JURNAL PENDIDIKAN KIMIA (JPKIM)
ISSN: 2085-3653| e-ISSN: 2549-3116

J. Pendidik. Kim 2023, 15(1), 53 - 59
DOI 10.24114/jpkim.v15i1.42971

Research Article

Effect of ethanol leaf extract of *Plukenetia volubilis* on blood glucose and triglyceride levels of mice induced by alloxan

Dewi Handayani, Zahra Salsabila, Hermansyah Amir, Nurhamidah and Sura Menda Ginting

Chemistry Education Program, Bengkulu University, Bengkulu 38371, Indonesia

Received 28 January 2023 ♦ **Revised** 02 May 2023 ♦ **Accepted** 03 May 2023

Citation: Handayani, D., Salsabila, Z., Amir, H., Nurhamida, N., & Ginting, S. M. (2023). E Effect of ethanol leaf extract of Plukenetia volubilis on blood glucose and triglyceride levels of mice induced by alloxan. Jurnal Pendidikan Kimia (JPKIM), 15(1), 53–59. https://doi.org/10.24114/jpkim.v15i1.42971

Keywords

Alloxan
Glucose
Mice
Triglyceride
Plukenetia volubilis

Corresponding author:
E-mail: d.handayani@unib.ac.id
(Dewi Handayani)

Abstract

The study aims to determine the phytochemical profile of ethanol extract of kacang saca leaves and its effect on reducing blood glucose and triglyceride levels. Used 18 mice were divided into six groups, namely the normal group, the positive control group (glibenclamide treatment), the negative (alloxan induction), and the treatment group doses used were 0.0262 mg/dL, 0.0525 mg/dL, and 0.105. mg/dL. The treatment of mice was carried out for 10 days with three measurements, namely before treatment, on the 7th day, and on the 10th day of giving the extract. Phytochemical test results showed the presence of flavonoid compounds, alkaloids, steroids, saponins, and tannins. The data obtained were analyzed using the SPSS application. The results of the measurement of blood glucose levels in mice on the 7th day showed normal numbers, the results of data analysis showed no significant difference, namely 0.164. In the measurement of triglycerides, triglyceride levels fell in two groups, namely groups 1 and 3. Data on the 10th day there was an increase in blood glucose and triglycerides. Analysis of the data showed that there was no significant difference in each group on day 7 and day 10. The ethanol extract of cacao beans has the potential to reduce glucose levels used for 7 days but does not affect the triglyceride levels of mice.

Introduction

Diabetes mellitus is one of the most common diseases in Indonesia. The number of diabetics in Indonesia is 19,465 million in 2021 and the death rate due to diabetes has reached 236,711 people. Normal blood glucose value is 60-100 mg/dL and serum glucose, is 70-11- mg/dL. When the glucose level is greater than 180 mg/dL, glucosuria (sugar in the urine) can occur. The high blood sugar of more than 200 mg/dL can cause diabetes mellitus. Diabetes mellitus (DM) or diabetes is a disease in which blood sugar levels are high because the body cannot release or use insulin. As a fat-sparing hormone, insulin promotes lipogenesis while inhibiting lipolysis and lipid oxidation. Insulin promotes energy storage when food is plentiful (Huang et al. 2020).

Diabetes can cause complications to other diseases and is deadly, such as damage to the retina of the eye, nerve damage, heart disease, and stroke. Prolonged hyperglycemia can affect metabolic processes indirectly (Wahyudi et al. 2015). Diabetes mellitus and dyslipidemia are known to be very closely related, this condition is characterized by an increase in cholesterol and triglyceride levels (Muntafiah et al. 2017).

Dyslipidemia in diabetics is characterized by increased fasting and postprandial triglyceride levels, low HDL cholesterol, increased LDL cholesterol, and a predominance of dense LDL particles (Rasyid et al. 2018). Triglyceride (TG) is a lipid profile consisting of one glycerol molecule attached to three fatty acids. Triglycerides with cholesterol form blood fats. Triglycerides contain lots of Very Low-Density Lipoproteins (VLDL) and chylomicrons (Puspitasari and Aliviameita, 2018). Triglyceride levels in the blood are also affected by intake. Excessive intake of fats and carbohydrates can increase triglyceride levels in the blood (Ramadhani and Probosari, 2014).

