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Plant Anatomy of *Smallanthus sonchifolius* (Poepp) H. Rob and *Tithonia diversifolia* (Hemsl) A.Gray as a Function of Reducing Sugar Content

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ABSTRACT

The number of people with diabetes mellitus worldwide is on the rise; according to the 11th edition (2024/2025) of the International Diabetes Federation (IDF) Diabetes Atlas, approximately 19.5–20.4 million people are living with diabetes. The plants *Smallanthus sonchifolius* and *Tithonia diversifolia* are used by the community because they can lower blood sugar levels. The objective of this study is to distinguish the macroscopic and microscopic identification characteristics of as well as the chemical compound identification characteristics. Research Method: Pure experimental method macroscopic characterization, microscopic characterization, and chemical testing of the plants *Smallanthus sonchifolius* and *Tithonia diversifolia* . Results and Discussion Macroscopic Identification Characterization *Smallanthus sonchifolius* and *Tithonia diversifolia* have taproots, round stems, are succulent and woody, and have wavy-edged leaves arranged in opposite pairs or scattered. Microscopic characterization include the presence of calcium oxalate. The chemical composition of the leaves, stem bark, and roots contains saponins, polyphenols, flavonoids, and alkaloids—antioxidants that can improve insulin sensitivity.Conclusion: Macroscopic identification characteristics of *Smallanthus sonchifolius* and *Tithonia diversifolia*: taproot with a tuber; taproot of without a tuber; round, woody stems; serrated-edged leaves; opposite and scattered leaf arrangement. Microscopic identification characteristics of *Smallanthus sonchifolius* : presence of Ca-oxalate; *Tithonia diversifolia* : Ca-oxalate not found. Chemical identification characteristics of: contains saponins, flavonoids, polyphenols, and alkaloids.

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1. Introduction

Diabetes mellitus is a metabolic disorder characterized by hyperglycemia a condition in which a person's blood sugar (glucose) levels rise above normal limits and impaired metabolism of carbohydrates, fats, and proteins, which is caused by reduced insulin secretion or reduced insulin sensitivity, or both (Ministry of Health Regulation, 2025). Diabetes mellitus is a chronic metabolic disorder characterized by hyperglycemia caused by impaired insulin secretion, resistance to insulin action, or both. This prolonged hyperglycemia is the basis for various complications that occur (Malek et al., 2023; Saeedi et al., 2019). Currently, the number of people with diabetes mellitus worldwide is increasing. The prevalence of diabetes in Indonesia has risen significantly over the past decade, in line with increases in obesity, unhealthy lifestyles, and high-sugar diets (Ministry of Health Regulation, 2025).

According to the 11th edition of the International Diabetes Federation (IDF) Diabetes Atlas (2024/2025), approximately 19.5–20.4 million Indonesian adults will be living with diabetes by 2025. This figure indicates that approximately 1 in 10 adults in Indonesia will have diabetes by 2025 (IDF Report, 2024/2025). The government ranks Indonesia as one of the countries with the highest number of people with diabetes in the world (fifth highest). China is the country with the largest number of adults living with diabetes in the world, with 140.87 million people living with the disease. Next, India is recorded as having 74.19 million people with diabetes, Pakistan 32.94 million, and the United States 32.22 million. Indonesia ranks fifth with 19.47 million people living with diabetes. It is estimated that 643 million people will have diabetes by 2030 (11.3% of the population). If current trends continue, this number will surge to 783 million (12.2%) by 2045. Globally, diabetes ranks among the top 10 causes of death. (WHO, 2021).

The primary causes are a combination of insulin resistance and pancreatic β-cell dysfunction, which affects insulin secretion (Zimmet, 2022). Many treatments have been developed to prevent and manage diabetes mellitus, including the use of various traditional medicines. The use of traditional medicines is an alternative option given their abundant availability around us. Additionally, the presence of tannin compounds is believed to enhance insulin sensitivity, thereby allowing insulin to function effectively (Sari et al., 2020). The development of natural compounds for treating diabetes mellitus is urgently needed. Besides being expensive, chemical drugs cause side effects that lead to abnormalities. Therefore, treatment using herbal plants is something that can no longer be postponed. The plants *Smallanthus sonchifolius* and *Tithonia diversifolia* are currently the subject of public discussion due to their utility, namely their ability to lower blood sugar levels and regulate blood glucose through mechanisms that improve pancreatic function in insulin production, owing to their antioxidant content (Yan et al., 2019; Nurmawati & Wulandari, 2017).

