



The Effect of *Nigella Sativa L.* Extract on Blood Glucose Levels in Alloxan-Induced Hyperglycemic *Mus musculus*

Nur Khoirunnisa¹, Armanto Makmun², Zulfiyah Surdam³, Muhammad Jabal Nur⁴, Abdul Mubdi Ardiansar⁴, Zulfahmidah⁵

¹Medical Education Program, Faculty of Medicine, Universitas Muslim Indonesia

²Department of Public Health, Faculty of Medicine, Universitas Muslim Indonesia

³Department of Anatomy, Faculty of Medicine, Universitas Muslim Indonesia

⁴Department of Internal Medicine, Faculty of Medicine, Universitas Muslim Indonesia

⁵Department of Biochemistry, Faculty of Medicine, Universitas Muslim Indonesia

*Corresponding Author: Armanto Makmun

E-mail: armanto.makmun@umi.ac.id



Article Info

Article history:

Received 27 February 2025

Received in revised form 7 April 2025

Accepted 20 April 2025

Keywords:

Black Cumin Extract

Blood Glucose

Alloxane

Hyperglycemia

Abstract

Hyperglycemia is one of the conditions of increasing blood glucose levels. There are various treatment options in patients with hyperglycemia, one of which is non-drug therapy with traditional medicine. A traditional medicinal plant with various benefits, namely black cumin which is known to have a variety of ingredients that can lower blood glucose levels. Knowing the effect of black cumin extract on blood glucose levels in mice with alloxane-induced hyperglycemia. The research design used was a pre and post test with control group design with a total sample of 27 mice divided into 3 groups where each group consisted of 9 heads. Group 1 is the control group while group 2 and group 3 will be treated respectively. The analysis was carried out with a paired sample t-test to see the differences between each group before and after treatment. The results of the study on the average blood glucose levels before treatment and after the administration of black cumin treatment there were changes in each group obtained a significance value of 0.000 at both doses of black cumin extract. Based on the results obtained, it is known that black cumin extract can reduce blood glucose levels where the greater the dose is directly proportional to the decrease in blood glucose levels.

Introduction

Hyperglycemia is characterized by blood glucose levels greater than 125 mg/dL when fasting and greater than 180 mg/dL two hours postprandial (Mouri & Badireddy, 2023; Prapurandina, 2010). Hyperglycemia is characteristic of various medical conditions including diabetes mellitus (Fadli, 2024). Diabetes mellitus (DM) is a metabolic condition in which blood glucose levels are abnormally high. There are two most common types of diabetes: type 1 diabetes mellitus (T1DM) and type 2 diabetes mellitus (T2DM) (Forouzanfar et al., 2014; Soelistijo et al., 2019). Diabetes is the main cause of medical conditions such as blindness, heart disease, and kidney failure which cause many deaths in humans around the world (International Diabetes Federation, 2021; Mohebbati & Abbasnezhad, 2020).

According to IDF (Indonesia Diabetes Federation) the prevalence of diabetes for 2021 is estimated to be 537 million adults worldwide with diabetes and will increase by 643 million in 2030 and is expected to continue to increase to 783 million in 2045. Indonesia is ranked 5th among the 10 countries with the highest number of people with diabetes. Based on the results

of the Basic Health Research (Riskesdas) in 2018, the incidence of diabetes mellitus increased from 6.9% in 2013 to 8.5% in 2018. These results show that only about 25% of people with diabetes know they have diabetes. Meanwhile, the prevalence rate of diabetes mellitus based on a doctor's diagnosis in the population aged > 15 years in South Sulawesi province in 2013 reached 1.6% and increased in 2018 to 1.8% (International Diabetes Federation, 2021; Nakrani et al., 2020).

