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Comparison of Postprandial Blood Sugar Levels After Consuming Green Tea and Black Tea *(Camellia sinensis (L.))*

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ABSTRACT

Background: Blood glucose levels are the amount of glucose content in blood plasma. Blood glucose levels are influenced by the amount of food consumed, weight gain and age, stress and emotional factors, and exercise. Increased blood glucose levels (hyperglycemia) have the potential to cause the risk of Diabetes Mellitus. Preventing hyperglycemia can usually be achieved with diet, exercise and the use of appropriate medication. The use of chemical drugs has side effects if consumed continuously. An alternative that can be done is to consume tea (*Camellia sinensis*) which has one function as an antidiabetic. The polyphenol content in tea is reported to slow sugar absorption by inhibiting α-amylase and α-glucosidase in vitro and in vivo. The polyphenol content in tea can regulate blood glucose levels.

Objective: This research was conducted to compare the effectiveness of black tea and green tea in controlling postprandial blood glucose.

Materials and Method: Experimental study with a quasi-experimental research design. Sampling was taken using purposive sampling based on inclusion and exclusion criteria. This study used 48 subjects aged 18-23 years who were divided into 3 groups who were treated by consuming 200 ml of green tea solution, black tea and a control group consuming mineral water.

Results: Comparison of postprandial blood glucose levels between groups that had consumed green tea and black tea on day 3 with a value of p=0.027 and on day 7 with a value of and p=0.002 ($p<0.05$).

Conclusion: It is known that postprandial blood glucose levels are lower in the group consuming green tea compared to the group consuming black tea. However, both have the effect of lowering blood glucose levels

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I. INTRODUCTION

According to the International Diabetes Federation (IDF) Diabetes Atlas in 2021 reported that 10.5% of the adult population (aged 20-79 years) suffers from diabetes, and almost half do not realize that they suffer from the disease. Without preventative action, the IDF predicts that by 2045 there will be 1 in 8 adults living with diabetes. This shows an increase of 46% or around 783 million people.[1] Based on data available in the IDF, the population is 179 million people in Indonesia, the prevalence of people suffering from diabetes is 10.8% with 19 million cases of diabetes in adult.[2]

Diabetes mellitus (DM) is a disease caused by lack of control over blood glucose levels.[3] Diabetes mellitus is characterized by blood glucose levels that are too high (hyperglycemia) which is caused by damage to pancreatic β cells, resulting in the inability to produce insulin or due to impaired sensitivity. insulin in peripheral tissues thereby inhibiting cells from utilizing glucose.[4] Postprandial glycemic control is important to prevent diabetes and delay its complications. Postprandial plasma glucose levels are determined by the amount and rate of digestion of carbohydrates consumed. Therefore, one therapeutic approach

to control postprandial hyperglycemia is to inhibit digestion and delay subsequent absorption of dietary carbohydrates.

Dietary carbohydrates are digested by α-amylase in the small intestine to produce oligosaccharides and disaccharides, which are then hydrolyzed by α-glucosidase to produce monosaccharides.

Preventive measures such as inhibiting α-amylase and α-glucosidase activity are strategies for managing type 2 diabetes because reduced glucose production effectively suppresses postprandial hyperglycemia.[5]

One drink that has become world famous is tea. Tea has many health benefits such as antioxidant, anti-cancer, hepatoprotective, cardioprotective, anti-obesity, improving intestinal flora, and antidiabetic effects. It is known that tea has many bioactive components, especially polyphenols such as cathecins and flavonoids, which have the potential to reduce the risk of diabetes mellitus.[6]

Research conducted by Isono et al (2021) shows the effect of black tea on postprandial blood glucose and insulin levels. The results showed that consumption of black tea after rice intake significantly reduced additional glucose and insulin compared with placebo drinks. In vitro in this study it was also stated that black tea inhibited the activity of α-glucosidase, sucrase, and αamylase.[5] Meanwhile, according to Widowati et al (2018), the polyphenol content of green tea is able to regulate blood glucose levels. The regulation of carbohydrate digestive enzymes, especially the enzymes a-amylase and aglucosidase in the small intestine, can be inhibited by polyphenols contained in green tea.[7] Based on this background, research was conducted to compare postprandial blood sugar levels after consuming various types of tea, especially green tea and black tea (*Camellia sinensis* (*L.*)) which are widely consumed by the public.