Morphologically and macroscopically, the two plants differ in their stems, leaves, and roots. Not many people have utilized them as herbal remedies to lower blood sugar, but some communities use them as a remedy for stomachaches and bloating by boiling them (Oda et al., 2016). Objective: To determine the differences in macroscopic characteristics of the roots, stems, and leaves, as well as the microscopic characteristics of the upper and lower epidermis, stomata, parenchyma, sclerenchyma, trichomes, vascular bundles, and the presence of saponins, polyphenols, flavonoids, and alkaloids in the plant *Smallanthus sonchifolius* and *Tithonia diversifolia* .

2. Methods

The method involved conducting a purely experimental study by performing macroscopic and microscopic identification and chemical testing on the plants *Smallanthus sonchifolius* and *Tithonia diversifolia* . For macroscopic plant characteristics, morphological observations and identification were performed; for microscopic characteristics, prepare anatomical slides by making incisions in roots, stems, and leaves. Each section is placed on a slide that has been moistened with distilled water and then covered with a cover slip and observed under a microscope. Chemical characterization was performed by testing leaf powders of *Smalanthus sonchifolius* and *Tithonia diversifolia* using test-tube assays for flavonoids, saponins, and alkaloids. Microscopic testing equipment: Microscope and optilab; Chemical testing equipment: test tubes, forceps, dropper pipettes, beaker glass (Pyrex), funnels, water bath, analytical balance (Ohaus). Macroscopic test materials: *Smallanthus sonchifolius* and *Tithonia diversifolia*. Microscopic test materials: microscope slides, cover slips, chloral hydrate (Merck). Chemical test materials: powdered leaves of the plants *Smalanthus sonchifolius and Tithonia diversifolia,* hydrochloric acid, methanol, ammonia, Baouchardat reagent, Mayer's reagent, $FeCl_3$.

3. Results and Discussion

3.1. Morphology of plant and macroscopic examination

The *Smallanthus sonchifolius* and *Tithonia diversifolia* plants used in this study were obtained from the Bina Agung Mandiri plant nursery located at Jl. Bantul Km 8.5, Diro hamlet, Pendowoharjo village, Yogyakarta. The plants were identified to confirm that they were *Smallanthus sonchifolius* and *Tithonia diversifolia*. Macroscopic examinations of *Smallanthus sonchifolius* and *Tithonia* *diversifolia* were conducted, covering the roots, stems, and leaves. Several characteristics of each plant were observed, including the roots (shape, color, and growth direction); the stems (diameter, branching, and growth direction); and the leaves (shape, tip, margin, length, width, and others). (Toscano-Garibay, J. D., et al. (2017). Macroscopic examination was conducted on *Smallanthus sonchifolius* and *Tithonia diversifolia*, covering the roots, stems, and leaves. Macroscopic examination is important in plant identification to facilitate the recognition of plants, as shown in Table 1.

Table 1. Macroscopic examination of *Smallanthus sonchifolius* and *Tithonia diversifolia*

Observation	Species		
	Smallanthus sonchifolius	***Tithonia diversifolia***	**Distinguishing characteristics**
Habitus	Herb	Shrub	Leaf surface: *Smallanthus* is rough, *Tithonia* is smooth
Root	Tuberous, brown in color, with dull white flesh.	Taproot, woody, non-tuberous	Stores food reserves
Stem	Moist, green, ridged, with a fine, hairy surface	Woody at the base, greenish-brown	*Smallanthus* stems are soft, *Tithonia* stems are woody
Leaves	Triangular/arrow-shaped, finely serrated edges, rough surface.	Lobed, palmate, coarsely toothed edges	broad heart-shaped leaves