Prevention and treatment of diabetes mellitus can be done in various ways, from application to consumption of drugs. One of the preventions of diabetes can be done by consuming herbal plants. Traditional medicines are increasingly in demand by the public because the plant-based ingredients are easy to obtain, easy to mix and the price is affordable, so the ingredients used must improve their quality and quality according to the needs of the community (Aminah et al. 2017).

One of the plants that have begun to be cultivated in Bengkulu province is the plant *Plukenetia volubilis* (Sacha inchi or saca nut) from the *Euphorbiaceae* family. Research data show that *Plukenetia volubilis* extract contains terpenoids, saponins, and phenolic compounds (flavonoids) which are known to have antioxidant, antiproliferative, and other activities (Nascimento et al. 2013). The utilization of the kacang saca plant focuses a lot on the part of the bean seed, one of which is the oil obtained from the bean part. Saca nut oil itself has been processed and marketed a lot because it has high economic value, it is used in various fields such as processed food, medicine to beauty products. Apart from processing the seeds of the cacao bean into oil, the seeds of this plant can also be consumed by frying or roasting as a snack. Part of the seed shell of this plant can also be used as a mixture of animal feed. The community has also started consuming the leaves of the kacang saca plant as tea which is believed to make the body healthier and can overcome diabetes.

The community has used the kacang saca plant for several parts of the plant, and the community has also begun to consume boiled water from the leaves of the kacang saca which is believed to be able to treat diabetes problems. However, there is currently no scientific research to prove this. Previous research on kacang saca leaf extract was conducted to determine the bioactive content in the leaf extract by Wang et al. (2018). In this study, further research was carried out regarding the effect of the content of kacang saca leaf extract on alloxan-induced decrease in glucose and triglyceride levels of mice.

Based on this description, the researchers conducted a study by observing the influence of Kacang saca (*Plukenetia volubilis*) leaf's ethanol etract on mice triglycerides (*Mus musculus*) Alloxan Induction. This research was conducted to determine the secondary metabolites in the ethanol extract of kacang saca leaves, the effect of giving the ethanol extract of kacang saca leaves on the blood glucose levels of mice, and triglyceride levels in the blood of mice.

Method

Materials

The sample used was the ethanol extract of Kacang saca leaves (*Plukenetia volubilis*) obtained from Bengkulu City using 18 male mice (*Mus musculus*) as test animal divided into 6 test groups.

Preparation of Kacang Saca Leaf Extract

The ethanol extract of kacang saca leaves (*Plukenetia volubilis*) was prepared using maseration method using 96% ethanol for 5 days of immersion. The filtered kacang saca leaves were repeated for 2 days. Separation of leaves and ethanol was carried out using filter paper. The filtrate obtained was evaporated using a rotary evaporator to obtain a thick extract. To remove the water content contained in the extract, the sample extract can be placed in a water bath.

Identification of Secondary Metabolities

Identification of secondary metabolites was carried out using the colour test reaction method to identify flavonoids, alkaloids, steroids, saponins, and tannins.

Treatment of the Test Animals

The treatment of the test animals was carried out on 6 test groups consisting of 18 mice divided into six groups, each of which was 3 mice per group. Distribution of 1 normal group, 1 positive control group, 1 negative control group, and 3 dose treatment groups.

Alloxan induction was carried out in the positive control group, negative control, and treatment group at a dose of 21 mg/kg BW mice (Asri, 2020; Simorangkir et al. 2022). The positive control group was given glibenclamide induction of 5 mg/kg BW. The dose treatment group was given doses of ethanol extract of kacang sacaleaves dose 1 (0.0262 g/kg BW), dose 2 (0.0525 g/kg BW), and dose 3 (0.105 g/kg BW).

