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Therapeutic potential of *Gynura procumbens* in obesity, metabolic syndrome, and diabetes

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Abstract: The growing global burden of obesity, metabolic syndrome, and diabetes has led to increased interest in alternative treatment methods due to the limitations of conventional therapy, including side effects, high cost, limited long-term effectiveness, and psychological factors. As a result, researchers are increasingly turning to the search for alternative natural compounds that can provide safe and effective treatment for metabolic disorders. Among plant-based compounds, *Gynura procumbens*, a traditional medicinal plant from Southeast Asia used for the prevention and treatment of various diseases, including metabolic disorders, has garnered particular attention.

This review examines the therapeutic potential of *G. procumbens* ("longevity spinach"), a traditional medicinal plant from Southeast Asia, in the treatment of obesity, metabolic syndrome, and diabetes. The plant is rich in bioactive compounds, including flavonoids, saponins, tannins, and phenolic acids, that have the ability to influence key metabolic pathways associated with the regulation of glucose, lipid, and blood pressure levels. Recent studies shows that *G. procumbens* extracts have a positive impact on reducing blood glucose levels, improving insulin resistance, regulating the lipid profile, and promoting weight loss, as well as reducing oxidative stress and suppressing inflammatory processes in animal models, which holds promise for further application in the treatment of metabolic disorders.

Analyzing recent literature on animal model experiments and some preclinical and clinical trials, this review evaluates the plant's phytochemical profile, mechanisms of action, physiological effects, and safety aspects. Particular attention should be paid to determining the optimal dose, treatment duration, and potential side effects and interactions with other medications that may be used by patients. Thus, *G.procumbens* has the potential to become an important component in comprehensive therapeutic strategies for the treatment of obesity, diabetes, and metabolic syndrome, but further research is necessary to confirm its clinical value definitively and identify the particular active compounds.

Keywords: obesity, metabolic syndrome, diabetes, *Gynura procumbens*, lipid metabolism, oxidative stress, inflammation, human health; antioxidant.

1. INTRODUCTION

Obesity, metabolic syndrome, and diabetes are among the most pressing public health challenges of the 21st century. The prevalence of these conditions continues to rise globally, contributing to increased morbidity, mortality, and economic burden (Garus-Pakowska, 2023). Obesity is characterized by excessive fat accumulation, while metabolic syndrome refers to a cluster of metabolic disturbances, including central obesity, hypertension, dyslipidemia, and insulin resistance. Diabetes, particularly type 2 diabetes mellitus (T2DM), is closely associated with these conditions, as insulin resistance and chronic low-grade inflammation are common underlying mechanisms (Vatashchuk et al., 2022). Despite the availability of pharmacological treatments, managing these conditions remains difficult due to the side effects, high costs, and limited long-term success of current therapies (Clemente-Suárez et al., 2023; Thomas et al., 2023).

In recent years, there has been growing interest in exploring plant-based therapies as complementary or alternative approaches to conventional treatments. Traditional medicinal plants offer the potential to address multiple aspects of these metabolic diseases, often with fewer side

effects (Clemente-Suárez et al., 2023; Thomas et al., 2023). One such plant that has gained attention is *Gynura procumbens*, a medicinal herb traditionally used in Southeast Asia for managing a range of health conditions, including hypertension, inflammation, and diabetes. Known locally as "Sambung Nyawa" or "longevity spinach," *G. procumbens* has been consumed both as food and medicine, suggesting its safety for regular use (Jobaer et al., 2023).

Emerging scientific evidence suggests that *G. procumbens* may possess anti-obesity, antidiabetic, and anti-inflammatory properties. Phytochemicals such as flavonoids, saponins, tannins, and phenolic acids present in the plant are believed to contribute to its therapeutic potential. These compounds have shown promise in modulating key metabolic pathways, improving insulin sensitivity, regulating lipid profiles, and reducing oxidative stress and inflammation (Jobaer et al., 2023; H.-L. Tan et al., 2016).