Diabetes mellitus is a disease that has two treatment options: drug therapy and non-drug therapy. When blood sugar levels can no longer be regulated or non-drug therapy fails, drug therapy is often used. Non-drug therapy for people with diabetes mellitus is carried out through dietary control and also traditional medicine (herbs) which can be used for treatment because it is proven to be quite safe when used with the right dose and appropriate indications. One of the traditional medicinal plants with various benefits is black cumin (*Nigella sativa* L) (Irdalisa et al., 2015; Marlinda, 2015).

Various forms of *Nigella sativa* L (*N. Sativa*) such as oil extracts, and seeds have been used in traditional medicine to treat several ailments such as fever, cough, diarrhea, bronchitis, and digestive problems. *N. Sativa* is said to have anti-diabetic, antioxidant, anti-cancer, hypolipidemic, and anti-inflammatory therapeutic effects. The therapeutic effects of *N. sativa* are mainly contributed by thymoquinone (Fahmi et al., 2020; Hamdan et al., 2019). Thymoquinone (2-isopropyl-5-methylbenzo-1,4-quinone) is the main bioactive component of *Nigella sativa* for treating various symptoms, including elevated blood glucose levels (Gray et al., 2016; Rejeki et al., 2018).

Methods

The research used experimental methods which included pre- and post-treatment evaluation of control and experimental groups. The research design allowed investigators to check the blood glucose changes in mice following black cumin extract application through comparison with an untreated control group. Black cumin extract administration was given to two groups while the negative control group received no treatment in this study. The researchers first established hyperglycemia in all mice through alloxan induction before giving only the treatment groups their extract.

Simple random sampling was used as the method to select samples which provided an equal opportunity for selecting every potential subject. The experimental mice included male *Mus musculus* subjects within the 2-3 months age range and weighing from 20 to 40 grams. The experimental design included 27 mice which were organized into three equal groups containing nine mice per group. The negative control group consisted of animals which received only alloxan in Group I. The experimental mice in Group II received black cumin extract treatment at 0.65 mg per 0.5 ml while Group III received a higher dose amounting to 1.30 mg per 0.5 ml.

The researchers determined the minimum sample size through experimental research by applying Federer's formula $(t-1)(n-1) \geq 15$ considering t for groups and n for subjects per group. An appropriate number of samples were used to achieve statistical significance in outcome analysis.

The black cumin extract was given through gastric sonde administration once daily to the mice for five days starting from the moment their hyperglycemic state was confirmed after receiving alloxan treatment. The mice received Alloxan intraperitoneally at 3.35 mg per mouse to develop hyperglycemia while measuring their blood glucose levels for confirmation of the induction effect.

Blood glucose measurements went through three time points for each mouse beginning with the baseline measurement before alloxan treatment followed by hyperglycemia testing after

alloxan exposure and finishing with testing after treatment administration. Standardized testing conditions were employed with the glucometer to measure blood glucose levels.

Testing normality required the Shapiro-Wilk test as part of the analysis process. The mean with standard deviation provided the measures of dispersion along with central tendency because all groups satisfied normal distribution requirements ($p > 0.05$). The changes in blood glucose level means were evaluated using One-way ANOVA then the Least Significant Difference (LSD) test determined specific group differences. The changes in each group received statistical evaluation through paired sample t-tests.

The experimental methods happened at the Research Laboratory of the Faculty of Medicine, Universitas Muslim Indonesia from October to December 2022 under animal research ethical protocols.

Result and Discussion

This study was conducted at the Research Laboratory of the Faculty of Medicine, Muslim University of Indonesia in October - December 2022. This study aims to determine the effectiveness of giving black cumin extract at a dose of 0.65 mg / 0.5 ml and black cumin extract at a dose of 1.3 mg / 0.5 ml with blood glucose levels in alloxan-induced mice (*Mus Musculus*). 3 Treatment groups of 9 mice each group, so the number of subjects used was 27 mice.