Measurement of the test animals was carried out three times, before treatment, after treatment on day 7, and after treatment on day 10. Measurement of glucose levels was carried out using a glucometer and

measurement of triglycerides was carried out using lipid. Measurement of blood levels was carried out by taking samples by injuring the tail of the mice.

Data Analysis

Data analysis was performed statistically for linear regression analysis using the ANOVA analysis method using SPSS statistics IBM 21 Software.

Results and Discussion

The results of examining secondary metabolites in the ethanol extract of kacang saca leaves were obtained by carrying out a color reaction test. A total of 94 grams of macerated extract was obtained from 890 grams of simple kacang saca leaves. The results showed that the ethanol extract of kacang saca leaves positively contained flavonoids, alkaloids, steroids, saponins and tannins. The results of this study are the same as the results of the previous studies by Wang et al (2018), where kacang saca leaves positively contain bioactive compounds such as phenolic compounds (flavonoids). The results of examining secondary metabolites in the ethanol extract of kacang sacaleaves obtained the following data in Table 1.

Table 1. Secondary Metabolities of Plukenetia volubilis Leaf Extract

Test	Result	Description
Flavonoid	+	Red color change occurs
Alkaloid	+	Brown precipitate formed
Terpenoid	-	No change
Steroid	+	Green color change occurs
Saponin	+	Foam formed
Tannin	+	A dark green color change occurs

Description: (-) : negative; (+) : positive

The study was conducted using male mice (*Mus musculus*) weighing 25-40 grams. Male mice were chosen based on the consideration that male mice have lower estrogen hormones than female mice and have more stable hormones than female mice which experience hormonal changes due to pregnancy and lactation (Juwita et al. 2017).

Based on research conducted by Nugrahani (2012) showed blood glucose levels when fasting mice averaged 73 mg/dl – 96.6 mg/dl and in normal conditions ranged from 62.8 mg/dl – 176 mg/dl (Nugrahani, 2012). The results of measurements in the study were that the average blood glucose level of mice was less than 70 mg/dl.

The blood glucose data of the mice taken were the average amount of blood glucose taken on the 7th and 10th day of extract administration for each group (Table 2).

Table 2. Average Glucose Blood of *Mus musculus*

Group	Average Glucose Blood ± SD			
	Before being induced by Alloxan	Day-0	Day-7	Day-10
Positive (glibenclamide)	43±6.93	227.000±70.36	96.00±8.00	125.67±55.17
Group 1 (Dose 0.0262 g/kgBW)	52.33±12.34	189.33±35.92	107.33±26.72	136.00±57.55
Group 2 (Dose 0.0525 g/kgBB)	55.33±15.18	168.67±4.16	88.33±6.81	84.00±34.18
Group 3 (Dose 0.105 g/kgBB)	49.67±7.37	192.33±33.65	93.67±18.71	139.67±35.47

The data in Table 2 shows that the average blood glucose level of mice in the positive group induced by glibenclamide has decreased blood glucose levels and reached a normal state (<120 mg/dl). Giving glibencalmid as a positive control because glibenclamide is a drug which can stimulate insulin granules to release insulin so that it can reduce blood glucose levels. Glibenclamide upgrade insulin secretion by directly closing ATP-sensitive K+ channels in pancreatic β-cells, causing membrane depolarization, opening voltage-dependent Ca^{2+} channels, and causing influx and increase of intracellular Ca^{2+}, triggering insulin exocytosis (Zhou et al. 2019).

In the treatment group it was shown that mice had decreased blood glucose levels compared to before the administration of the extract, this indicated that administration of kacang saca leaves extract for 7 days affected a decrease in blood glucose levels. On the 10th day, the average blood glucose level of mice in the treatment group showed that in groups 1 and 3 the blood glucose of mice experienced an increase in blood glucose levels, while in group 2 glucose decreased blood glucose. This shows that the administration of kacang saca leaves extract for 10 days affects the increase in blood glucose levels.

