INHIBITION OF α-GLUCOSIDASE ACTIVITY AND THE TOXICITY OF *Tristaniopsis merguensis* Griff. LEAF EXTRACT

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Abstract: This study aims to determine the antidiabetic activity and toxicity of the acetone extract of *Tristaniopsis merguensis* Griff leaf. The antidiabetic test was the α-glucosidase inhibition method, while the toxicity test used the Brine Shrimp Lethality Test (BSLT) method. The acetone extract possessed antidiabetic activity with an IC$_{50}$ value of 8.83 ± 0.31 (μg/mL). This value is not much different from the positive control of quercetin which has an IC$_{50}$ value of 6.04 ± 0.14 (μg/mL). The characteristics of the FT-IR spectrum of acetone extract showed that *Tristaniopsis merguensis* leaf has the groups Ar-OH (phenolic), -OH (hydroxyl), C=O (ketone) and C=C (aromatic). Based on the toxicity test, the *Tristaniopsis merguensis* leaf acetone extract has an LC$_{50}$ value of 959.25 ppm which means that the acetone extract is toxic. Therefore, the acetone extract of *Tristaniopsis merguensis* might be the potential agent of antidiabetic.

Keywords: Inhibition of α-glucosidase, acetone extract, *Tristaniopsis merguensis* Griff., Brine Shrimp Lethality Test, BSLT

Abstrak: Penelitian ini bertujuan untuk mengetahui aktivitas antidiabetes dan toksisitas dari ekstrak aseton daun *Tristaniopsis merguensis* Griff. Uji aktivitas antidiabetes ditentukan berdasarkan metode inhibisi enzim α-glucosidase, sedangkan toksisitas ditentukan berdasarkan metode Brine Shrimp Lethality Test (BSLT). Ekstrak aseton memiliki aktivitas antidiabetes dengan nilai IC$_{50}$ 8,83 ± 0,31 (μg/mL). Nilai ini tidak jauh berbeda dari kontrol positif quersetin yang memiliki nilai IC$_{50}$ 6,04 ± 0,14 (μg/mL). Karakteristik spektrum FT-IR ekstrak aseton menunjukkan bahwa daun *Tristaniopsis merguensis* memiliki gugus fungsi Ar-OH (fenolik), -OH (hidroksil), C=O (keton) dan C=C (aromatik). Berdasarkan uji toksisitas, ekstrak aseton daun *Tristaniopsis merguensis* memiliki nilai LC$_{50}$ sebesar 959,25 ppm yang berarti bahwa ekstrak aseton bersifat toksik. Oleh karena itu, ekstrak aseton dari *Tristaniopsis merguensis* berpotensi untuk dijadikan agen antidiabetes.

Kata kunci: Inhibisi α-glucosidase, ekstrak aseton, *Tristaniopsis merguensis* Griff., Brine Shrimp Lethality Test, BSLT
Introduction

The *Tristaniopsis merguensis* Griff in Bangka Belitung is known as the Pelawan tree. This tree has been used by many people of Bangka to get Pelawan honey and Pelawan mushrooms. Based on reports from the people of Bangka, mushrooms and honey Pelawan has several properties as a cough and diabetes medicine. Besides, the main composition of the Pelawan tree is the phenolic composition. Phenolic compounds, in general, have good antioxidant activity. Based on the research of Verotta *et al*., (2001) secondary metabolites of the genus *Tristaniopsis* containing tannins 1.04%, flavonoids 0.03% saponins 0.95%. The majority of the secondary metabolite of the genus *Tristaniopsis* is phenolic compounds such as tannins and flavonoids. Phenolic compounds generally have certain biological activities.

In Indonesia, diabetes mellitus type 2 is a chronic disease that is increasing every year. This disease is caused by many factors, such as food, diet, physical activity, and age (Kahn, 1996). One of treatment diabetes mellitus is inhibiting the performance of the α-glucosidase enzyme. This enzyme contributes to breaking down carbohydrates into glucose. If the inhibition of the enzyme α-glucosidase, blood sugar levels can be reduced. Therefore, α-glucosidase (AGI) enzyme inhibitors are needed.

Acarbose is one of the synthetic α-glucosidase inhibitors, but it has been reported to cause many side effects such as gastrointestinal and hepatic problems (Feng, 2011). Long-term use can increase levels of glutamate oxalate transaminase and or glutamate pyruvate transaminase in 15% of patients using acarbose (Sun *et al*., 2017). Therefore, the development of α-glucosidase inhibitors from natural ingredients is needed to reduce the side effects of synthetic drugs such as acarbose.

