
12. Lolok N., Yuliastri W. O., & Abdillah, F. A. (2020). Efek Antidiabetes Kombinasi Ekstrak Etanol Daun Pandan Wangi (*Pandanus amaryllifolius Roxb*.) dan Daun Salam (*Syzygium polyanthum Wight*.) Pada Tikus Putih Dengan Metode Induksi Aloksan. *Jurnal Mandala Pharmacon Indonesia*, *6*(1), 13–29.
13. Mantovani, A., Dalbeni, A., Beatrice, G., Cappelli, D., & Gomez-Peralta, F. (2022). Non-Alcoholic Fatty Liver Disease and Risk of Macro-and Microvascular Complications in Patients with Type 2 Diabetes. *Journal of Clinical Medicine* 11(4): 1–15. https://doi.org/10.3390/jcm11040968
14. Mulya, E. (2015). Gambaran Histopatologis Hati Tikus (*Rattus novergicus*) yang Diinfeksi Trypanosoma evansi Setelah Pemberian Ekstrak Kulit Batang Jaloh (*Salix tetrasperma Roxb*). *Jurnal Medika Veterinaria*, *9*(2), 141–145.
15. Mutia, M. S., & Suhartomi. (2022). *Buku Monografi Model Hewan Coba Diabetes: Diet Tinggi Lemak Dan Induksi Sterptozotosin*. eds. Linda Chiuman, Novalina Siregar, and Annisa Annastasya. Medan: Unpri Press. http://jurnal.unprimdn.ac.id/index.php/ISBN/article/view/3005/1925.
16. Nogueira, J. P., & Cusi, K. (2024). Role of Insulin Resistance in the Development of Nonalcoholic Fatty Liver Disease in People with Type 2 Diabetes: From Bench to Patient Care. *Diabetes Spectrum* 37(1): 20–28. https://doi.org/10.2337/dsi23-0013
17. Prambudi, D. T. A., Meles, D. K., & Widiyatno, T. V. (2022). Aktivitas Antihiperglikemia Fraksi Etil Asetat Daun Salam (*Syzygium Polyanthum*) Terhadap Tikus Yang Diinduksi Aloksan Monohidrat. *Jurnal Kajian Veteriner* 10(1): 20–28. https://doi.org/10.35508/jkv.v10i1.6469
18. Pratama, A. A. (2024). Literature Review: Antidiabetic Activity of Bay Leaf Infusion (*Syzygium Polyanthum*). *Sean Institute Eduhealth Journal* 15(03): 322–29. https://doi.org/10.54209/eduhealth.v15i03
19. Riduan, R. J., & Mustofa, S. (2017). Penatalaksanaan KAD Dan DM Tipe 1 Pada Anak Usia 15 Tahun. *Jurnal Medula Unila* 7(2): 114–22.
20. Shakya, A. K.. (2020). Drug-Induced Hepatotoxicity and Hepatoprotective Medicinal Plants: A Review. *Indian Journal of Pharmaceutical Education and Research* 54(2): 234–50.
21. Suhartomi, Gulo, K. N, Saragih, A. D., Martinus A. R., & Ikhtiari, R. (2020). Antioxidant Properties of Sweet Orange Peels in Several Fractions of Methanolic Extract. In *Proceedings of the International Conference on Health Informatics and Medical Application Technology - Volume 1: ICHIMAT*, Medan: Scitepress Digital Library, 371–78. https://doi.org/10.5220/0009515503710378
22. Widodo, W. D. P., Parisa, N., Tamzil, N. S., Lusiana, E., Ardita, N., Putri, A. A. A., Permata, S. B., & Ditamor, A. F. (2023). The Potential of Bay Leave (*Syzygium Polyanthum*) As an Antidiabetic Agent. *International Journal of Islamic and Complementary Medicine* 4(2): 63–70. https://doi.org/10.55116/IJICM.V4I2.60