II. MATERIALS AND METHODS

This type of research is experimental research with a quasi-experimental design which has a control group, but cannot fully function to control external variables that influence the implementation of the experiment. The research method uses pre-test and post-test techniques. Research participants were preclinical students at the Faculty of Dentistry, Prof. Dr. Moestopo (B) University Jakarta Indonesia are men and women aged 18-23 years who have met the inclusion criteria, namely not having systemic diseases, not taking medication, not doing heavy physical activity before the examination, not regularly consuming tea and not smoking.

The research subjects, totaling 48 people, were divided into 3 groups, namely Group 1 who were given a 200 ml green tea solution @Kepala Djenggot, Group 2 who were given a 200 ml black tea solution @Tong Tji and Group 3 who were given a black tea solution @Tong Tji, the control group consumed 200 ml of mineral water.

Subjects had their postprandial blood sugar levels measured (2 hours after eating) 3 times using an *autocheck* glucometer, namely before treatment, after treatment on days 3 and 7 for a duration of 15 minutes after the subjects consumed green tea, black tea and mineral water. Ethical approval for this research was issued by the Health Research Ethics Committee, Faculty of Dentistry, Prof. DR. Moestopo (B) University Jakarta Indonesia, with number:101/KEPK/FKGUPDMB)/VI/2024.

Research data was analyzed using SPSS software. Postprandial blood glucose levels will be presented in numerical form on a mg/dL scale. Data will be tested first with the *Shapiro Wilk* test because the sample size is <50. If the data distribution is normal then statistical analysis is carried out using the parametric *One-way ANOVA* test, whereas if the data distribution is not normal then the non-parametric *Kruskal-Wallis* test is carried out. *Post Hoc Games-Howell* and *Bonferroni Post Hoc* test to see significant differences between pairs of treatment groups studied. Differences between groups are declared significant if the p value <0.05. All tests were carried out with a 95% confidence level ($\propto$= 0.05).

III. RESULTS AND ANALYSIS

The research results obtained by comparing postprandial blood sugar levels after consuming green tea and black tea (*Camellia sinensis (L.*)), are as follows:

Table 1. Group Normality Test Results Before Treatment, Day 3 and Day 7 After Treatment.

Blood Glucose Measurement	Treatment Sig.	Sig.	Number of Samples
Before Treatment	Green tea	0.99	16
	Black tea	0.861	16
	Control	0.156	16
Day 3 After Treatment	Green tea	0.131	16
	Black tea	0.252	16
	Control	0.102	16
Day 7 After Treatment	Green tea	0.115	16
	Black tea	0.200	16
	Control	0.000	16

The results of the normality test (Table 1) show that the data before treatment and the 3rd day after treatment have a significance value of p>0.05 so it can be concluded that the data is normally distributed. Data on the 7th day after treatment found p = 0.000 in the control group, so because one group did not meet the requirements (p>0.05), the data in the group 7 days after treatment was considered not normally distributed.

Based on the normality test of the three data, hypothesis testing will continue using parametric statistical tests on the group before treatment and on the 3rd day after treatment, namely with the *One-way ANOVA* test to determine whether there is a significant difference in blood glucose values. before and after treatment in the group consuming green tea and black tea. On day 7, the group will continue with a non-parametric statistical test, namely the *Kruskal-Wallis* test, to

find out whether there is a significant difference between the groups consuming green tea and black tea. The difference in the average blood glucose values of the three groups for each measurement can be seen in Table 2.

Table 2. Average Blood Glucose Values for the Three Groups for Each Measurement

Treatment Group	Average Blood Glucose Before Treatment (mg/dL)	Average Blood Glucose Day 3 After Treatment (mg/dL)	Average Blood Glucose Day 7 After Treatment (mg/dL)
Green tea	105.44	83.56	76.69
Black tea	83.50	99.25	87.94
Control (Mineral Waters)	94.38	91.75	92.88

Based on the calculation of average blood glucose in Table 2, it shows that there was a significant decrease in average blood glucose in the group that consumed green tea. This decrease can be seen from the 3rd day of green tea consumption with a difference of -21.88, namely from 105.44 mg/dL to 83.56 mg/dL. On day 7, the green tea group also experienced a decrease from the average on day 3, namely 83.56 mg/dL to 76.69 mg/dL on day 7 (difference -6.87). Meanwhile, in the black tea treatment group, the average blood glucose value before treatment was actually lower than on the 3rd day after treatment, namely from 83.50 mg/dL to 99.25 mg/dL
(difference +15.75). In the black tea group, there was a decrease in the average blood glucose value from day 3 to day 7, namely from 99.25 mg/dL to 87.94 mg/dL (difference -11.31). For the control group (mineral water) it can be seen that there was a decrease in blood glucose since before treatment and after day 3, namely -2.63, namely from 94.38 mg/dL to 91.75 mg/dL. Meanwhile, on day 7, the blood glucose test result was 92.88, which was higher than day 3. Based on the data above, it can be concluded that on average there was a decrease in blood glucose levels in the green tea and black tea groups.