In recent years, many studies of α-glucosidase inhibitors derived from natural compounds. It has been reported that antioxidant compounds with high IC₅₀ such as flavonoids, alkaloids, terpenoids, anthocyanins, glycosides, and phenolics have α-glucosidase inhibitor properties (Kumar, 2011). One of the active compound as antioxidants and α-glucosidase inhibitors is the phenolic group such as ellagitannin. *Terminalia chebula* Retz. identified as containing ellagitannins such as chebulanin, chebulagic acid, and chebulinic acid. These compounds are proven to be potent α-glucosidase inhibitors (Goa, 2008). On the other hand, bark extracts from *Tristaniopsis calobuxus* (*Myrtaceae*) also contain many phenolic compounds, such as ellagic acid, (+)-gallocatechin, (-)-gallocatechin, and (-)-epigallocatechin (Bellosta, 2003). The acetone extract of *T. merguensis* leaf itself has been reported to have a total phenolic content of 215.22 mg gallic acid equivalent (GAE) /g dry extract and IC₅₀ value of 22.1454 µg /mL (Roanisca *et al*., 2019). The high content of phenolic and antioxidant *T. merguensis* leaves is also expected to have an impact on its antidiabetic activity.
with the hope that in the future it can be used as herbal medicine. One indicator of the efficacy of herbal drugs is knowing their toxicity. Therefore, *T. merguensis* which is a superior plant in Bangka Belitung is expected to know the antidiabetic activity and toxicity.

**Research Methods**

**Materials and Tools**

The materials used in this study included the leaves of *T. merguensis*, methanol p.a Merck, technical acetone, enzyme α-glucosidase from *Saccharomyces cerevisiae* (EC 3.2.1.20), quercetin dihydrate, dimethyl sulfoxide (DMSO) p.a. Merck, p-nitrophenyl-α-D-glucopyranoside, seawater, KBr, Na₂CO₃ Merck, Na₃HPO₄ Merck, NaH₂PO₄ Merck, *Artemia salina*, and filter paper. While the tools used in this study included erlenmayer, rotary vacuum evaporator glass IKA RV-10, measuring, Büchner funnel, dropper, test tube, spatula, measuring flask, analytical balance, stirring rod, test tube rack, hot plate, UV-Vis spectrophotometer 1800 Shimadzu, and FT-IR spectrophotometer thermolyne.

**Extract Preparation**

*T. merguensis* leaf samples were from Kimak Village, Bangka Regency. The sample was dried for two weeks in the open air and avoided to be exposed to direct sunlight. Then the leaf samples ware mashed into dry powder. The dried powder of the leaves was taken 1 kg and macerated using 10 L acetone solvent for 3 x 24 hours. Every 1 x 24 hours, a change of solvent was made on the same powder. The filtrate obtained was evaporated with a vacuum rotary evaporator until thick acetone extract was obtained (Mahardika & Roanisca, 2018). The characteristic of *T. merguensis* extract was based on FT-IR spectrum measurements.

**α-Glucosidase Inhibition Activity**

Antidiabetic activity testing was carried out based on enzymatic reactions in vitro from Dewi *et al.*, 2013. This test begins with the preparation of reagents such as phosphate buffer pH 7.0 from Na₂HPO₄ and NaH₂PO₄ solution, making 4 mg p-nitrophenyl-α-D-glucopyranoside solution, preparation of α-glucosidase enzyme, and making 0.2 mg Na₂CO₃ solution. Extract samples were dissolved in 1 mL DMSO at various concentration. The concentrations were 7.5; 5; 2.5; and 1 μg/mL. Inhibition of α-glucosidase activity was carried out by adding a 5 μL test solution with p-nitrophenyl-α-D-glucopyranoside as much as 250 μL and phosphate buffer pH 7.0 M as much as 495 μL. This solution was homogenized and preincubated for 5 minutes at 37°C. The reaction started with the addition of 250 μL of α-glucosidase solution (0.062 units), which was dissolved in a pH 7.0 phosphate buffer. Incubation was continued for 15 minutes. The reaction was stopped by adding 1 mL of Na₂CO₃ 0.2 M. Enzyme activity was measured at λ
400 nm from the absorbance of p-nitrophenol. Measurements were made three times. The positive control used quercetin as a comparison (Dewi et al., 2013).