This review aims to explore the potential of *G. procumbens* in the treatment of obesity, metabolic syndrome, and diabetes mellitus 2 type by examining both preclinical and clinical evidence. We will discuss the phytochemical composition of the plant, potential mechanisms of its action, and the physiological effects observed in various experimental models (Hassan et al., 2010; Meng et al., 2021; Wu et al., 2011). Additionally, the safety profile, limitations, and areas requiring further research will be outlined. Through this synthesis, we aim to provide a comprehensive understanding of how *G. procumbens* could contribute to the development of new therapeutic strategies for metabolic disorders.

By bridging traditional knowledge with modern scientific insights, *G. procumbens* may offer a holistic approach to addressing the growing epidemic of metabolic diseases. However, to fully harness its potential, further research particularly clinical trials is needed to confirm its efficacy and determine optimal dosages for human applications.

2. METHODOLOGY

This review article follows a structured approach to ensure a comprehensive and unbiased synthesis of the available evidence on the potential of *G. procumbens* in managing obesity, metabolic syndrome, and diabetes. The methodology for this review consists of several key steps, including the literature search strategy, inclusion and exclusion criteria.

A systematic search was conducted across multiple scientific databases to identify relevant peer-reviewed articles. The following databases were used: PubMed, Scopus, Web of Science, Google Scholar. The search terms included combinations of keywords related to the topic, such as: "*G. procumbens*", "anti-obesity" or "obesity treatment", "metabolic syndrome" or "insulin resistance", "antidiabetic" or "type 2 diabetes", "herbal medicine" or "plant-based therapy"

The search was limited to articles published in English to ensure clarity and consistency. No restriction on publication date was applied, although preference was given to recent studies (published within the last 10 years) to capture the latest advances.

Studies were screened based on the following inclusion criteria:

1. Original research articles (in vivo, in vitro, or clinical studies) focused on the effects of *G. procumbens*.
2. Studies reporting on outcomes related to obesity, metabolic syndrome, or diabetes.
3. Reviews or meta-analyses that provide useful context or summarize previous findings.
4. Articles with clear descriptions of methods, results, and phytochemical analysis of *G. procumbens*.

The following exclusion criteria were used:

1. Studies that focus on unrelated therapeutic uses of *G. procumbens* (e.g., wound healing, antimicrobial activity).
2. Research on plant species other than *G. procumbens*.
3. Articles with insufficient data on metabolic outcomes.
4. Non-peer-reviewed sources (e.g., conference abstracts, editorials).

3. PHYTOCHEMICAL COMPOSITION

G. procumbens, commonly known as Sambung Nyawa or longevity spinach, is a perennial herb belonging to the Asteraceae family (H.-L. Tan et al., 2016). Native to Southeast Asia, particularly in regions of Malaysia, Indonesia, Thailand, and China, it is widely cultivated for both medicinal and culinary purposes (Bari et al., 2021). This section explores the botanical characteristics and phytochemical composition of the plant, which contribute to its therapeutic properties. *G. procumbens* is a creeping plant with lush green foliage and distinctive growth patterns. Its adaptability and ease of growth make it a popular herb in home gardens across Southeast Asia, where it is consumed both as food and traditional medicine (Sutthammikorn et al., 2021).

The therapeutic potential of *G. procumbens* lies in its rich phytochemical profile, consisting of bioactive compounds with antioxidant, anti-inflammatory, and metabolic regulatory properties (Haque et al., 2021; H. H. Kim et al., 2021). Key classes of compounds identified in the plant include:

***Flavonoids**:*

The leaves and stem of *G. procumbens* contain both simple flavonoids such as quercetin, kaempferol, and flavonoid glycosides such as rutin (Kaewseejan et al., 2015). Flavonoids contribute to antioxidant activity by scavenging free radicals and reducing oxidative stress (Kaewseejan et al., 2015; H. H. Kim et al., 2021; Krishnan et al., 2015), which is crucial in managing diabetes and metabolic syndrome. These compounds also exhibit anti-inflammatory effects, suppressing cytokines involved in chronic low-grade inflammation (M.-Y. Cao, Wu, Wu, et al., 2022).