Blood Glucose Level Measurement Results

Measurement of blood glucose levels in this study was done three times in each group where the initial measurement was done to determine blood glucose levels before alloxan was given, the next measurement was done after alloxan induction and the third measurement was done after treatment, where there were 3 treatments group 1 was only given alloxan, group 2 was given alloxan at a dose of 0.65 mg / 0.5 ml, while group 3 was given alloxan at a dose of 1.30 mg / 0.5 ml.

Table 1. Group I (Initial Blood Glucose Level, After Alloxan Administration and Untreated)

Group	Total	Initial Blood Glucose Level	Blood Glucose Levels After Alloxan Administration	Untreated Blood Glucose Levels
I	9	104	202	120
		82	188	146
		84	228	138
		171	214	158
		123	234	169
		173	219	126
		82	169	172
		92	179	111
		105	241	112

Table 2. Group II (Initial Blood Glucose Level, After Alloxan Administration and After Alloxan 0.65 mg/0.5 ml)

Group	Total	Initial Blood Glucose Level	Blood Glucose Levels After Alloxan Administration	Blood Glucose Levels After <i>N. Sativa</i> 0.65 mg/0.5 ml
II	9	131	190	130
		119	181	82
		159	222	120

		101	192	103
		97	269	136
		90	179	112
		105	377	121
		93	198	91
		105	219	111

Table 3. Group III (Initial Blood Glucose Level, After Alloxan Administration and After Alloxan 1.30 mg/0.5 ml)

Group	Total	Initial Blood Glucose Level	Blood Glucose Levels After Alloxan Administration	Blood Glucose Levels After <i>N. Sativa</i> 1.30 mg/0.5 ml
III	9	126	202	72
		100	239	81
		117	209	78
		107	169	88
		77	188	84
		97	232	56
		89	210	54
		136	188	54

Data Analysis Results

The results of the Saphiro Wilk normality test showed that the data were normally distributed in each group ($p \Rightarrow 0.05$) so that the measure of data concentration used was the mean and for data distribution used standard deviation.

Table 4. Average Changes in Blood Glucose Levels of Each Group Before and After Treatment

Average Blood Glucose Level	Number (n)	Mean \pm SD	<i>Sig</i>
Group 1	9	69,11 \pm 36,886	0,013*
Group 2	9	113,44 \pm 57,799	
Group 3	9	133,33 \pm 28,567	

* $p=0,05$

Description:

Group 1: Mice that are only given alloxan

Group 2: Mice given a dose of black cumin extract 0.65 mg / 0.5 ml

Group 3: Mice given black cumin extract at a dose of 1.30 mg / 0.5 ml

From the table above, the mean value and standard deviation of each group of average blood glucose levels before treatment and after treatment were obtained. Group 1 has a mean value and standard deviation of 69.11 and 36.886. Group 2 has a mean and standard deviation of 113.44 and 57.799. While for group 3 has a mean value and standard deviation of 133.33 and 28.567.

Based on table 4 also obtained anova test value or Sig value of 0.013 ($p < 0.05$). This shows there is a significant average change between groups of blood glucose level difference before treatment and after treatment.

Furthermore, to find out which group has a significant difference, it is continued with the Post Hoc Test analysis test with the Least Significant Difference (LSD) procedure.