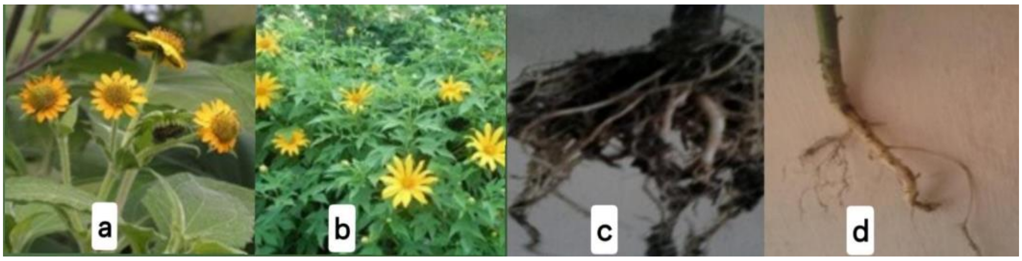

Figure 1. Plant morphology (a) *Smallanthus sonchifolius* (b) *Tithonia diversifolia* (c) Root of *Smallanthus sonchifolius* (d) Root of *Tithonia diversifolia*

Figure 2. Morphology of (a) Stem *of Smallanthus sonchifolius* (b) Stem of *Tithonia diversifolia* (c) Leaf of *Smallanthus sonchifolius* (d) Leaf of *Tithonia diversifolia*

The characteristics of the roots, stems, and leaves of *Smallanthus sonchifolius* and *Tithonia diversifolia* are as follows:

3.1.1. Roots

Roots are the most important part of a plant because they anchor the plant in the ground. It can be observed that the roots of *Smallanthus sonchifolius* are fibrous, whereas those of *Tithonia diversifolia* are taproots; this is evident from the presence of a primary root that continues to grow into a main root that branches out into smaller roots. The roots of *Smallanthus sonchifoliu*s are light yellow, while those of *Tithonia diversifolia* are brown. The growth direction of *Smallanthus sonchifolius* is downward; it has a coarse texture, is odorless, and possesses a tuber, whereas *Tithonia diversifolia* grows downward, has a coarse texture, is odorless, and does not possess a tuber. (Shelef et al., 2017). The root tips of both plants also continue to grow. The root branches are fine and fibrous. Root hairs are parts of the root that are actually just elongated protrusions of the outer root skin cells. They resemble hairs or bristles. The presence of these root hairs greatly expands the root's absorption surface, allowing for the uptake of more water and nutrients (Taiz et al., 2015).

3.1.2. Stem

The difference in the stems of *Smallanthus sonchifolius* is that the stems are round, with a diameter ranging from 0.5 to 2 cm, whereas those of *Tithonia diversifolia* range from 0.5 to 1.2 cm. These differences in stem diameter indicate variations in stem structure and strength related to the ability to support the canopy and each plant’s adaptation to its environment (Raven et al., 2018).

3.1.3. Leaves

The leaves of *Smallanthus sonchifolius* and *Tithonia diversifolia* have a finely hairy surface, with a dark green upper surface and a light green lower surface. Both plants have alternate leaf arrangement, pinnate leaves, a distinctive odor, and are tasteless. The differences observed between *Smallanthus sonchifolius* and *Tithonia diversifolia* are as follows: the leaves of *Smallanthus sonchifolius* are ovate, with a pointed tip, a rounded base, and serrated margins, whereas the leaves of *Tithonia diversifolia* are oblong, with a tapering tip, a tapering base, and margins that are deeply lobed. The length of *Smallanthus sonchifolius* leaves is 14.5–26.8 cm, and the width is 7.5–26 cm, whereas *Tithonia diversifolia* leaves have a length of 10.5–25.1 cm and a width of 5.5–21 cm. (Sintowati, 2021).

3.2 Microscopic examination

Microscopic examination was conducted on leaves of *Smallanthus sonchifolius* and *Tithonia diversifolia* to identify diagnostic features and determine the differences between *Smallanthus sonchifolius* and *Tithonia diversifolia*. Microscopic examinations were conducted using fresh leaf samples and leaf powder in pharmacognosy to identify fragments of the epidermis, stomata, and trichomes. Chloroform solution was used as a clarifying agent. The microscopic examinations included observations of the epidermis, stomata, parenchyma, sclerenchyma, trichomes, oxalate crystals, and transport file.