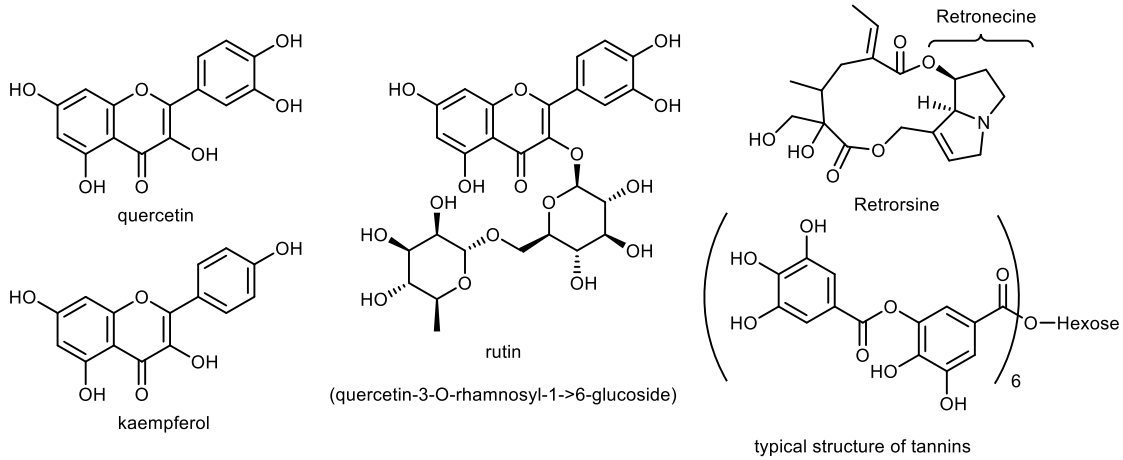

Figure 1. Compounds present in *G. procumbens*.

***Phenolic Acids**:*

Caffeic acid and its derivative, are among the key phenolic acids found in the plant (Agunloye & Oboh, 2018). These compounds play a role in regulating glucose metabolism (Algariri et al., 2014) by enhancing insulin sensitivity and protecting pancreatic beta cells from oxidative damage (Tahsin et al., 2022). However, *G. procumbens* contains much large varieties of phenolic acids (Fig. 2) and their mono- and di-esters with quinic acid, as reviewed in (Haque et al., 2021).

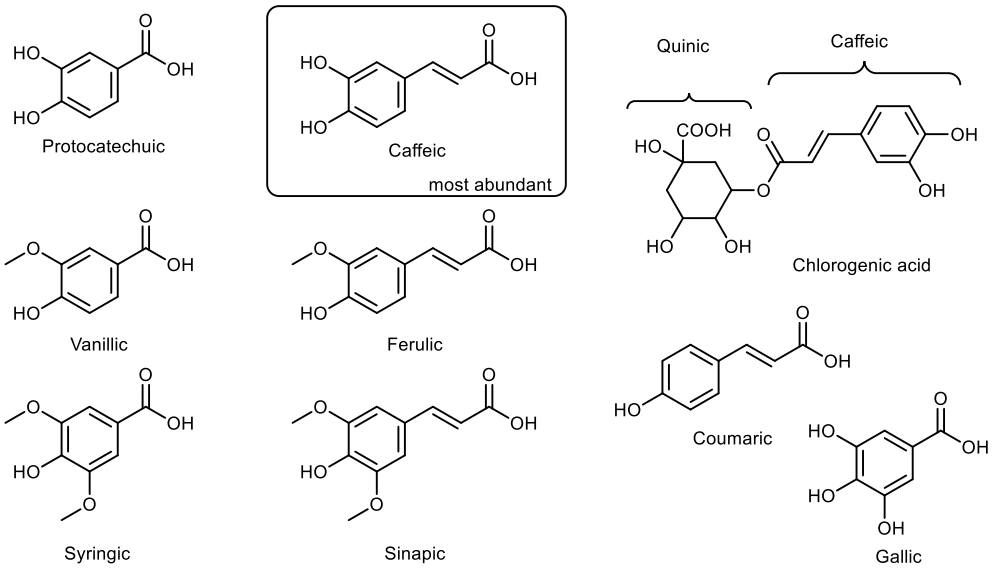

Figure 2. Phenolic acids present in *G. procumbens*.