Testing day 0 with the Kruskal-Wallis method because based on the normality and homogeneity tests the data on day 0 were not normally distributed and not homogeneous, the Asymp Sig value was obtained 0.838. Based on these data Table 3, significant results were obtained for the 7th and 10th days. On the 7th day the value of sig. 0.602 > 0.05 and on the 10th day the sig. 0.485 > 0.05, the average decision-making in each group with different doses is that there is no difference in the average for each group on day 7 and day 10. For data on day 0, the Kruskal-Wallis test is used. Based on the Kruskal-Wallis test data, the Asymp Sig value was obtained. 0.733 where the value is > 0.05 which means there is no difference in each group with different doses.

Table 3. ANOVA Data Analysis of Mice Blood Glucose Levels

Treatment	Sig.
Before alloxan induction	0.586
Day 7	0.602
Day 10	0.485

Normal mice blood glucose levels can be seen in Fig.-1 showing that normal group mice have an average blood glucose level of 65 mg/dl. This blood sugar is in a normal state and is based on observations of the physical condition and activity of mice under normal circumstances. In the treatment group (P1, P2, and P3) mice were given alloxan induction to increase blood sugar levels in mice. Alloxan works by destroying insulin production in pancreatic beta cells (Priyoherianto et al. 2021). The toxic effect of alloxan can damage insulin receptors and damage pancreatic beta cells. As a result of this damage, insulin cannot be produced normally, causing blood glucose to be taken up and used to be converted into energy, resulting in high blood glucose levels (Putri et al. 2014; Simorangkir et al. 2022).

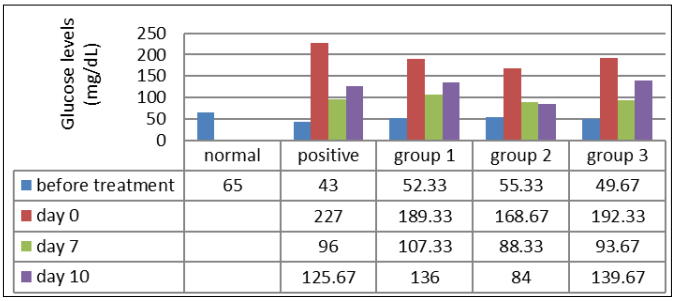

Fig.-1. Average Blood Glucose Levels of Mice

In Fig.-1, after being given alloxan induction treatment, there was an increase in blood glucose in mice. In the positive group with glibenclamide induction on the seventh day, there was a decrease in blood glucose reaching the normal limit of 96 mg/dL and an increase on the 10th day to 125.67 mg/dL. The dose of the extract treatment group decreased on the 7th day, respectively 107.33 mg/dL, 88.33 mg/dL, and 93.67 mg/dL.

Administration of ethanol extract of kacang saca leaves was able to reduce alloxan-induced blood glucose levels in mice, this was due to the presence of bioactive compounds contained in the ethanol extract of kacang saca leaves. The results of the phytochemical screening carried out showed that the ethanol extract of kacang saca leaves positively contained secondary metabolites, namely flavonoids, alkaloids, steroids, saponins, and tannins. Test of triglyceride levels in the blood of mice given kacang saca leaves extract for 10 days. Blood triglyceride levels were measured on the 7th and 10th day after administration of the leaves extract. The data obtained is as follows (Table 4).

Table 4. Average Triglyceride Blood of Mice

Group	Average TGL Blood ± SD		
	Day-0	Day-7	Day-10
Positive (glibenclamide)	78.33 ± 25.89	Lo (<50)	Lo (<50)
Group 1 (Dose 1)	77.33 ± 25.65	61.00 ± 10.58	76.67 ± 24.13
Group 2 (Dose 2)	77.67 ± 30.66	103.00 ± 71.43	70.33 ± 5.50
Group 3 (Dose 3)	113.00 ± 49.52	56.67 ± 13.27	163.67 ± 33.56

The data in Table 4 shows that the average triglyceride levels in the blood of mice on day 7 in the positive group induced by glibenclamide had decreased triglyceride levels and reached a normal state (<150 mg/dl). In the treatment group, groups 1 and 3 showed that the mice had decreased triglyceride levels, while in group 2

there was an increase in triglycerides compared to before giving the extract. This shows that administration of kacang sacaleaves extract for 7 days affects triglyceride levels in the blood.