Table 2. Microscopic Examination of *Smallanthus sonchifolius* and *Tithonia diversifolia*

Observations	Plant Species		Distinguishing Characteristics
	Smallanthus sonchifolius	***Tithonia diversifolia***	
Stomata Type	Anisocytic	Anisocytic	Neighboring cells: More than 3
Stomata size	18.64 mm	16.66 mm	Stomata Width
Epidermis atas	Polygonal	Polygonal	Polygonal Cells
Epidermis bawah	Cell Walls: Convoluted	Cell Walls: Convoluted	No
Parenkim	Polygonal	Polygonal	No
There are trikomata	Present	Present	No
Kristal Ca-Oksalat	Present	No	Drusen/Star Shape
Sklerenkim	Thin	Thin	No
Transport file	Present,	Present,	No
Root cross section	Epidermis, Endodermis, Parenchym	Epidermis, Parenchyma, Xylem,	Pith: Parenchyma
Stem cross section	Convoluted, Xyle	Convoluted Phloem:	Convoluted Bundles
Leaf cross section	Trichomes	Trichomes	No

Based on microscopic observations, the leaves of *Smallanthus sonchifolius* and *Tithonia diversifolia* share many similarities, as both have anisocytic stomata. Anisocytic stomata consist of three or more subsidiary cell, with one cell clearly smaller than the others. The upper epidermis of *Smallanthus sonchifolius* and *Tithonia diversifolia* leaves is polygonal, while the lower epidermis has undulating cell walls. The epidermis serves as a protective layer; numerous stomata on the abaxial surface regulate gas exchange and photosynthesis. Epidermal cells contain vacuoles (cell compartments) that serve, among other functions, to store the secondary metabolite saponin, which can inhibit glucose absorption in the intestines, thereby lowering blood sugar levels. (Saputri & Sa’ad, 2023). As shown in Table 2, the *Smallanthus sonchifolius* plant has a larger stomatal size of 18.46 mm compared to *Tithonia diversifolia* at 16.66 mm. The leaves *of Smallanthus sonchifolius* and *Tithonia diversifolia* show differences in calcium oxalate crystals, whereas none are visible in *Tithonia diversifolia* . In the cross-sectional examination of the leaves, the presence of the epidermis, trichomes, vascular bundles, and parenchyma was also found. Stomata play an active role in photosynthetic metabolism, supporting the production of plant compounds that help: stabilize blood sugar, improve pancreatic function an organ located behind the stomach. (Kartika & Yuliani, 2023). Within the pancreas are the islets of Langerhans, which contain: β (beta) cells that produce insulin. When blood sugar levels are high, β cells release insulin, which helps glucose enter the body's cells, causing blood sugar levels to drop (Dewi & Haryoto, 2025; Röder et al., 2016).

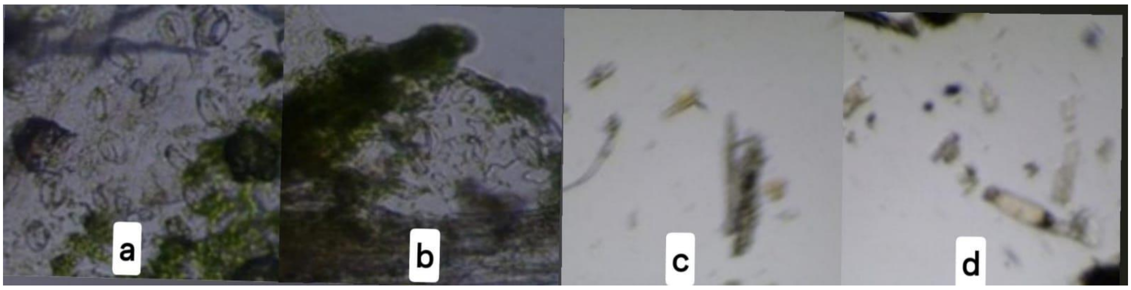

Figure 3: Microscopic *views of* (a) Stomata *of Smallanthus sonchifolius* (b) Stomata *of Tithonia diversifolia* (c) Sclerenchyma and parenchyma of *Smallanthus sonchifolius* (d) Sclerenchyma and parenchyma of *Tithonia divesifolia*