The percentage of inhibition was determined based on the following equation 1:

\[ \% \text{ inhibition} = \frac{(C-S)}{C} \times 100 \]

Where, C= blank absorbance (DMSO)
S= Sample absorbance (the difference between absorption with and without enzymes)

Inhibition of the sample against concentration was plotted to get a straight line equation. The strength of inhibition was expressed in IC\textsubscript{50} values. This value was obtained from the value of x with y = 50 from the results of the linear equation.

**Toxicity Test**

This toxicity test is based on the Brine Shrimp Lethality Test (BSLT) method. Preparation of the test solution was carried out, making 1000 ppm by dissolving 50 mg extract in seawater 50 mL. Its solution was diluted with various concentrations of 5, 10, 20, 40, 50, 100, 125 ppm. Then a vial tube was prepared, then put a test solution from each concentration variation of 10 ml and 10 larvae of *A. salina* are added. 2 days old until. Each concentration was calculated as the percentage of larvae that died within 24 hours and compared with a control solution using seawater. Toxicity is determined by looking at the LC\textsubscript{50} value that can kill *A. Sanila* larvae up to 50% through the calculation of probit analysis (probability unit) (Albuntana et al., 2011).

**FTIR Analysis**

FT-IR analysis is based on the KBr pellet method. The dried extract was mixed in KBr then made pellets using manual pressing (Shimadzu). Furthermore, it was analyzed using an FT-IR thermolyne spectrophotometer (Purwakusumah et al., 2014).

**Results and Discussion**

**Inhibition of α-Glucosidase Activity**

Antidiabetic activity is carried out in vitro by the α-glucosidase enzyme inhibition method. A-glucosidase inhibition is one approach to reduce postprandial hyperglycemia, thereby delaying glucose absorption and controlling hyperglycemia in diabetic patients (Dewi et al., 2013). The ideal of the antidiabetic compound must have hypoglycemic properties. Therefore in-vitro testing of inhibition of this enzyme can be used as a reference in antidiabetic screening. The results of this test are shown in Table 1. Measurement of inhibition was carried out three times at each concentration.
Antidiabetic testing of acetone extract of *Tristaniopsis merguensis* leaves has antidiabetic activity with an IC50 value of 8.83 ± 0.31 μg/mL. This value is not much different from the positive control quercetin, which has an IC50 value of 6.04 ± 0.14 μg/mL. Quercetin is a phenolic compound with a class of flavonoids that has been reported to actively inhibit the enzyme α-glucosidase, which plays a role in controlling blood sugar (Khuankaew, 2014). The smaller the IC50 value, the better the activity of the compound.

**Table 2. The Activity of α-glucosidase enzyme inhibition from Myrtaceae Extract**

| No. | Sample                        | Solvent     | IC50 (μg/mL) |
|-----|-------------------------------|-------------|--------------|
| 1.  | *Tristaniopsis merguensis*     | Acetone     | 8.83±0.31    |
| 2.  | *Syzygium sumatranum* (Myrtaceae) (Saraswati, 2010) | Methanol    | 13.99        |
| 3.  | *Syzygium hyntum* (Myrtaceae) (Saraswati, 2010) | Methanol    | 23.38        |
| 4.  | *Syzygium paucifunctatum* (Myrtaceae) (Saraswati, 2010) | Methanol    | 12.69        |
| 5.  | *Eugenia jambolana* (Myrtaceae) (Ahmed et al., 2009) | Distilled water | 68.3± 1.4    |
| 6.  | *Psidium guajava* (Myrtaceae) (Nkobole et al., 2011) | Acetone     | 62.7 ± 0.19  |
| 7.  | *Syzygium cumini* (Myrtaceae) (Saraswati, 2010) | Methanol    | 8.17         |

*T. mergensis* is included in the *Myrtaceae* family. Based on the α-glucosidase inhibition test on plants in one family such as *S. sumatranum, S. hyntum, S. paucifunctatum, S. Cumini, P. Guajava,* and *E. jambolana* (Table 2), the α-glucosidase inhibition activity of *T. merguensis* leaf extract in this study was better than the antidiabetic activity of methanol in *S. sumatranum, S. hyntum, S. paucifunctatum,* and *P. Guajava* acetone extracts, and water extracts from *E. jambolana*. But the antidiabetic activity in this study was no better than the methanol extract in *S. Cumini*. Ethanol extract *S. cumini* itself has been reported to contain many active compounds that are preventing degenerative diseases such as antidiabetic (Sari et al., 2018). When compared with plants in one family *Myrtaceae*, the acetone extract of *T. merguensis* leaves has the potential as an antidiabetic.
Extract Characterization Based on FT-IR Analysis

The acetone extract of *T. merguensis* Griff was obtained by the functional group analysis using FT-IR spectrophotometer. FT-IR spectrum of acetone extract of *T. merguensis* leaves is shown in Figure 1 and Table 3.