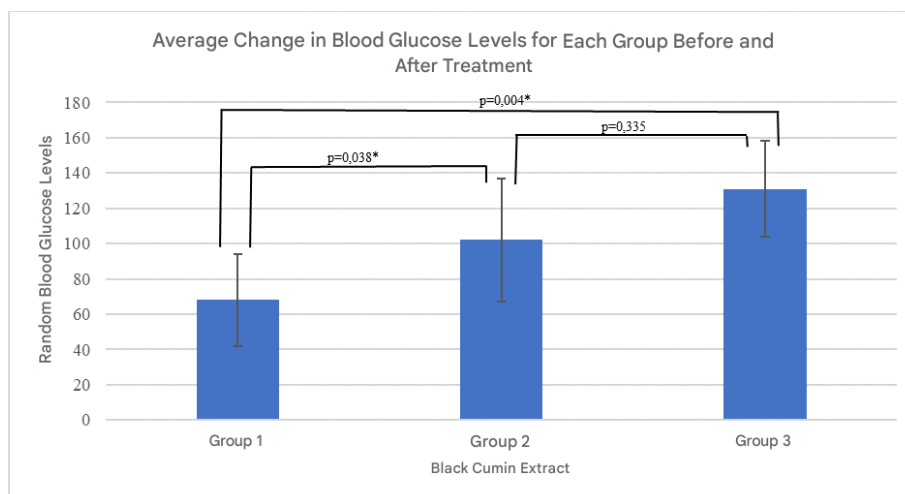


Figure 1. Post Hoc Tests of Mean Changes in Blood Glucose Levels of Each Group Before and After Treatment

Based on the Post Hoc Tests graph above, it shows that there is a significant difference in average blood glucose levels between group 1 against group 2 and group 3 and vice versa. This is indicated by the significance value of 0.038 and 0.004 ($p < 0.05$). While for group 2 against group 3 there is no significant difference and vice versa. This is indicated by a significance value of 0.335 ($p > 0.05$).

Furthermore, Paired Sample T-Tests analysis test was conducted. To find out more specifically about the decrease in blood glucose levels after treatment in each group.

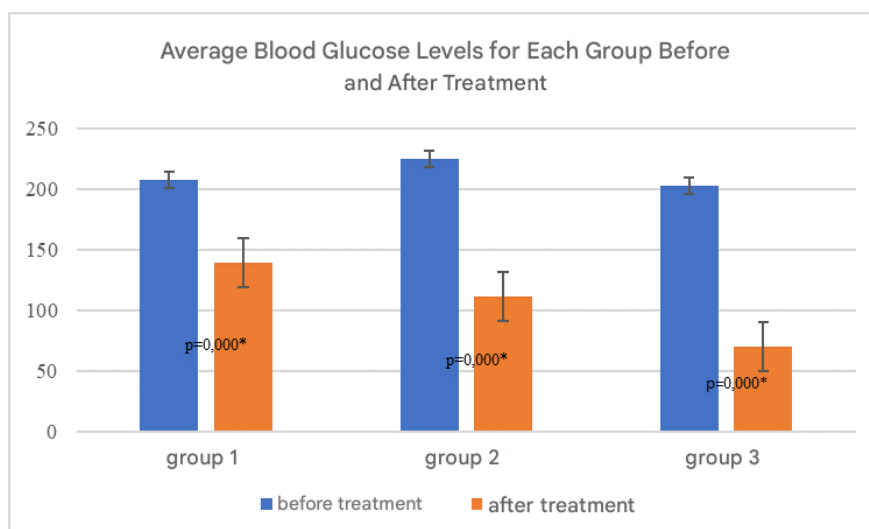


Figure 2. Paired Sample T-Tests of Average Blood Glucose Levels of Each Group Before and After Treatment and After Treatment

Based on the graph above, the significance value of the three groups is 0.000. This means that there is a significant difference in average blood glucose levels before treatment and after treatment of the three groups above ($p < 0.05$). This indicates that groups II and III were given black cumin extract there was a significant decrease in average blood glucose levels, and in group I which was only given alloxan also experienced significant changes in blood glucose levels.

In this study, 3 groups were used, namely the control group, treatment group I and treatment group II. The control group induced alloxan so that it becomes hyperglycemia is needed to determine the increase in blood glucose levels, treatment group I and treatment group II in this study is black cumin extract with a dose of 0.65 mg / 0.5 ml and a dose of 1.30 mg / 0.5ml. It is necessary to see the effect of black cumin extract on reducing blood glucose levels.

Based on the calculation of the dose of alloxan obtained is 3.35 mg / mice given intraperitoneally. The test material used is black cumin extract with a dose of 0.65 mg / 0.5 ml and a dose of 1.30 mg / 0.5ml. This dose is obtained based on the effective dose in rabbit animals which is converted to the dose of mice. Administration of the test material is done once a day orally using a gastric sonde for 5 consecutive days.