Data that had been carried out by the ShapiroWilk normality test showed that the data before treatment and the data on day 3 after treatment were normally distributed, then statistical analysis was carried out using the *One-way ANOVA* test. A treatment can be said to be significantly different between groups if the p value is <0.05. The results of the *One-way ANOVA* test can be seen in Table 3 below:

Table 3. Results of *One-way ANOVA* test on groups before treatment.

Treatment Group	Average (SD)	Number of Samples	Sig.
Green tea	105.44 (23.997)	16	0.003
Black tea	83.50 (9.041)	16	
Control (Mineral Waters)	94.38 (15.331)	16	

Based on the results of the *One-way ANOVA* test in Table 3, it shows that the three groups before treatment had a significant value of p<0.05, so further data calculations can be carried out using the Post Hoc test which can be seen in Table

Table 4. *Post Hoc Games-Howell* Test Results in the Pre-Treatment Group.

Group 1	Group 2	Number of Samples	Sig.
Green tea	Black tea	16	0.008
Green tea	Control	16	0.284
Black tea	Control	16	0.056

Based on the *Post Hoc Games-Howell* test in Table 4, the results showed that before treatment, the green tea group was significantly different from black tea with a significance value of 0.008. For the green tea group and the control group, it has a significance value of 0.284. For the black tea group and the control group, it has a significance value of 0.056.

Table 5. *One-way ANOVA* test results for groups on the 3rd day after treatment.

Treatment Group	Average (SD)	Number of Samples	Sig.
Green tea	83.56 (11.063)	16	0.032
Black tea	99.25 (15.097)	16	
Control (Mineral Waters)	91.75 (21.101)	16	

The results of the *One-way ANOVA* test in Table 5 state that the three groups 3 days after treatment have a significance value of p<0.05, so further data calculations can be carried out using the *Post Hoc Bonferroni* test.

Table 6. *Post Hoc Bonferroni* Test Results for the 3rd Day Group After Treatment.

Group 1	Group 2	Number of Samples	Sig.
Green tea	Black tea	16	0.027
Green tea	Control	16	0.486
Black tea	Control	16	0.598

The results of the *Bonferroni Post Hoc* Test in Table 6 show that the significance value for the green tea group and the black tea group is 0.027 (P<0.05), which means they are significantly different. The green tea group compared to the control group had a significance value of 0.486, while the black tea group compared to the control group had a significance value of 0.598 (p>0.05).

The results of the normality test on the comparison of blood sugar levels on the 7th day after treatment showed that the distribution was not normal at p<0.05 (see Table 1). So for the 7th day group, the *Kruskall-Wallis* test was carried out.

Table 7. Results of the *Kruskall-Wallis* test in the 7th day group after treatment.

Treatment Group	Average (SD)	Number Samples	of Sig.
Green tea	76.69 (7.587)	16	0.000
Black tea	87.94 (10.363)	16	
Control (Mineral Waters)	92.88 (16.182)	16	

Based on the *Kruskall Wallis* test in Table 7, the p value = 0.000. Because the p value <0.05, there is at least a difference between the two groups. To find out these differences, a post hoc test is needed. The *Post Hoc* test for Kruskal Wallis is *Mann-Whitney*.

Table 8. *Mann-Whitney Post Hoc* Test Results for the 7th Day Group After Treatment.

Group 1	Group 2	Number of Samples	Sig.
Green tea	Black tea	16	0.002
Green tea	Control	16	0.000
Black tea	Control	16	0.539

Based on the Mann-Whitney Post Hoc test in Table 8, it was found that the results of the differences 7 days after treatment between the black tea and green tea groups were significantly different with a value of p = 0.002 (p<0.005). The green tea group and the control group were also significantly different with a value of p = 0.000 (p<0.05). The black tea group and the control group were not significantly different because p = 0.539 (p>0.05).