Saponins:

Saponins possess lipid-lowering properties, contributing to improved lipid profiles by reducing triglyceride and cholesterol levels (Ahmad Nazri et al., 2019; Murugaiyah et al., 2018). They also exhibit mild anti-inflammatory effects and may influence appetite regulation (S. Cao et al., 2024).

Tannins:

These polyphenolic compounds are typically esters of gallic acid and a hexose (Fig. 1). They show astringent properties and contribute to the plant's antioxidant activity (Nasiruddin & Sinha, 2020). Tannins were reported to play a role in controlling glucose absorption, which may benefit diabetic patients (Ziaul et al., 2021).

Terpenoids:

G. procumbens contains several terpenoids with antihypertensive and anti-inflammatory effects (Ahmad Nazri et al., 2021). It includes simple volatile terpenoids like pinene and limonene, more complex sesquiterpenes like caryophyllene build of three isoprene units, and glycosylated derivatives that are not volatile. These compounds help modulate blood pressure by promoting vasodilation and improving vascular health (Shahlehi & Petalcorin, 2021).

Alkaloids and Steroids:

While present in smaller quantities, these compounds contribute to the overall pharmacological activity of the plant, including modulation of metabolic pathways and anti-inflammatory responses (Bai et al., 2021; Mumu et al., 2023). The most notable representatives are esters of bicyclic compound Retronecine (Fig 1), like retrorsine.

4. PLANT EXTRACTION AND STANDARDIZATION

Extracts of *G. procumbens* are typically prepared using alcohols or water, to isolate bioactive compounds.

Ethanolic and methanolic extracts are commonly used in experimental studies, as these solvents effectively extract flavonoids, saponins, and phenolic acids (Amin et al., 2021; Jobaer et al., 2023; Kaewseejan et al., 2015; Manogaran et al., 2020). In many cases such extracts are evaporated and residuals are extracted with heptane, ethyl acetate, butanol ore other solvents to obtain extract of more specific class of compounds.

Aqueous extracts are popular in traditional medicine, where the leaves are steeped in water to prepare herbal infusions or teas (Amin et al., 2021; Liu et al., 2019).

Standardization of plant extracts is essential to ensure consistent bioactive compound concentrations across studies (Chaachouay & Zidane, 2024). However, variability in cultivation conditions, harvesting practices, and extraction methods can influence the composition of phytochemicals, making it challenging to compare findings across different studies.

5. PHARMACOLOGICAL EFFECTS OF *GYNURA PROCUMBENS* IN OBESITY, METABOLIC SYNDROME, AND DIABETES: EVIDENCE FROM *IN VIVO* AND *IN VITRO* STUDIES

G. procumbens has attracted attention of scientific community mainly due to its popularity in folkloric medicine in tropical Asian countries where it is used to treat various diseases. However, high content of polyphenolic compounds and specific alkaloids makes prospective to study its ability to manage obesity, metabolic syndrome, and diabetes through multiple biochemical and physiological pathways. This section explores the evidence from *in vitro*, *in vivo*, and clinical studies, highlighting the plant's key mechanisms of action and its observed therapeutic outcomes.

1) Anti-Obesity Effects

Obesity is a major driver of metabolic disorders, and *G. procumbens* has demonstrated promising anti-obesity effects through several mechanisms:

Inhibition of adipogenesis*:* Extracts of *G. procumbens* were shown to reduce the differentiation of preadipocytes into mature fat cells by downregulating lipogenic genes (Manogaran et al., 2020). Namely, ethanol extract and its various fractions obtained using water, chloroform, ethyl acetate, and hexane were capable of reducing the accumulation of lipid droplets and total cholesterol in murine macrophages. Importantly, they also reduced the secretion of the pro-inflammatory cytokines TNF-α and IL-1β, the levels of which are typically elevated in atherosclerotic plaques. It was accompanied by suppression of the expression of the LOX-1 gene, which is responsible for the uptake of oxidized cholesterol, and enhancement of the activity of the ABCA-1 gene, which facilitates the efflux of excess lipids from macrophages (Manogaran et al., 2020).