![FT-IR spectrum of acetone extract of *T. merguensis* leaves](image)

Figure 1. FT-IR spectrum of acetone extract of *T. merguensis* leaves

The wavenumber at 3316 which broad at 3400-3100 cm\(^{-1}\) is a vibration -OH stretching group-broadband due to the interaction of hydrogen bonds. The -OH group may be derived from phenols (Ar-OH), aromatics from phenols are shown to have wavenumber at 751 cm\(^{-1}\). In addition, the absorption of C-H aromatic stretching uptake, which is generally located at 3160-3050 cm\(^{-1}\) may be overlap with the -OH group. The presence of aromatic compounds is also supported by the appearance of wavenumber at 1609 cm\(^{-1}\) which is vibrations of C=C stretching. Based on this analysis, the acetone extract of *T. merguensis* is thought to contain aromatic compounds such as phenolic compounds or polyphenols (Roanisca *et al.*, 2019).

Table 3. Vibration mode of functional groups from FT-IR Spectrum

| Wavenumber (cm\(^{-1}\)) | Vibration Mode                      |
|--------------------------|------------------------------------|
| 3316                     | -OH stretching                     |
| 2951                     | \(\text{CH}_3\) stretching, asymmetric \(\text{CH}_2\) stretching |
| 1713                     | C=O stretching                     |
| 1609                     | C=C aromatic stretching            |
| 1449                     | \(\text{CH}_2\) bending             |
| 1329                     | C-H bending                        |
| 1018                     | C-O alcohol stretching             |
| 747                      | C-H aromatic bend                  |
Based on this spectrum, *T. merguensis* extract contains CH$_3$ (methyl) and CH$_2$ (methylene) groups which are shown wavenumber at 2951 cm$^{-1}$ which is the vibration of CH$_3$ stretching and asymmetric CH$_2$ stretching (Maobe *et al.*, 2013). This is also supported by the wavenumber 1449 to 1329 cm$^{-1}$ which is the vibration of CH$_2$ bending and C-H bending. Therefore, the extract of *T. merguensis* contains methyl and methylene groups.

In addition, the extract of *T. merguensis* also contains a group C=O (carbonyl) is characterized by the appearance of wavenumber 1713 cm$^{-1}$. It is thought to be the wavenumber of the ketone carbonyl group. It is because there are no wavenumber 1280-1150 cm$^{-1}$ which is a characteristic of the C-O-C ester group, or the absence of a wavenumber of about 2800 cm$^{-1}$ which is a characteristic of C-H aldehydes.

Based on FTIR spectrum data analysis (Figure 1), *T. merguensis* extract contains compounds that have Ar-OH (phenolic), -OH (hydroxyl), C = O (ketone) and C=C (aromatic) groups. The results of Mahardika & Roanisca (2019) study, phytochemical *T. merguensis* leaf extract contains alkaloids, tannins and flavonoids. When compared to the phytochemical test, it is assumed that the signal comes from the compound.

**Toxicity Test**

In this study, the toxicity test was carried out using the Brine Shrimp Lethality Test (BSLT) method. This test was treated on the *T. merguensis* acetone extract. BSLT test results were performed by calculating the percentage of *Artemia salina* larvae mortality against acetone extract of *T. merguensis* leaves. The results are shown in Table 4. The greater the extract concentration, the higher the percentage of *A. salina* deaths.

| Concentration (ppm) | Mortality (%) | Log of Concentration | Probit Value |
|---------------------|--------------|----------------------|--------------|
| 5                   | 10           | 0.699                | 3.72         |
| 10                  | 10           | 1.000                | 3.72         |
| 20                  | 15           | 1.301                | 3.96         |
| 40                  | 20           | 1.602                | 4.16         |
| 50                  | 20           | 1.699                | 4.16         |
| 100                 | 30           | 2.000                | 4.48         |
| 125                 | 30           | 2.097                | 4.48         |
| 0                   | 0            | 0                    | 0            |