IV. DISCUSSION

Blood glucose is sugar found in the blood which is formed from carbohydrates in food and stored as glycogen in the liver and skeletal muscles. Blood sugar levels are the amount of glucose content in blood plasma. Blood glucose levels are influenced by the amount of food consumed, weight gain and age, stress and emotional factors, and exercise.[8] Blood glucose levels are maintained through gluconeogenesis and glycogenolysis. A decrease in blood glucose levels, called hypoglycemia, can disrupt brain function, resulting in dizziness and loss of consciousness. On the other hand, blood glucose levels that are too high in the blood, called hyperglycemia, can also have a bad impact because this condition is related to diabetes.[9] According to the American Diabetes Association and the Centers for Disease Control and Prevention, normal blood glucose levels based on the results of an oral glucose tolerance test are <140. mg/dL, fasting <100 mg/dL, and postprandial (2 hours after fasting) ≤ 140 mg/dL. If the blood glucose level is more than this number, then a person can be said to be suffering from prediabetes and diabetes.[10]

There are three main causes of elevated blood sugar levels: 1) problems with the pancreas, which can cause low blood sugar or abnormal insulin release; 2) increased liver glucose due to increased gluconeogenesis; and 3) obstruction of glucagon, catecholamines, and insulin in tissues, thereby interfering with the flow and digestion of glucose.[11] Postprandial glycemic control is important to prevent diabetes and/or delay its complications. The easiest way to prevent hyperglycemia is to control blood glucose levels within the normal range. Management focuses on keeping blood sugar levels as normal as possible, without causing hypoglycemia. This can usually be achieved with diet, exercise, and the use of appropriate medications.[12]

According to the World Health Organization (WHO), in 2030 Indonesia will be ranked number 4 in the world behind India, China and the United States, with a total of 21.3 million people suffering from DM.[13] Based on data from the Basic Health Study (Riskesdas) 2018 shows that the prevalence of risk factors for type 2 diabetes in children aged 5-18 years in 2013 was 10.8% of children, which increased to 18.8% in 2018. 2018. *Riskesdas* noted that the prevalence of diabetes mellitus increases at the age of 5-18 years (Indonesian Ministry of Health, 2018).[14] Most diabetes mellitus patients consistently use chemical drugs which of course have side effects if consumed continuously. Therefore, it is important to continue to look for substitutes or alternatives to these chemical drugs so that they can reduce their side effects.[13]

Tea (*Camellia sinensis*) has been a part of human culture for thousands of years and remains a staple drink in many countries today. As a popular drink throughout the world, tea has many bioactivities and health benefits, such as antioxidant, anticancer, hepatoprotective, cardioprotective, anti-obesity, improving
intestinal flora, and antidiabetic effects.[15]

Green tea is produced from the fresh leaves of Camellia sinensis and has played an important role in medicine throughout history, especially in Asian countries. Green tea contains a variety of effective compounds, including antioxidants, vitamins, carbohydrates, proteins, minerals, and flavonoid-like polyphenols, which may be beneficial in preventing diabetes. The most prominent effect of green tea on human health is mainly due to the content of catechins, which belong to the family of flavonoid-like polyphenols. The four main catechins found in green tea extract are epicatechin (EC), epigalloc catechin (EGC), epicatechin gallate (ECG), and epigallocationchin gallate (EGCG).[16]

Black tea is produced from fresh leaves of
Camellia sinensis. Black tea is one of the most widely consumed drinks in the world. During the oxidation process, the polyphenols contained in tea leaves, namely catechins, are enzymatically converted into a number of polymerized

polyphenols including theaflavins and thearubigen. The health benefits of black tea are found in its polyphenol content, namely antioxidant, anti-inflammatory, anticancer and antihypertensive effects. In vitro research states that black tea extract can interfere with carbohydrate absorption because it has the ability to inhibit the α-amylase, α-glucosidase, and sodium-glucose transporters. Another study also stated that black tea extract also induced carbohydrate malabsorption by 25% in healthy adult research volunteers.[12]

Based on the type of tea and its benefits, research was conducted to compare the effectiveness of black tea and green tea in controlling blood glucose. The experimental study used 48 subjects who were divided into 3 groups treated with green tea and black tea, 16 people in the group who consumed water as the control group. The research subjects were Faculty of Dentistry, Prof. Dr. Moestopo (B) University Jakarta Indonesia students with an age range of 18-23 years, 7 male subjects and 41 female subjects. Blood sugar measurements were carried out postprandial on the 3rd and 7th days after tea consumption. Based on the research results, it was found that on the third day, there was a decrease in postprandial blood glucose levels in the green tea group compared to black tea with a value of p=0.027 (P<0.05). However, when compared with the control group, neither black tea nor green tea had a significant difference on day 3 with a value of p=0.486 in the green tea group and control, and in the black tea group and control p=0.598 (P>0.05) . On the 7th day, blood glucose levels were also measured and the results were significant between the black tea and green tea groups with a value of p=0.002 (P<0.05). In the green tea group and the control group there was also a significant difference with a value of p=0.000 (p<0.05). In the black tea group and the control group, there was no significant difference with a value of p=0.539 (P>0.05).