Lipid metabolism enhancement*:* The plant promotes fat oxidation and reduces fat accumulation in tissues, potentially improving body composition and weight control (Ahmad Nazri et al., 2019). The addition of ethanol extract of *G. procumbens* at doses of 250 and 500 mg/kg to a group of Sprague-Dawley rats with a postmenopausal model of led to a significant decrease in body weight, in a dose-dependent manner. The effect began to appear after 3 months of administration (Ahmad Nazri et al., 2019). In animal models of high-fat diet-induced obesity, *G. procumbens* significantly reduces body weight, total cholesterol, and triglyceride levels, indicating its role in lipid regulation (Murugaiyah et al., 2018).

Appetite regulation*:* Although direct studies on appetite suppression are limited, the anti-obesity effects may be partly mediated by modulating hormones involved in hunger regulation, such as leptin and ghrelin (Bengin et al., 2024).

2) Modulation of Metabolic Syndrome Components

Metabolic syndrome involves multiple interconnected risk factors, including obesity, hypertension, dyslipidemia, and insulin resistance. Evidence suggests that *G. procumbens* can target several aspects of metabolic syndrome:

Blood pressure regulation*:* The plant exhibits vasodilatory effects by increasing nitric oxide production, contributing to reduced blood pressure (Ahmad Nazri et al., 2019). Blood pressure

increased significantly in the group of Sprague-Dawley postmenopausal rats and decreased with the addition of ethanol extract of *G. procumbens* at doses of 250 and 500 mg/kg body weight. A decrease in blood pressure was observed already in the first month of treatment with *G. procumbens* extract (Ahmad Nazri et al., 2019).

Improvement in lipid profiles*:* Studies in postmenopausal group of Sprague-Dawley rats show that *G. procumbens* extract at doses of 250 and 500 mg/kg body weight lowers total cholesterol, low-density lipoprotein (LDL), and triglycerides while increasing high-density lipoprotein (HDL) in plasma (Ahmad Nazri et al., 2019). However, the administration of *G. procumbens* extract did not affect the plasma lipid profile in non-postmenopausal group (Ahmad Nazri et al., 2019). In high fat diet-induced hyperlipidemic rats, the ethanolic extracts of *G. procumbens* at doses of 250, 500, and 1000 mg/kg significantly reduced the serum total cholesterol and triglycerides, LDL-cholesterol levels while increased serum HDL-cholesterol in a dose-dependent manner (Murugaiyah et al., 2018).

Anti-inflammatory activity*: G. procumbent* contains significant amounts of flavonoids, saponins, and other bioactive compounds that suppress pro-inflammatory cytokines, thereby mitigating chronic low-grade inflammation a hallmark of metabolic syndrome (M.-Y. Cao, Wu, Xie, et al., 2022; Manogaran et al., 2020). Namely, ethanol 0–100 μg/mL extracts from *G. procumbens* flowers significantly suppressed pro-inflammatory factors, including IL-6, IL-1β, NO, and TNF-α, as well as their mRNA expression in LPS-stimulated RAW264.7 macrophages. Compounds present in such extracts may reduce inflammation by inhibiting nuclear transcriptional activity (M.-Y. Cao, Wu, Xie, et al., 2022). Another study has shown that the ethanol extract of G. procumbens (90 μg/mL) reduces the secretion of the pro-inflammatory cytokines TNF-α and IL-1β macrophages (Huang et al., 2019; Manogaran et al., 2020).

Through these combined effects, *G. procumbens* offers comprehensive metabolic benefits, addressing multiple components of the syndrome simultaneously.

3) Antidiabetic Effects

G. procumbens has demonstrated strong antidiabetic properties in preclinical studies, supporting its potential use in managing type 2 diabetes. The following mechanisms have been observed:

Improved glucose uptake and insulin sensitivity: Extracts of *G. procumbens* enhance glucose uptake in peripheral tissues by modulating insulin receptor pathways and activating glucose transporter proteins (GLUT4) (Aung et al., 2021). Treatment with 1% *G. procumbens* powder significantly reduced the elevated serum glucose levels in the high-fat diet-fed mice. Additionally, treatment with *G. procumbens* ethanolic and water extracts enhanced GLUT4 membrane translocation more prominently in C2C12 muscle cells than in 3T3-L1 adipocyte cells, while GLUT4 expression showed a significant increase only in the 3T3-L1 cells (Aung et al., 2021).