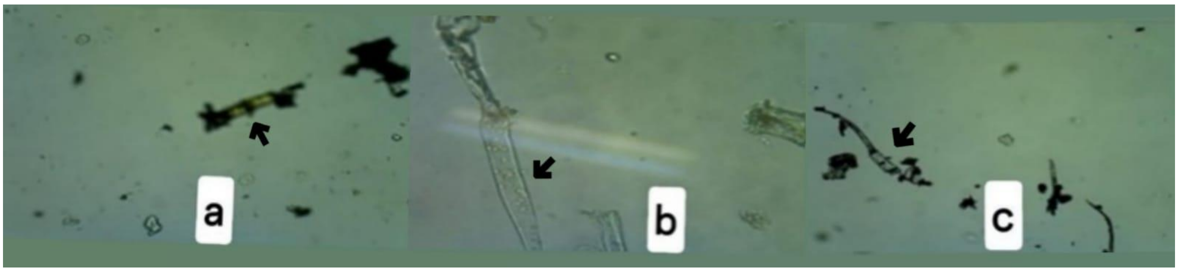

Figure 4: Microscopic images (a) Ca-oxalate crystals prisma/stiloid *of Smallanthus socnchifolius* (b) Glandular trichomes of *Smallanthus sonchifolius* (c) Glandular trichomes of *Tithonia diversifolia*

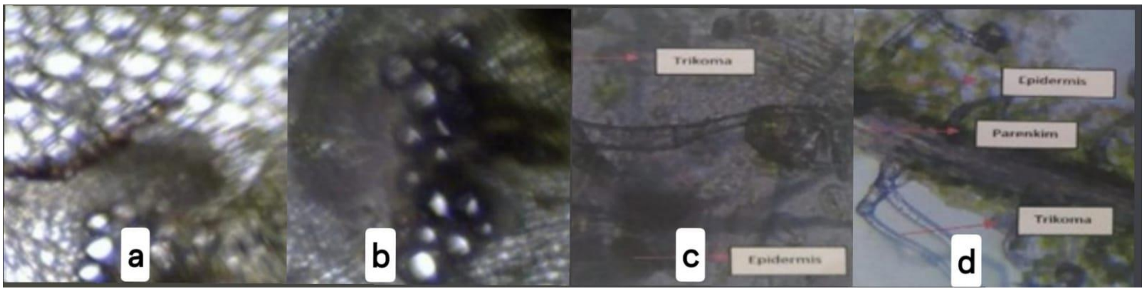

Figure 5: Microscopic cross-sections of the transport file and trichomes a.Root the transport file of *Smallanthus sonchifolius*, b. The transport file of *Tithonia diversifolia stem c.* Leaf trichomes *of Smallanthus sonchifolius* d. *Leaf tirichomes of Tithonia diversifolia*

3.3. Chemical composition analysis

The plant *Smallanthus sonchifolius* is rich in flavonoids, sesquiterpenes, and inulin. Meanwhile, *Tithonia diversifolia* contains saponins, polyphenols, and flavonoids (Silva et al., 2024). The mesophyll, composed of palisade and spongy tissues, is rich in chloroplasts that produce numerous active metabolites (flavonoids, polyphenols) which help: improve insulin sensitivity, reduce insulin resistance, and mitigate oxidative stress. (Rahman et al., 2021). Inulin/fructooligosaccharides (FOS), as well as various sesquiterpene compounds (sesquiterpene lactones) and phenolic acids. Inulin and FOS are prebiotics that play a role in modulating gut microbiota and help stabilize blood glucose levels. Additionally, sesquiterpene compounds such as enhydrin have been reported to have antihyperglycemic effects through anti-α-glucosidase activity and the potential to stimulate insulin secretion (Prasetyo, 2021). Therefore, chemical content analysis of saponins, polyphenols, flavonoids, and alkaloids was conducted. Based on its chemical and anatomical composition, insulin leaf works through several mechanisms, namely by increasing insulin sensitivity so that cells can absorb glucose more easily. (Triastuti et al., 2025). Reducing insulin resistance to aid pancreatic function. Inhibiting glucose absorption in the intestines (due to saponins). High antioxidant content reduces oxidative stress, which is important for people with diabetes. Slowing down carbohydrate breakdown to prevent blood sugar spikes after meals. (Erwin et al., 2023).

Table 3. Results of Chemical Composition Analysis of the Leaves powder of *Smallanthus sonchifolius* and *Tithonia diversifolia*

Observation	Species			
	Saponin	**Polifenol**	**Flavanoid**	**Alkaloid**
Smallanthus sonchifolius	+	+	+	+
Tithonia diversifolia	+	+	+	+

Saponin compound testing yielded positive results for *Smallanthus sonchifolius* and *Tithonia diversifolia* upon shaking, resulting in foam formation; the foam remained stable upon the addition of HCl. Testing for polyphenol compounds by adding $FeCl_3$ to the powder of S. sonchifolius produced a blackish-blue color, indicating that *Smallanthus sonchifolius* contains polyphenols (Febrianti & Pasaribu, 2021).