Data on the 10th day showed the average triglyceride levels in the blood of mice in the treatment group, groups 1, and 3 showed that the mice had experienced an increase in triglyceride levels, while in group 2 there was a decrease in triglycerides compared to before administration of kacang saca leaves extract. This shows that giving kacang sacaleaves extract for 10 days affects triglyceride levels in the blood. The data obtained was then tested using ANOVA (Table 5), this test was carried out to compare the data on the results of the treatment of each group with different doses.

Table 5. ANOVA Data Analysis of Mice Triglyceride Blood Levels

Treatment	Sig.
Day 0	0.533
Day 10	0.001

On day 7, an analysis using Kruskal-Wallis was used because the data distribution was not normally distributed, the data obtained was 0.338. For the 10th day treatment, data <0.05 was obtained, so the Post Hoc test was carried out. The ANOVA test is a test to see if there is a difference in each group. The results of the Post Hoc test showed that the group showing the difference in mean was treatment group 3.

The results of the statistical analysis for the triglyceride level test on the 7th and 10th days were > 0.05, meaning that the average in each group with different doses was the same or there was no difference in each group. For the 10th day treatment, data were obtained <0.05 so that Post Hoc test. The ANOVA test is a test to see if there is a difference in each group. The results of the Post Hoc test showed that the group showing the difference in mean was treatment group 3.

Triglycerides are important as an energy source and after storage, act as an energy reserve as well as for insulation against cold weather (Nordestgaard, 2017). Triglyceride is a type of fat that makes up cholesterol and is one of the fats in the blood that is absorbed by the intestine after experiencing hydrolysis. Based on the research data, it was shown that mice that were subjected to alloxan induction treatment so that they experienced diabetes or hyperglycemia showed an increase in triglyceride levels in the blood mice. Patients with diabetes mellitus experience an increase in free fatty acids in the blood and the levels of these fatty acids are in line with the fluctuations in blood glucose levels, increased levels of free fatty acids in the blood will reduce tissue sensitivity to insulin which is related to triglyceride levels (Wardani et al 2015).

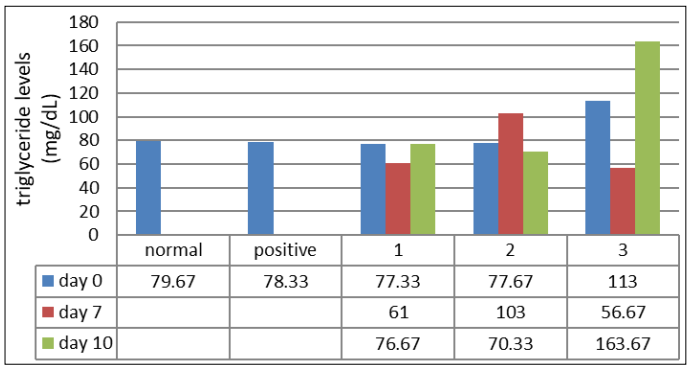

Fig.-2. Average Blood Triglyceride of Mice

This was shown in Fig.-2, the triglyceride levels of the mice before undergoing treatment or before being given alloxan induction which was within normal limits (<150 mg/dl). The results of measuring triglyceride levels in the positive group on days 7 and 10 showed Lo (<50 mg/dL), these results indicated that triglyceride levels were lower than 50 mg/dL so Lipidpro could not be detected.