Beta-cell protection: The plant exhibits antioxidant properties that protect pancreatic beta cells from oxidative stress, helping to maintain insulin secretion (Hassan et al., 2010). The antidiabetic effects of compounds from *G. procumbens* were studied in diabetic rats induced with streptozotocin. The water extract from *G. procumbens* leaves at 500 mg/kg and 1000 mg/kg significantly lowered blood glucose levels after 14 days of treatment. The extract had minimal impact on pancreatic β-cells in the islets of Langerhans but significantly enhanced glucose uptake in muscle tissues (Hassan et al., 2010).

Reduction of oxidative stress: By increasing antioxidant enzyme levels (such as catalase and superoxide dismutase) and decreasing malondialdehyde (MDA), *G. procumbens* mitigates oxidative damage associated with diabetes (Ahmad Nazri et al., 2019). In the postmenopausal group of Sprague-Dawley rats, superoxide dismutase, catalase, and glutathione peroxidase activities were lower, and malondialdehyde levels were higher compared to the control group. However,

supplementation with *G. procumbens* increased enzyme activities and reduced malondialdehyde levels. The findings indicated that 500 mg/kg dose of *G. procumbens* can help reduce oxidative stress and protect cell membranes from damage by modifying antioxidant enzyme activity in postmenopausal rats (Ahmad Nazri et al., 2019).

In diabetic animal models, the administration of *G. procumbens* extracts leads to lower fasting glucose levels, reduced insulin resistance, and improved glycemic control. Some studies report a reduction in HbA1c (glycosylated hemoglobin) levels, suggesting long-term glycemic benefits (Hui-Wen Lee, 2012). In particular, treatment with aqueous and ethanolic extracts of *G. procumbens* leaves (at doses of 50, 100, and 150 mg/kg body weight) significantly lowered fasting blood glucose and HbA1c levels in diabetic rats after 42 days. The ethanolic extract produced greater improvements than the aqueous extract at the same dosage (Hui-Wen Lee, 2012).

4) Clinical Evidence and Human Studies

Although most research on *G. procumbens* has been conducted in animal (Ahmad Nazri et al., 2019; W. Kim et al., 2021; Sutthammikorn et al., 2021) and cell (M.-Y. Cao, Wu, Xie, et al., 2022; Jermnak et al., 2022; J. N. Tan et al., 2022) models, there are several preliminary clinical studies that indicate promising results:

In human subjects with mild hypertension or metabolic abnormalities, daily consumption of *G. procumbens* tea has shown improvements in blood pressure and lipid profiles (H.-L. Tan et al., 2016). This is in line with *in vitro* study on human osteosarcoma cell line. Addition of ethanolic extract of *G. procumbens* leaves and stem of the plant at 5-160 μg/ml concentrations significantly inhibit the proliferation and metastasis of U2-OS cells in culture. The presumed molecular mechanism of action of the extract is related to the inhibition of nuclear translocation of NF-κB factor (Wang et al., 2013).

Ethanol extract of *G. procumbens* leaves demonstrates significant anti-inflammatory properties that are also associated with NF-κB pathway (J. N. Tan et al., 2022). When the extract is applied at doses of 20, 40, and 60 μg/mL, a reduction in monocyte binding to activated human endothelial cells is observed. The mechanism of action includes blocking the NF-κB pathway, which leads to decreased synthesis of key inflammatory proteins (ICAM-1, VCAM-1, and MCP-1). These findings provide preliminary scientifical validation of the traditional use of the plant in inflammatory conditions. However, detailed studies and identification of active molecules involved are necessary to verify the findings and use them for the development of new medications against atherosclerosis (J. N. Tan et al., 2022).

To sum up, to date human studies of *G. procumbens* efficacy in managing obesity, metabolic syndrome, and diabetes are at the very initial stages. The optimal dosage and long-term safety profile for human use require further exploration. However, the main problem in the field is the absence of the identification of particular active biomolecules in the extracts that is the crucial step for many further experiments.