On the first day of the experiment, before being induced with alloxan, the blood glucose levels of mice in all groups showed normal results. On the 6th day after induction, alloxan-induced test animals were checked for blood glucose levels. The results showed that the test animals experienced hyperglycemia which began to appear from the 6th day after alloxan induction. At mice whose immune system is not strong are very at risk of death. So that mice must always be kept so that mice in the control group do not cause death.

Blood glucose levels on day 11, namely GDS after the treatment test, showed that there was a decrease in each group, but the greatest decrease in blood glucose levels occurred in the group with the administration of black cumin extract at a dose of 1.30 mg / 0.5 ml.

Based on the Saphiro Wilk normality test, the average blood glucose levels of all groups were normally distributed ($p > 0.05$). The homogeneity test showed that each group was homogeneous, continued with the One Way Anova statistical test, the results obtained a value of $p = 0.013$ ($p = < 0.05$) which means that there are changes in the average blood glucose levels in the three groups. Furthermore, tested with Post Hoc Tests with the LSD method, the results obtained showed that there was a significant difference in average blood glucose levels between group 1 with mice that were only given alloxan against group 2 with mice given a dose of black cumin extract 0.65 mg / 0.5 ml ($p = 0.038 *$) and group 3 with mice given a dose of black cumin extract 1.30 mg / 0.5 ml ($p = 0.004 *$), This happens because groups 2 and 3 are given black cumin extract which has an antihyperglycemia effect while having antioxidant activity and a protective effect on pancreatic beta cell damage due to alloxan and maintaining pancreatic cell integrity so that it can increase serum insulin levels can be seen from the results of in vitro studies conducted by El Daly (2008) which shows that black cumin extract can increase serum insulin levels. Meanwhile, in group 2 and group 3 ($p = 0.335$) there was no significant difference in average blood glucose levels, this is because mice in groups 2 and 3 were both given black cumin extract but with different doses (Rezeki, 2019; Rofiandy et al., 2019, 2019).

To find out more about the specifications of the average decrease in blood glucose levels in each group, the Paired Simple T Test was conducted, the results of this test in group 1 which is a control group where only given alloxan and after an increase in blood glucose levels then only given standard feed but experienced a significant decrease in blood glucose levels ($p = 0.000 *$). The increase in blood glucose levels / hyperglycemia conditions that occur in each group is caused by alloxan induction which has the ability to inhibit glucose-induced insulin secretion and produce pancreatic beta cell necrosis selectively (Banda et al., 2018; Lenzen, 2008).

The decrease that occurs in group 1 mice occurs because the diabetogenic effect of alloxan is not permanent and will decrease over time as evidenced in research conducted by Bo Ahren and Gordan Sundkvist which states that alosan causes a pronounced hyperglycemia effect in the first days but on day 15 after alloxan induction, blood glucose levels in mice decrease. In addition, the mice's own immune system also causes a decrease in blood glucose levels, although the process of decreasing is slower (Ahrén & Sundkvist, 1995; Pertiwi et al., 2021).

For the results of the Paired Simple T Test for group 2 mice given black cumin extract at a dose of 0.65 mg / 0.5 ml and group 3 mice given black cumin extract at a dose of 1.30 mg / 0.5 ml also showed a significant decrease in blood glucose levels ($p = 0.000 *$). However, the effect of black cumin in reducing blood glucose levels at a dose of 0.065 mg / 0.5 ml is not as effective as the dose of black cumin 1.30 mg / 0.5 ml. The results of this analysis indicate that the dose of 1.30 mg / 0.5 ml is the optimal dose in reducing blood glucose levels. This proves that there is a possibility of other substances in black cumin extract or the composition of substances in black cumin extract that affect the hypoglycemia effect at higher doses (Husna, 2008; Wadud, 2015).