Determination of toxicity is based on probit analysis by determining the linear line equation between log concentration (x) and probit value (y). The linear equation obtained is used to determine the concentration of death of 50% *A. salina*
The results of the *T. merguensis* leaf extract test had an LC$_{50}$ value of 959.252 ppm. LC$_{50}$ values between 30-1000 ppm are categorized as toxic; it is mean that *T. merguensis* leaf extract is toxic (Ningdyah, Alimuddin, & Jayuska, 2015). The value of R$^2$ (coefficient of determination) obtained is 0.9552 which means that 95.52% of deaths can be caused by changes in the concentration of *T. merguensis* extract (Dhone et al., 2018). When compared with species in one family (*Myrtaceae*), the toxicity of *T. merguensis* extract is lower than the ethanol extract of *Syzygium samarangense* and ethyl acetate of extract *Eugenia uniflora* with LC$_{50}$ values of 170.01 ppm and 79.43 ppm (Swantara et al., 2016).

*A. salina* absorbs compounds in the leaves of *T. merguensis* through the digestive tract. This absorption process through the cell membrane. Then the toxicity compound from the extract enters the cell, causing a failure in the metabolism of *A. salina*. The increased concentration of the extract can cause many toxic compounds to spread widely in the body of *A. salina* so that it can cause death. This metabolic failure can cause death and can be observed within 24 hours to cause the death of 50% *A. salina* (Ningdyah et al., 2015).

**Conclusions**

Based on the results of the study, the antidiabetic testing of the acetone extract of *T. merguensis* has antidiabetic activity with an IC$_{50}$ value of 8.83 ± 0.31 (μg / mL). This value is not much different from the positive control, quercetin which has an IC$_{50}$ value of 6.04 ± 0.14 (μg / mL). The characteristics of functional groups from the acetone extract of *T. merguensis* using FTIR that have the Ar-OH (phenolic), -OH (hydroxyl), C= O (ketone) and C = C (aromatic) groups. Based on the toxicity test, the acetone extract of *T. merguensis* leaves has an LC$_{50}$ value of 959.252 ppm which means that the acetone extract is toxic. Therefore, the acetone extract of *T. merguensis* leaves has the potential as an antidiabetic.

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**References**

Ahmed, F., Jnns, C., & Nv, T. (2009). An In Vitro Study on the inhibitory Activities of *Eugenia jambolana* Seeds Against Carbohydrate Hydrolyzing Enzymes. *J .Young Pharm.*, 1(4), 317–321. https://doi.org/10.4103/0975-1483.59320

Albuntana, A., Yasman, & Wardhana, W. (2011). Toxicity test of extracts of the four sea cucumber (*Family holothuriidae*) from East Penjaliran island, Seribu Islands, Jakarta based on the brine shrimp lethality test (BSLT).
Inhibition of α-Glucosidase Activity and The Toxicity of *Tristaniopsis merguensis* Griff. Leaf Extract

**Journal Ilmu Dan Teknologi Kelautan Tropis**, 3(1), 65–72.

Dewi, R. T., Tachibana, S., & Darmawan, A. (2013). Effect on α-glucosidase inhibition and antioxidant activities of butyro lactone derivatives from *Aspergillus terreus* MC751. *Medicinal Chemistry Research*, 23(1), 454–460. https://doi.org/10.1007/s00044-013-0659-4

Dhone, B. S., Cunha, T., & Darmakusuma, D. (2018). Uji toksisitas ekstrak karang lunak sarcophyton sp asal timor terhadap larva artemia salina leach. *Chem. Notes*, 1(1), 32–40.

Enggiwanto, S., Istiqomah, F., Daniati, K., Roanisca, O., & Mahardika, R. G. (2018). Ekstraksii daun pelawan (*Tristaniopsis merguensis*) sebagai antioksidan menggunakan Microwave Assisted Extraction (MAE). *Indonesian Journal of Pure and Applied Chemistry*, 1(2), 50–55.

Feng, J. Y.-W. (2011). Bio-assay guided isolation and identification alpha-glucosidase inhibitors from the leaves of *Aquilaria sinensis*. *Phytochemistry*, 72, 242-247.

Goa, H. H. (2008). α-Glucosidase inhibitory effect by the flower buds of Tussilago farfara L. *Food Chemistry*, 106, 1195-1201.

Kahn, C. R. (1996). Genetics of non-insulin-dependent (type-II) diabetes mellitus. *Annu. Rev. Med.*, 104, 509-31.

Khuankaew, S. S. (2014). Ethnobotanical study of medicinal plants used by Tai Yai in Northern Thailand. *Journal of Ethnopharmacology*, 151, 829-938.