5) Summary of Pharmacological Findings

G. procumbens exhibits a wide range of metabolic benefits, including anti-obesity, antihypertensive, lipid-lowering, and antidiabetic effects. It acts through multiple pathways, such as improving insulin sensitivity, regulating lipid metabolism, and reducing oxidative stress and inflammation. While the preclinical evidence is robust, more clinical studies are needed to establish the plant's therapeutic potential in humans.

By targeting the underlying mechanisms of obesity, metabolic syndrome, and diabetes, *G. procumbens* offers a holistic approach to managing these chronic conditions. Future research should focus on standardizing plant extracts, conducting long-term human trials, and identifying potential drug-plant interactions to ensure safe and effective use.

6. SAFETY, DOSAGE, AND TOXICITY

Safety and Toxicity

G. procumbens has a high safety profile, with no serious adverse effects reported in experimental or clinical studies (Amin et al., 2021; J. N. Tan et al., 2020). It has been consumed traditionally as food in several cultures, indicating its suitability for long-term use (M.-Y. Cao, Wu, Xie, et al., 2022; Kaewseejan et al., 2015). Daily consumption of *G. procumbens* tea does not show negative effects on humans (H.-L. Tan et al., 2016). However, further toxicity studies and clinical trials are needed to establish optimal dosages and ensure its safety for therapeutic applications. Experiments in rats show that oral administration of methanolic extract of *G. procumbens* leaves at a dose of 1000-5000 mg/kg did not cause any deaths or significant abnormalities in behavior, body weight, blood parameters, biochemical parameters and organ structure confirming the safety of *G. procumbens* in rodents even with long-term use of high doses (Sutthammikorn et al., 2021).

Dosage

Oral administration of extracts of *G. procumbens* are normally done at doses close to 200-500 mg per kilogram of body weight (Haque et al., 2021). Namely, Sprague-Dawley rats were orally administered ethanol extract of *G. procumbens* in two doses (250 and 500 mg/kg) once a day. Studies have shown that the higher dose (500 mg/kg) provided a more pronounced therapeutic effect. It was found that *G. procumbens* exhibits antioxidant properties by reducing oxidative stress and protecting cell membranes through the regulation of antioxidant enzymes activity and normalizing lipid profile in rats with postmenopausal atherosclerosis compared to control animals (Ahmad Nazri et al., 2019). Similar doses were used in a study of the effects of aqueous extract of *G. procumbens* leaves on fertility in diabetic Sprague-Dawley rats where doses 150, 300, and 450 mg/kg body weigh were used. The aim of the experiment was to examine hormonal profile changes and determine the plant's effectiveness in improving reproductive function (Kamaruzaman et al., 2018).

Lower doses can be effective also. An experimental study was conducted on gerbils that were orally administered ethanol extract of *G. procumbens* roots at doses of 30 mg/kg and 300 mg/kg daily for 3 weeks in ischemic groups. The results demonstrated that preventive administration of *G. procumbens* significantly enhances neuronal viability in the hippocampus following ischemia by reducing microglial activity and decreasing levels of proinflammatory cytokines (IL-6, IL-1β and TNF-α) (W. Kim et al., 2021).

Solutions of extracted compounds in most works are of 20-80 μg/mL concentration (Haque et al., 2021). However, higher concentrations are also used. For example, the application of ethanol extract from *G. procumbens* roots at a concentration of up to 200 μg/ml accelerates the healing of diabetic wounds in *C57BL/6* mice with diabetes induced by intraperitoneal administration of streptozotocin at a dose of 0.2 ml. This therapeutic effect is achieved through stimulation of new blood vessel formation (angiogenesis), as well as enhanced cell migration and proliferation in the damaged area (Sutthammikorn et al., 2021).

To sum up, typical dosages of *G. procumbens* extracts are 200-500 mg/kg of body weight or 20-80 μg/mL.

7. CONCLUSIONS AND PESRPECTIVES

G. procumbens, a traditional medicinal plant from Southeast Asia, is rich in bioactive molecules, most notable of which are alkaloids of retronecine family, flavonoids, and polyphenolic compounds. Plant extracts show promising therapeutic potential for managing obesity, metabolic syndrome, and diabetes. Preclinical studies have suggested that flavonoids, saponins, tannins, and phenolic acids

present in the plans leaves and stem contribute to its anti-obesity, antidiabetic, and anti-inflammatory properties.