The results showed that consumption of green tea had a significantly greater effect in reducing postprandial blood glucose levels compared to black tea and controls with mineral water. Although from the average it can be seen that there was a slight decrease in postprandial blood glucose levels in the black tea group on day 7 compared to day 3 with a difference of 11.31mg/dL. The results of this research are in line with research conducted by Diana Holidah et al. (2018), who compared green tea, black tea and the oolong. The research results showed that green tea was the greatest in reducing blood glucose by 59.68%. This shows that green tea extract has higher α-glucosidase enzyme inhibitory activity compared to black tea.[13]

Flavanols or what are known as catechins form three different classes, namely flavan-3-ol, flavan4-ol, and flavan-3,4-diol. Among these three classes, the one that was recorded to have anti-αglucosidase and anti-α-amylase activity simultaneously was the catechin structure of the flavan-3-ol group. Taking into account the inhibition of α-glucosidase, this catechin compound is considered to be able to competitively inhibit this digestive enzyme as strongly as standard drugs.[17]

Based on the composition of tea, between green tea and black tea, green tea contains more catechins than black tea. Catechins in green tea inhibit glucose uptake, and epicatechin gallate inhibits SGLT1, which is the largest glucose transporter in the intestine. Black tea contains more polyphenols such as theaflavins and thearubigen than green tea. These polymerized polyphenols have been reported to reduce sugar absorption by inhibiting α-amylase and αgluosidase both in vitro and in vivo, with theaflavins showing the strongest inhibitory effect. Theaflavins are also reported to be the main source of α-glucosidase inhibition among black tea polyphenols.[5,18]

Several research reports have found the effect of consuming green tea for controlling blood glucose, namely that consuming green tea regularly every day can control type 2 diabetes mellitus. In a retrospective cohort study conducted in Japan, it was found that individuals who drank 6 cups of green tea or more per day had a 33% lower risk of further developing type 2 diabetes when compared with individuals who consumed less than one cup per week. In research conducted in Indonesia by Anoto et al. (2024), stated that there was a difference of 44,920 mg/dL between patients who consumed green tea and those who did not. This means that green tea can significantly reduce blood glucose levels.[11]

Research has been conducted on black tea which can also lower blood sugar levels, although not as significantly as green tea. In this study, participants who consumed black tea experienced a decrease in postprandial blood glucose levels on day 7 by 11.31 mg/dL compared to day 3. This is in line with research on Chinese people at risk of diabetes who consumed black tea showing a 45% reduction in the risk of diabetes.[19] In research conducted by Holidah et al. (2018) stated that blood glucose levels decreased in the black tea group by 50.88% compared to oolong tea
41.06%.[13] This research was carried out in vitro to determine the inhibition of α-glucosidase between black tea, turmeric and ginger, it was found that tea Black tea inhibits α-glucosidase more than turmeric and ginger, which both contain polyphenols.[20] Based on research and several other studies that have been carried out, it can be found that both black tea and green tea both have the effect of lowering blood glucose levels. This is because the presence of catechins and polyphenols in tea can inhibit the work of α-glucosidase in the intestine so that glucose metabolism can be inhibited.

CONCLUSIONS

Based on research and data analysis that has been carried out regarding the comparison of consumption of green tea and black tea (Camellia sinensis L.) on postprandial blood glucose levels, it can be concluded that the ratio of consumption of green tea and black tea is 0.027 on the 3rd day and 0.002 on the third day 7th. Postprandial blood glucose levels were lower in the group consuming green tea compared to the group

consuming black tea. So it can be concluded that green tea and black tea both have an effect in lowering blood glucose levels.

REFERENCES

I. https://idf.org/about-diabetes/diabetes-factsfigures/ accessed on 28/04/24 pukul 11:14.

II. https://idf.org/our-network/regions-andmembers/western-pacific/members/indonesia/ accessed on 28/4/24 pukul 11:18.

III. Sapra A, Bhandari P. Diabetes. [Updated 2023 Jun 21]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. tersedia di: https://www.ncbi.nlm.nih.gov/books/NBK551501/ [diakses pada 17 November 2023]

IV. Sholikah TA, Wulandari S, Ariesta I, Hakim MA, Hafizhan M. The hypoglicemic effects of tapak liman (Elephantopus scaber L) plant extract on albino rat (Rattus novergicus) models of diabetes mellitus. Jurnal Kedokteran dan Kesehatan Indonesia. 2020;11(2):172-179.