After being given the alloxan induction treatment, mice that had diabetes showed an increase in blood triglyceride levels when compared to the condition before the treatment, with an average of 77.33 mg/dl, 77.67 mg/dl, 113 mg/dl, and 78.33 mg/dl. Blood glucose levels have a significant relationship with increased blood fat levels (Arifin et al. 2019). There is a relationship between blood glucose levels and blood triglyceride levels in mice. If carbohydrates that enter the body exceed the need for energy or are stored as glycogen, the excess carbohydrates will be converted into triglycerides and stored in adipose tissue (Siregar and Makmur, 2020).

Conclusion

Secondary metabolite compounds of kacang saca leaves extract are flavonoids, alkaloids, steroids, saponins, and tannins. These secondary compounds of ethanol extract of kacang saca leaves was proven to reduce blood glucose levels in mice by administering it for 7 days, treatment of ethanol extract of kacang saca leaves had no effect on decreasing blood triglyceride levels of mice. The treatment of ethanol extract of kacang saca leaves for more than 7 days may cause side effects due to increased levels of glucose and triglycerides and organ damage in mice given ethanol extract of kacang saca for 10 days.

Acknowledgments

This research was carried out with a grant Fundamental Research from the LPPM Universitas Bengkulu (Contract Number: 2014/UN30.15/PP/2022).

Conflict of Interests

The author (s) declares that there is no conflict of interest in this research and manuscript.

References

Aminah, A., Tomayahu, N., & Abidin, Z. (2017). Penetapan kadar flavonoid total ekstrak etanol kulit buah alpukat (Persea americana Mill.) dengan metode spektrofotometri UV-Vis. *Jurnal Fitofarmaka Indonesia*, 4(2), 226-230. https://doi.org/10.33096/jffi.v4i2.265

Arifin, A. Y., Ernawati, F., & Prihatini, M. (2019). Hubungan kadar glukosa darah terhadap peningkatan kadar lemak darah pada populasi studi kohor kecamatan Bogor Tengah 2018. *Jurnal Biotek Medisiana Indonesia*, 8(2), 87-93. https://doi.org/10.22435/jbmi.v8i2.2721

Asri, R. (2020). Pengembangan e-modul pengaruh ekstrak kebiul solid lipid nanoparticle terhadap glukosa darah mencit untuk meningkatkan kemampuan berpikir kritis mahasiswa. Tesis. FKIP Program Pascasarjana S2 Pendidikan IPA, Universitas Bengkulu. Bengkulu.

Huang, Z., Huang, L., Waters, M. J., & Chen, C. (2020). Insulin and growth hormone balance: Implications for obesity. *Trends in Endocrinology & Metabolism*, 31(9), 642–654. https://doi.org/10.1016/j.tem.2020.04.005

Juwita, R., Saleh, C., & Sitorus, S. (2017). Antihyperuricemia activity test from green leaf of plant red bud (Syzygium myrtifoliumwalp.) to male mice (Mus musculus). *Jurnal Atomik*, 2(1), 162-168.

Muntafiah, A., Yulianti, D., Cahyaningtyas, A. H., & Damayanti, H. I. (2017). Pengaruh ekstrak jahe merah (Zingiber officinale) dan madu terhadap kadar kolesterol total tikus model diabetes melitus. *Scripta Biologica*, 4(1), 1-3. https://doi.org/10.20884/1.sb.2017.4.1.329

Nascimento, A. K. L., Melo-Silveira, R. F., Dantas-Santos, N., Fernandes, J. M., Zucolotto, S. M., Rocha, H. A. O., & Scortecci, K. C. (2013). Antioxidant and antiproliferative activities of leaf extracts from Plukenetia volubilis Linneo (Euphorbiaceae). *Evidence-Based Complementary and Alternative Medicine*, 2013, 1–10. https://doi.org/10.1155/2013/950272

Nordestgaard, B. G. (2017). A test in context: lipid profile, fasting versus nonfasting. *Journal of the American College of Cardiology*, 70(13), 1637–1646. https://doi.org/10.1016/j.jacc.2017.08.006

Nugrahani, S. S. (2012). Root, stem and leaf extract on meniran to reduce blood glucose level. *KEMAS: Jurnal Kesehatan Masyarakat*, 8(1), 51-59.