Tithonia diversifolia also yielded positive results. Testing for flavonoids in S. sonchifolius with the addition of ammonia produced a yellowish-green color. In *Tithonia diversifolia*, it produced an orange-yellow color. This occurs because flavonoids are phenolic compounds and are water-soluble. In addition to the addition of ammonia, the addition of 95% ethanol, magnesium powder, and hydrochloric acid P also produced an orange-yellow color (Ramadhani et al., 2025).

The alkaloid test resulted in a brown color upon the addition of Dragendroft's and Bouchardat's reagents dissolved in HCl. Mayer's reagent, which forms a precipitate, is used to detect alkaloids; the reagent binds to the alkaloids, producing a nonpolar mercury complex.Test results for *Smallanthus sonchifolius* and *Tithonia diversifolia* both indicated the presence of the alkaloid (Febrianti & Pasaribu, 2021). Based on the chemical analysis conducted, it was found that the plants *Smallanthus sonchifolius* and *Tithonia diversifolia* share many similarities, as both contain saponins, polyphenols, flavonoids, and alkaloids. These compounds in *Smallanthus sonchifolius* and *Tithonia diversifolia* indicate that flavonoids act as antioxidants capable of enhancing insulin sensitivity (Suyono et al., 2025). Saponins can help reduce glucose absorption in the intestines. Alkaloids are compounds that have the potential to regulate sugar metabolism. They work by inhibiting the enzyme α-glucosidase, reducing the breakdown of carbohydrates into glucose in the intestines and increasing insulin sensitivity (Alhujaily et al., 2022).

Flavonoids aid insulin receptor function, and their antioxidant activity protects pancreatic β-cells from oxidative damage. They inhibit gluconeogenesis and reduce glucose production in the liver. The leaves of *Smallanthus sonchifolius* lower blood sugar through antioxidant effects and increased insulin sensitivity; they are safe for long-term use. (Unesa Journal of Chemistry, 2025) The leaves of *Tithonia diversifolia* have a stronger hypoglycemic effect by stimulating insulin secretion; both are potential herbal antidiabetic agents derived from leaves (Fitriyanto et al., 2020).

4. Conclusion

Macroscopic identification characteristics of *Smallanthus sonchifolius*: taproot with a tuber, soft round stem, wavy leaves, opposite *and* decussate*; Tithonia diversifolia*: taproot without a tuber, round woody stem, alternate and scattered leaves. Microscopic identification characteristics: The leaves of *Smallanthus sonchifolius* contain Ca-oxalate, whereas the leaves *and Tithonia diversifolia* do not contain Ca-oxalate. Chemical compound identification characteristics of *Smallanthus sonchifolius*, and *Tithonia diversifolia*: the presence of saponins, flavonoids, polyphenols, and alkaloids.

REFERENCES

Alhujaily, M., Dhifi, W. & Mnif, W. (2022). An overview of the potential of medicinal plants used in the development of nutraceuticals for the management of diabetes mellitus: Proposed biological mechanisms. *Processes*, 10(10), 2044.

Dewi, T.A. & Haryoto, H. (2025). Antidiabetic activity of fractions from ethanol extract of yacon leaves (*Smallanthus sonchifolius*). *CERATA Journal of Pharmaceutical Sciences*.

Erwin et al. (2023). Determination of Total Flavonoid Content (TFC) and Antioxidant Activity of Insulin Plants. *Journal of Science and Health.*

Fitriyanto, R.E., Sugiarto. & Ardiyanto, D.T. (2020). Effects of methanol extracts of insulin leaves (*Tithonia diversifolia* (Hemsley) A. Gray) on insulin resistance and secretion in alloxan-induced obese diabetic rats. *JKKI: Indonesian Journal of Medicine and Health*.

Febrianti, I., Erwin, & Pasaribu, S.P. (2021). Phytochemical screening and bioactivity of leaf, stem, and stem bark extracts of the insulin plant (*Smallanthus sonchifolius*). *Proceedings of the National Chemistry Seminar.*

International Diabetes Federation. IDF Diabetes Atlas 11th Edition 2024/2025: Prevalence of Diabetes in Indonesia. (IDF Report) used as the source for the figures 19.5–20.4). https://diabetesatlas.org/data-by-location/country/indonesia/.