The decrease in blood glucose levels in groups 2 and 3 was caused by black cumin which has a protective effect on pancreatic beta cells from damage caused by alloxan, black cumin is proven to help increase proliferation and assist in the regeneration of damaged pancreatic beta cells. Research conducted by Nefranindy which tested the effectiveness of black cumin extract on reducing blood glucose levels in two different groups showed significant results. Research by Alimohammadi et al, with Thymoquinone (TQ) given intragastrically to diabetic rats showed a significant effect in increasing insulin, besides that Alimohammadi et al gave 5 mg / kg of black cumin extract intraperitoneally to produce hypoglycemia effects and provide pancreatic beta cell protection. According to previous research, black cumin has the active ingredient thymoquinone as the main component in essential oil ($\pm 50\%$) which functions as an antioxidant also has the benefit of fighting oxidative effects or free radical electron chains produced by alloxan against the pancreas. In addition, the content of linoleic acid (PUFA) and oleic acid (MUFA) from the oil remains where PUFA has a protective effect on disorders of glucose tolerance and insulin insensitivity and MUFA has an effect in controlling glucose metabolism and can reduce insulin resistance (Fiscarina et al., 2022; Itsiopoulos et al., 2018; Rezeki, 2019; Rofiandy et al., 2019).

Mohtashami and Entezari's research showed a significant decrease in GDP and an increase in insulin in 41 people with type II DM who used black cumin oil therapy for 40 days.¹³ In addition, Hamdan, A. et al in their research proved that black cumin was proven to control diabetes by reducing significant fasting blood glucose levels and a significant increase in serum insulin, which research conducted by researchers shows that black cumin can be used as an adjuvant for oral antidiabetic drugs in controlling diabetes (Hamdan et al., 2019; Rofiandy et al., 2019).

Although black cumin extract has a hypoglycemia effect, at certain dose levels toxicity can occur so it is necessary to know with certainty about the safest and most effective dose to be used in treatment (Isnaeni, 2011; Stevani, 2016). According to research conducted by Abukhader using Wistar Albino rats that were given black cumin at a dose of 30 mg/kg and 40 mg/kg, they showed signs of toxicity such as lethargy, abdominal swelling, goosebumps (piloerection), irritability, and weight loss. The study also found that doses of 22.5 mg/kg and 15 mg/kg were the maximum doses of black cumin that could be tolerated by the body via the intraperitoneal route in male and female rats, respectively. When administered orally at doses of 500 mg/kg and 300 mg/kg, signs of toxicity such as dyspnea, abdominal distension, weight loss, diarrhea, and hypoactivity can be observed in rats (Farooq et al., 2021; Nuryadi et al., 2017).

Conclusion

Based on the results of research and discussion, it can be concluded that: 1) Blood glucose levels of mice with alloxan-induced hyperglycemia, before the administration of black cumin extract (*Nigella sativa* L) at a dose of 1.3 mg / 0.5 ml and 0.65 mg / 0.5 ml changed with an average blood glucose level before and after treatment in group 1 69.11 g / dL, group 2 by 113.44 g / dL and group 3 by 133.33 g / dL; 2) The results of the average blood glucose levels

of mice with hyperglycemia induced by alloxan experienced changes in average blood glucose levels after being given black cumin extract (*Nigella sativa* L). Black cumin extract at a dose of 1.30 mg / 0.5 ml showed more significant changes in blood glucose levels than black cumin extract at a dose of 0.65 mg / 0.5 ml.

Based on the research process that has been carried out, the researcher suggests: 1) Conduct further research related to the content in black cumin (*N. sativa*) that has the most influential effect on reducing blood glucose levels; 2) Conduct further research on the side effects of black cumin (*N. sativa*) extract; 3) Take more varied doses to get the best dose in lowering blood glucose levels; 4) Conduct further research regarding the toxicity effects that can arise from black cumin (*N. sativa*) extract.