Priyoherianto, A., Ratih Suci, P., Cahya Fatimah, P. R., & Wijayanti, A. N. (2021). Uji aktivitas antidiabetes kombinasi ekstrak etanol daun eceng gondok (Eichhornia crassipes (Mart.) Solms) dan daun sintrong (Crassocephalum crepidioides (Benth.) S. Moore) pada mencit. *Jurnal Insan Farmasi Indonesia*, 4(1), 44–53. https://doi.org/10.36387/jifi.v4i1.602

Puspitasari, P., & Aliviameita, A. (2018). Relationship between lipid profile and blood glucose levels in diabetes mellitus patients. *Medicra (Journal of Medical Laboratory Science/Technology)*, 1(2), 77-83. https://doi.org/10.21070/medicra.v1i2.1831

Putri, D. K. S. C., Hermanto, B., & Wardani, T. (2014). Effect of infusum salam leaves (Eugenia polyantha) on blood glucose level on the rat (Rattus norwegicus) in alloxan induced. *Veterinaria Medika*, 7(1), 7-16.

Ramadhani, A., & Probosari, E. (2014). Perbedaan kadar trigliserida sebelum dan setelah pemberian sari bengkuang (Pachyrrhizus erosus) pada wanita, Dissertation, Universtas Diponerogo. Jawa Tengah.

Rasyid, N. Q., Muawanah, M., dan Rahmawati, R. (2018). Gangguan dislipidemia pada pasien diabetes mellitus. *In Seminar Nasional Hasil Penelitian & Pengabdian Kepada Masyarakat*, p. 149-152.

Simorangkir, M., Sinaga, E., & Silaban, S. (2022). Hepatoprotective and histological pancreas effects of Sarang Banua (Clerodenrum fragrans Vent Willd) leaf extract in alloxan-induced diabetic rats. *Rasayan Journal of Chemistry*, 15(3), 1846-1854. http://doi.org/10.31788/RJC.2022.1536979

Simorangkir, M., Sinaga, E., Pasaribu, R., & Silaban, S. (2022). Antidiabetic activity of leaf extract of Clerodenrum fragrans Vent Willd in Rattus novergicus induced by alloxan. *Jurnal Bioteknologi & Biosains Indonesia (JBBI)*, 9(1), 119-125. https://doi.org/10.29122/jbbi.v9i1.5264

Siregar, F. A., & Makmur, T. (2020). Metabolisme lipid dalam tubuh. *Jurnal Inovasi Kesehatan Masyarakat*, 2020, 1(2), 60-66. https://doi.org/10.36656/jikm.v1i2.293

Wahyudi, T., Widyastuti, S. K., & Suarsana, I. N. (2015). Profil lipoprotein plasma tikus dalam kondisi hiperglikemia. *Indonesia Medicus Veterinus*, 4(2), 116-121.

Wang, S., Zhu, F., & Kakuda, Y. (2018). Sacha inchi (Plukenetia volubilis L.): Nutritional composition, biological activity, and uses. *Food Chemistry*, 265, 316–328. https://doi.org/10.1016/j.foodchem.2018.05.055

Wardani, E., Sunaryo, H., Sopiani, M. Z., & Fatahillah, M. (2015). Aktivitas antihypertrigliserida dan antihiperglikemik ekstrak daun kelor (Moringa oleifera Lam.) pada tikus hipergliserida diabetes. *Media Farmasi*, 12(2), 199-212. http://dx.doi.org/10.12928/mf.v12i2.3759

Zhou, J., Kang, X., Luo, Y., Yuan, Y., Wu, Y., Wang, M., & Liu, D. (2019). Glibenclamide-Induced Autophagy Inhibits Its Insulin Secretion-Improving Function in β Cells. *International Journal of Endocrinology*, 2019, 1–8. https://doi.org/10.1155/2019/1265175