Kartika, R. & Yuliani, D. (2023). *Analysis of the anatomy, secretory structure, and histochemistry of Tithonia diversifolia (Hemsley) A. Gray leaves*. IPB Repository.

Malek, A., Cepeda, F., Kerner, T., Nowakowska, B., Birhan, F. & Zghebi, H. (2023). A Systematic Review of Type 2 Diabetes: Chronic Metabolic Disorder. *Journal of International Journal of Endocrinology and Disorders*, Vol. 2(2).

Nuroini et al., (2018). Testing the Effectiveness of Moonflower (*Tithonia diversifolia*) Leaf Extract in Lowering Blood Glucose Levels. *Scientific Journal of Pharmacy*.

Nurmawati, T. & Wulandari, N. (2017) Effectiveness of yacon tubers and leaves on blood sugar levels. *STRADA Scientific Journal of Health*.

Oda, S., et al. (2016). Morphological and Genetic Characteristics of Yacon (*Smallanthus sonchifolius*) Cultivated in Japan. *Journal of Plant Studies*.

Prasetyo, R. (2021). Antidiabetic effects of leaf, flower, and root extracts of *Tithonia diversifolia* on alloxan-induced Wistar rats. *Health Journal*.

Ramadhani, M.A., Hati, A.K., Lukitasari, N.F. & Jusman, A.H. (2025). Phytochemical Screening and Determination of Total Flavonoid and Total Phenolic Content in Insulin Leaf (*Tithonia diversifolia*) Extract. *Indonesian Journal of Pharmacy and Natural Products*.

Review: Unesa Journal of Chemistry. (2025). *Pharmacological and Toxicological Effects of Yakon Leaves (Smallanthus sonchifolius)*.

Raven, P.H., Evert, R.F. & Eichhorn, S.E. (2018). *Biology of plants (8th ed.)*. New York: W.H. Freeman and Company.

Rahman, N.F., Nursamsiar, M., Megawati, H., Handayani, C.A.M.S. (2021). Total Phenolic and Flavonoid Contents and Antioxidant Activity of Kembang Bulan Leaves (*Tithonia diversifolia*). *Indonesian Journal of Pharmaceutical Science and Technology*.

Sari, N., et al. (2020). The Potential of Tannin Compounds in Lowering Blood Sugar Levels: A Review Article. *Journal of Clinical and Community Pharmacy*.

Sintowati, R., Nurhayati, N., Daselva, S., & Prasetyo, R. (2021). Antidiabetic effects of leaf, flower, and root extracts of *Tithonia diversifolia*. *Health Journal*.

Saputri, S. & Sa'ad, M. (2023). Determination of phenolic and flavonoid levels in insulin leaf (*Smallanthus sonchifolius*) fractions using UV-Vis spectrophotometry. *Pharmacy Medical Journal*.

Suyono Saputri, D. et al. (2025). The effect of solvent variation on the antioxidant activity of insulin leaf extract (*Smallanthus sonchifolius*). *Jurnal Farmasi Medica*.

Shelef, O., Gross, A., & Rachmilevitch, S. (2017). Role of plants in a constructed wetland: Current and new perspectives. *Ecological Engineering*, 98, 405–419.

Saeedi, P., et al. (2019), Global and Regional Diabetes Prevalence Estimates. Diabetes Research and Clinical Practice, 157, 107843. *Health Journal.*

Silva, I.F., et al. (2024). Effects of *Smallanthus sonchifolius* flour on metabolic parameters: A systematic review highlighting flavonoids, sesquiterpene lactones, and inulin. *Pharmaceuticals*.

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Triastuti et al. (2025). The effectiveness of yacon leaf extract as an antihyperglycemic therapy in mice. *Herb-Medicine Journal*.

Taiz, L., Zeiger, E., Møller, I.M., & Murphy, A. (2015). *Plant physiology and development*. Sunderland: Sinauer Associates.

Yan, X., et al. (2019). *Smallanthus sonchifolius*: A Review of Its Phytochemistry, Pharmacology, and Nutritional Value. *Frontiers in Pharmacology*.

Ziimmet, P., Alberti, K.G.M.M. & Shaw, J. (2022). Diabetes Mellitus and Its Metabolic Complications: The Role of Adipose Tissues. *International Journal of Molecular Sciences*, 22(14), 7644.