V. Isono Y, Watanabe H, Kumada M, Takara T, Iio SI. Black tea decreases postprandial blood glucose levels in healthy humans and contains highmolecular-weight polyphenols that inhibit αglucosidase and α-amylase in vitro: a randomized, double blind, placebo-controlled, crossover trial. Functional Foods in Health and Disease. 2021 Mei 12;11(5):222-37.

VI. Meng JM, Cao SY, Wei XL, Gan RY, Wang YF, Cai SX, Xu XY, Zhang PZ, Li HB. Effects and mechanisms of tea for the prevention and management of diabetes mellitus and diabetic complications: An updated review. Antioxidants. 2019 Jun 10;8(6):170.

VII. Widowati W, Sanndra F, Mozef T, Rizal, Rihibiha DD, Laksmitawati DR, Sumitro SB, Widodo MA. Teh manfaat bagi kesehatan. Yogyakarta: Rumah Pengetahuan; 2018:16,52,244,30-31.

VIII. Hantzidiamantis PJ, Awosika AO, Lappin SL. Physiology, Glucose. 2022 Sep 19. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 PMID:31424785.

IX. Chandel NS. Carbohydrate metabolism. Cold Spring Harbor perspectives in biology. 2021 Jan 1;13(1):a040568.

X. American Diabetes Association. Newly Diagnosed with Diabetes. Tersedia di:https://diabetes.org/living-with-diabetes/newlydiagnosed

XI. Anoto DA, Basuki SP, Setiyabudi R. Efektifitas Pemberian Konsumsi Teh Hijau terhadap Penurunan Gula Darah Diabetes Melitus Tipe 2

XII. (DMT2)". Jurnal Ilmiah Permas: Jurnal Ilmiah STIKES Kendal. 2024;14(2):479-88.

XIII. Butacnum A, Chongsuwat R, Bumrungpert A. Black tea consumption improves postprandial glycemic control in normal and pre-diabetic subjects: A randomized, double-blind, placebocontrolled crossover study. Asia Pacific journal of clinical nutrition. 2017 Jan;26(1):59-64.

XIV. Holidah D, Yasmin Y, Christianty FM. Uji aktivitas antidiabetes ekstrak teh hitam dan teh hijau secara in vitro menggunakan metode inhibisi enzim α-glukosidase. Pustaka Kesehatan. 2018 May 4;6(2):235-9.

XV. Agustina R, Puspita M, Widiawati S. Gambaran glukosa darah pada anak remaja di MAN Kota Jambi. Science: Indonesian Journal of Science. 2024 Jul 12;1(2):72-7.

XVI. Meng JM, Cao SY, Wei XL, Gan RY, Wang YF, Cai SX, Xu XY, Zhang PZ, Li HB. Effects and mechanisms of tea for the prevention and management of diabetes mellitus and diabetic complications: An updated review. Antioxidants. 2019 Jun 10;8(6):170.

XVII. Xu R, Bai Y, Yang K, Chen G. Effects of green tea consumption on glycemic control: a systematic review and meta-analysis of randomized controlled trials. Nutrition & Metabolism. 2020 Dec;17:1-3.

XVIII. Lam TP, Tran NV, Pham LH, Lai NV, Dang BT, Truong NL, Nguyen-Vo SK, Hoang TL, Mai TT, Tran TD. Flavonoids as dual-target inhibitors against α-glucosidase and α-amylase: a systematic review of in vitro studies. Natural Products and Bioprospecting. 2024 Dec;14(1):4.

XIX. Kodagoda KH, Wickramasinghe I. Health benefits of green and black Tea: A Review. International Journal of Advanced Engineering Research and Science. 2017;4(7):237217.

XX. Anggraini, Tuti. Proses dan Manfaat Teh. Erka: Padang. 2017. ISBN: 978-602-6506-37-5. 1-2.

XXI. Hasan AE, Andrianto D, Rosyidah RA. Uji Penghambatan α-Glukosidase dari Kombinasi

XXII. Ekstrak Kunyit, Teh Hitam dan Jahe: The αGlucosidase Inhibition Test from a Combination of Turmeric Extract, Black Tea, and Ginger. Jurnal Agroindustri Halal. 2022 Apr 27;8(1):137-46.