There are several evidences that *G. procumbens* bioactive compounds can positively affect key metabolic pathways involved in these disorders. Research indicates it can inhibit adipogenesis, enhance lipid metabolism, improve insulin sensitivity, protect pancreatic beta cells, and reduce oxidative stress and inflammation all crucial in the pathogenesis of obesity, metabolic syndrome, and type 2 diabetes. However, none of particular active compounds was identified so far to the best of our knowledge.

Preliminary clinical studies have shown improvements in blood pressure, lipid profiles, and glycemic control in individuals with metabolic abnormalities. However, the data from human trials remains very limited due to the lack of large-scale, well-designed studies and variability in the phytochemical composition of *G. procumbens* extracts, which can depend on plant origin and preparation methods.

To fully realize the therapeutic potential of *G. procumbens*, future research should prioritize comprehensive characterization of the chemical composition of the plant extracts and their standardization. Another promising direction of the research that is not covered to date is the exploration of synergistic effects with conventional therapies or other complementary approaches. By integrating traditional knowledge with scientific validation, *G. procumbens* may offer a holistic approach to addressing the growing epidemic of obesity, metabolic syndrome, and diabetes.

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Гусак В.В., Швадчак В.В., Шеремета Л.М., Абрат О.Б. Терапевтичний потенціал *Gynura procumbens* при ожирінні, метаболічному синдромі та діабеті. *Журнал Прикарпатського університету імені Василя Стефаника. Біологія*, **11** (2024), С20–С32.

Анотація. Глобальне поширення ожиріння, метаболічного синдрому та діабету зумовило підвищення інтересу до альтернативних методів їх лікування через обмеження традиційної терапії, зокрема побічні ефекти, високу вартість, обмежену довгострокову ефективність та психологічні фактори. У зв'язку з цим, науковці все більше звертаються до пошуку альтернативних природних засобів, здатних забезпечити безпечне й ефективне лікування метаболічних розладів. Серед рослинних засобів особливу увагу привертає *Gynura procumbens*, рослина з традиційної медицини Південно-Східної Азії, яка використовується для профілактики і лікування різних захворювань, включаючи метаболічні розлади. Цей огляд досліджує терапевтичний потенціал *Gynura procumbens* ("шпинат довголіття"), традиційної лікарської рослини Південно-Східної Азії, у лікуванні цих метаболічних розладів. Ця рослина багата на біоактивні сполуки, включаючи флавоноїди, сапоніни, таніни та фенольні кислоти, які здатні впливати на ключові метаболічні шляхи, пов'язані з регуляцією рівня глюкози, ліпідів та артеріального тиску. Огляд останніх досліджень показує, що екстракти *Gynura procumbens* знижують рівень глюкози в крові, покращують інсулінорезистентність, регулюють ліпідний профіль, сприяють зниженню маси тіла, зменшують оксидативний стрес і пригнічують запальні процеси у тваринних моделях, що робить цю рослину перспективною для подальшого застосування у лікуванні метаболічних порушень.

Аналізуючи експерименти на тваринних моделях та деякі доклінічні й клінічні дослідження, цей огляд оцінює фітохімічний профіль рослини, механізми дії, фізіологічні ефекти та безпечність застосування. Особлива увага повинна бути приділена визначенню оптимальної дози, тривалості лікування, а також можливих побічних ефектів і взаємодії з іншими препаратами, що можуть використовуватися пацієнтами. Таким чином, *Gynura procumbens* має потенціал стати важливим компонентом у складі комплексних терапевтичних стратегій для лікування ожиріння, діабету та метаболічного синдрому, однак подальші дослідження є необхідними для остаточного підтвердження її клінічної цінності та ідентифікації конкретних активних речовин.

Ключові слова: ожиріння, метаболічний синдром, діабет, *Gynura procumbens*, метаболізм ліпідів, оксидативний стрес, запалення, здоров'я людини, антиоксиданти.