References

- Ahrén, B., & Sundkvist, G. (1995). Long-term Effects of Alloxan in Mice. *International Journal of Pancreatology*, 17(2), 197–201. <https://doi.org/10.1007/BF02788539>
- Banda, M., Nyirenda, J., Muzandu, K., Sijumbila, G., & Mudenda, S. (2018). Antihyperglycemic and Antihyperlipidemic Effects of Aqueous Extracts of *Lannea edulis* in Alloxan-Induced Diabetic Rats. *Frontiers in Pharmacology*, 9. <https://doi.org/10.3389/fphar.2018.01099>
- Fadli, R. (2024, August 12). *Disebut Jintan Hitam, Ini 9 Manfaat Habbatussauda bagi Kesehatan*. Halodoc.Com.
- Fahmi, N. F., Firdaus, N., & Putri, N. (2020). Pengaruh Waktu Penundaan Terhadap Kadar Glukosa Darah Sewaktu dengan Metode Poct pada Mahasiswa. *Jurnal Nursing Update*, 11(2), 1–11.
- Farooq, J., Sultana, R., Taj, T., Asdaq, S. M. B., Alsalman, A. J., Mohaini, M. Al, Al Hawaj, M. A., Kamal, M., Alghamdi, S., Imran, Mohd., Shahin, H., & Tabassum, R. (2021). Insights into the Protective Effects of Thymoquinone against Toxicities Induced by Chemotherapeutic Agents. *Molecules*, 27(1), 226. <https://doi.org/10.3390/molecules27010226>
- Fiscarina, Makmun, A., Zulfiyah Surdam, Asrini Safitri, & Arsal, A. S. F. (2022). Uji Efektivitas Ekstrak Jintan Hitam Terhadap Penurunan Kadar Glukosa Darah pada Mencit yang Hiperglikemia. *Fakumi Medical Journal: Jurnal Mahasiswa Kedokteran*, 2(8), 573–577. <https://doi.org/10.33096/fmj.v2i8.109>
- Forouzanfar, F., Bazzaz, B. S. F., & Hosseinzadeh, H. (2014). Black Cumin (*Nigella sativa*) and Its Constituent (Thymoquinone): a Review on Antimicrobial Effects. *Iranian Journal of Basic Medical Sciences*, 17(12), 929–938.
- Gray, J. P., Zayasbazan Burgos, D., Yuan, T., Seeram, N., Rebar, R., Follmer, R., & Heart, E. A. (2016). Thymoquinone, a Bioactive Component of *Nigella Sativa*, Normalizes Insulin Secretion from Pancreatic β -Cells under Glucose Overload Via Regulation of Malonyl-CoA. *American Journal of Physiology-Endocrinology and Metabolism*, 310(6), E394–E404. <https://doi.org/10.1152/ajpendo.00250.2015>
- Hamdan, A., Haji Idrus, R., & Mokhtar, M. H. (2019). Effects of *Nigella Sativa* On Type-2 Diabetes Mellitus: a Systematic Review. *International Journal of Environmental Research and Public Health*, 16(24).
- Husna, M. (2008). *Pengaruh Pemberian Minyak Jinten Hitam (Nigella Sativa L.) Terhadap Kadar Glikosa Darah pada Tikus Putih Diabetes Akibat Induksi Aloksan*. Universitas Sebelas Maret.
- International Diabetes Federation. (2021). IDF Diabetes Atlas 10th Edition. *Diabetesatlas.Org*.