Kumar, S. N. (2011). Alpha-glukosidase inhibitors from plants: A natural approach to treat diabetes. *Pharmacognosy Reviews*, 5, 19-29.

Mahardika, R. G., & Roanisca, O. (2018). Antioxidant activity and phytochemical of extract ethyl acetate pucuk idat (*Cratoxylum glaucum*). *Indo. J. Chem. Res.*, 5(2), 481–486.

Mahardika, R. G., & Roanisca, O. (2019). Microwave-Assisted Extraction of polyphenol content from Leaves of *Tristaniopsis merguensis*. *ASEAN Journal of Chemical Engineering*, 19(2), 110–119. https://doi.org/10.22146/ajche.50448

Maobe, M. A. G., Nyarango, R. M., & Box, P. O. (2013). Fourier Transformer Infra-Red Spectrophotometer Analysis of Urtica dioica Medicinal Herb Used for the Treatment of Diabetes, Malaria and Pneumonia in Kisii Region, Southwest Kenya. *World Applied Sciences Journal*, 21(8), 1128–1135. https://doi.org/10.5829/idosi.wasj.2013.21.8.2876

Ningdyah, A. W., Alimuddin, A. H., & Jayuska, A. (2015). Uji toksisitas dengan metode BSLT (Brine Shrimp Lethality Test) terhadap hasil fraksinasi ekstrak kulit buah tampoi. *Jurnal Kimia Katulistiwa*, 4(1), 75–83.

Nkobole, N., Houghton, P. J., Hussein, A., & Lall, N. (2011). Antidiabetic Activity of *Terminalia sericea* Constituents. *Natural Product Communications*, 6(11), 1585–1588. https://doi.org/10.1177/1934578X1100601106

Purwakusumah, E. D., Rafi, M., Syafitri, U. D., Nurcholis, W., Agung, M., & Adzkiya, Z. (2014). Identification and Authentication of Jahe Merah Using Combination of FTIR Spectroscopy and Chemometrics. *AGRITECH*, 34(1), 82–87.

Roanisca, O., Mahardika, R. G., & Sari, F. I. P. (2019). Total Phenolic and
Antioxidant Capacity of Acetone Extract of *Tristaniopsis meguensis* Leaves. *Stannum: Jurnal Sains Dan Terapan Kimia*, 1(1), 10–13.

Roanisca, O., Mahardika, R. G., & Setiawan, Y. (2019). *Tristaniopsis meguensis* Griff. Extract as Inhibitor for Corrosion of Stainless Steel *IOP Conference Series: Earth and Environmental Science*, 353 012020. https://doi.org/10.1088/1755-1315/353/1/012020

Saraswaty, V. (2010). Alpha Glucosidase Inhibitory Activity From *Syzigium* sp. *Teknologi Indonesia*, 33(1), 33–37.

Sari, A. N., Kusdianti, & Diningrat, S. D. (2018). Analisis Gc-Ms Senyawa Bioaktif Pencegah Penyakit Degeneratif Dari Ekstrak Etanol Kulit Buah Jamblang (*Syzygium cumini*). *Elkawnie: Journal of Islamic Science and Technology*, 4(2), 1–14. https://doi.org/10.22373/ekw.v4i2.4143

Sun, W., Sang, Y., Zhang, B., Yu, X., Xu, Q., Xiu, Z., & Dong, Y. (2017). Synergistic effects of acarbose and an Oroxylum indicum seed extract in streptozotocin and high-fat-diet induced prediabetic mice. *Biomedicine et Pharmacotherapy*, 87, 160–170. https://doi.org/10.1016/j.biopha.2016.12.096

Swantara, I. M. D., Rita, W. S., Made, I., & Suardhyana, A. (2016). Toksisitas senyawa flavonoid dari ekstrak etanol daun dewandaru (*Eugenia uniflora* Linn.) Sebagai skrining awal antikanker. *Jurnal Kimia*, 10(2), 181–189.

Verotta, L., Agli, M. D., Giolito, A., Guerrini, M., Cabalion, P., & Bosisio, E. (2001). In Vitro Antiplasmodial Activity of Extracts of *Tristaniopsis* Species and Identification of the Active Constituents: Ellagic Acid and 3, 4, 5-Trimethoxyphenyl- (6’- O-galloyl) - O- - D-glucopyranoside. *Journal of Natural Product*, 64(5), 603–607.