- Irdalisa, Safrida, Khairil, Abdullah, & Sabri, M. (2015). Profil Kadar Glukosa Darah pada Tikus Setelah Penyuntukan Aloksan Sebagai Hewan Model Hiperglikemik. *Jurnal EduBio Tropika*, 3(1), 1–50.
- Isnaeni, N. (2011). *Aktivitas Ekstrak Serbuk Jintan Hitam (Nigella Sativa L) Sebagai Upaya Preventif Hiperlipidemia: Uji Praklinik Secara In Vivo Pada Mencit yang Diinduksi Poloxamer*. Universitas Indonesia.
- Itsiopoulos, C., Marx, W., Mayr, H. L., Tatu-Babet, O. A., Dash, S. R., George, E. S., Trakman, G. L., Kelly, J. T., Thomas, C. J., & Brazionis, L. (2018). The Role of Omega-3 Polyunsaturated Fatty Acid Supplementation in the Management of Type 2 Diabetes Mellitus: a Narrative Review. *Journal of Nutrition & Intermediary Metabolism*, 14, 42–51. <https://doi.org/10.1016/j.jnim.2018.02.002>
- Lenzen, S. (2008). The Mechanisms of Alloxan- and Streptozotocin-Induced Diabetes. *Diabetologia*, 51(2), 216–226. <https://doi.org/10.1007/s00125-007-0886-7>
- Marlinda, L. (2015). Effectivity of Black Cumin Seeds Extract to Increase Phagocytosis. *J. Majority*, 4(3), 58–64.
- Mohebbati, R., & Abbasnezhad, A. (2020). Effects of Nigella sativa on Endothelial Dysfunction in Diabetes Mellitus: a Review. *Journal of Ethnopharmacology*, 252, 112585. <https://doi.org/10.1016/j.jep.2020.112585>
- Mouri, M., & Badireddy, M. (2023). Hyperglycemia. In *StatPearls [Internet]*. StatPearls Publishing.
- Nakrani, M. N., Wineland, R. H., & Anjum, F. (2020). *Physiology, Glucose Metabolism*. StatPearls Publishing.
- Nuryadi, Astuti, T. D., Utami, E. S., & Budiantara, M. (2017). *Dasar-dasar Statistik Penelitian* (Vol. 1). Sibuku Media.
- Pertiwi, M. B. B., Indahyani, D. E., & Praharani, D. (2021). Level Glukosa Darah pada Mencit Diabetes Setelah Pemberian Ekstrak Rumput Laut Coklat (Phaeophyta). *E-Journal Pustaka Kesehatan*, 9(2), 84–89. <https://doi.org/10.19184/pk.v9i2.12165>
- Prapurandina, N. (2010). *Efek Perseptif Jinten Hitam (Nigella Sativa L.) Sebagai Immunostimulan (Studi Kasus Di Wilayah Jakarta)*. Universitas Indonesia.
- Rejeki, P. S., Putri, E. A. C., & Prasetya, R. E. (2018). *Ovariektomi Pada Tikus dan Mencit* (Vol. 1). Pusat Penerbitan dan Percetakan Universitas Airlangga (AUP).
- Rezeki, I. N. (2019). The Role of Black Seed (Nigella sativa) as a Treatment for Diabetes Mellitus. *Jurnal Ilmiah Kesehatan Sandi Husada*, 8(2), 255–260. <https://doi.org/10.35816/jiskh.v10i2.157>
- Rofiandy, D. R., Sastra, H., & Indriyanti, A. (2019). Pengaruh Pemberian Ekstrak Air Biji Jinten Hitam Terhadap Kadar Glukosa Darah pada Mencit Model Diabetik. *Prosiding Pendidikan Dokter*, 5(1).
- Soelistijo, S. A., Lindarto, D., Decroli, E., Permana, H., & Sucipto, K. W. (2019). *Pedoman Pengelolaan dan Pencegahan Diabetes Melitus Tipe 2 Dewasa di Indonesia 2019*. PB Perkeni.
- Stevani, H. (2016). *Modul Bahan Ajar Cetak Farmasi: Praktikum Farmakologi*. Pusat Pendidikan dan Pelatihan Tenaga Kesehatan Kementerian Kesehatan RI.
- Wadud, S. A. (2015). *Uji Efektifitas Biji Jinten Hitam (Nigella sativa) Terhadap Pertumbuhan Bakteri Shigella dysenteriae*. UIN Syarif Hidayatullah Jakarta.