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THE POTENTIAL OF BASIL LEAVES (*OCIMUM BACILLICUM L.*) AND RED GINGER (*ZINGIBER OFFICINALE*) AS ANTIDIABETIC AGENTS: A SCOPING REVIEW

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ABSTRACT

Diabetes mellitus is a chronic metabolic disease characterized by elevated blood glucose levels due to beta cell dysfunction in the pancreas, which prevents the effective production and/or utilization of insulin. Various factors contribute to the increase in the prevalence of diabetes in 2021, with 12.1% of cases occurring in urban areas compared to 8.3% in rural areas. Antidiabetic drugs such as metformin are widely used and have gastrointestinal side effects. Using natural alternatives can provide safe effects. Basil leaves (Ocimum basilicum) and red ginger (Zingiber officinale) are active ingredients that can be used as herbal medicines that are easily found anywhere and have long been known in various traditional medicines for diseases. Usually, people consume them as vegetables and herbal medicine. Basil leaves and red ginger contain natural compounds that are beneficial to health and can boost the immune system, including as antidiabetic agents. The purpose of this review is to present comprehensive information on basil leaves and red ginger that have antidiabetic activity, conducted using a scoping review starting with the PRISMA guidelines. The information for this article was obtained using Google Scholar, Science Direct, Semantic Scholar, and PubMed from 2015 to 2025 resulting in 1229 articles, The results of this review were obtained from 8 articles that were used and met the inclusion criteria. Basil leaves contain flavonoids, phenols, and tannins, which play a role in lowering blood glucose levels by increasing insulin sensitivity and antioxidant activity. Red ginger is rich in gingerol and shogaol, which can lower blood glucose levels and reduce oxidative stress in the body. Both plants have significant potential as natural antidiabetics in lowering blood glucose levels through various mechanisms.

Keywords: antidiabetic; basil leaves; diabetes mellitus; red ginger

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INTRODUCTION

Diabetes mellitus, commonly known as diabetes, is a complex metabolic disorder characterized by chronically elevated blood glucose levels, leading to impaired insulin production or insulin utilization (Cavan et. al., 2015) . The term "diabetes mellitus" originates from the Greek word "diabetes," meaning "sweet," and the Latin word "mellitus," meaning "sweet." Historically, the term "diabetes" was first used around 250 to 300 BCE by the scientist Apollonius of Memphis. (Sapra and Bhandari, 2022). The prevalence of diabetes mellitus remains a serious public health issue, classified as a non-communicable disease (Al-Lawati, 2017). Globally, according to the International Diabetes Federation (IDF) in 2021, the prevalence of diabetes among those aged 20 to 79 was 537 million people in 2019, and it is estimated that the prevalence of diabetes will increase to 579 million people by 2030. If this condition continues without any efforts to combat the disease, by 2045 it will continue to increase to 700 million people (51%) worldwide. In addition, the number of people with diabetes in Indonesia in 2019 reached 10.7 million, and in 2021 it will increase to around 19.5 million. This places Indonesia in seventh place among countries with the highest prevalence of diabetes globally, and it is estimated that this number will continue to increase in

2045 to 28.6 million people with diabetes. The 2023 Indonesian Health Survey (SKI) found that 11.7% of the population had diabetes, an increase from the previous survey. This upward trend aligns with increasing risk factors, including obesity rates rising from 14.8% to 21.8%, overweight rates increasing from 11.5% to 13.6%, and central obesity rates climbing from 26.6% to 31%. These data collectively indicate that the number of diabetes mellitus patients in Indonesia is extremely high (Saeedi et al., 2019). Diabetes mellitus cases are more prevalent in urban areas and are expected to continue increasing alongside urbanization. Epidemiological data from the 2021 Basic Health Research (RISKESDAS) shows an increase in the prevalence of diabetes in urban areas (12.1%) compared to rural areas (8.3%). Based on gender, the prevalence of female patients was higher at 15.6%, while male patients were 12.4%. Various factors influence this, such as lifestyle, urbanization, genetic factors, educational status, and occupation. Additionally, it can increase the risk of complications such as heart disease, stroke, kidney failure, blindness, limb amputation, and even death. (Rosyidah, 2025) .

Diabetes mellitus is a metabolic condition with complex pathogenesis and a progressive pattern. In addition, there are various clinical manifestations, namely increased frequency of urination (polyuria), increased thirst and desire to drink (polydipsia), and increased appetite (polydipsia). This condition is often accompanied by serious complications such as complications in the eyes, heart, kidneys, nerves, and peripheral vascular system, with the triggering factors being hyperglycemia, oxidative stress in the body, and inflammatory processes. If not treated properly, complications at this stage will become irreversible (Elgebaly et al., 2019)(Elgebaly et al., 2019). Diabetes mellitus remains a serious health issue in Indonesia, with the increasing population, unhealthy lifestyles, irregular eating patterns, obesity, and unproductive diets leading to a continuous rise in the number of diabetes patients (Nasution et al., 2021).

Several effective strategies in the management of diabetes mellitus patients aim to control postprandial hyperglycemia and improve insulin function, including pharmacological approaches with oral antidiabetic drugs and non-pharmacological approaches such as dietary modifications and exercise (Ezeani et al., 2017). Pharmacological therapy approaches usually include biguanides, thiazolidinediones, insulin, and sulfonylureas. The use of oral medications aims to control glycemic status, but is often accompanied by side effects experienced by people with diabetes, such as digestive disorders, hypoglycemia, weight gain, and the risk of long-term organ toxicity. Combining drug therapy with natural approaches is also important to reduce symptoms and slow the progression of the disease. One widely used drug is metformin, which works by lowering blood glucose levels without causing hypoglycemia and has gastrointestinal side effects after consumption, such as diarrhea, nausea, and bloating (Kooti et al., 2016). Therefore, the current focus in diabetes treatment development needs to be on finding safe and affordable alternatives from natural ingredients, considering the many pharmacological side effects that are mostly caused by chemicals (Hameed et al., 2022). Several plants are being studied as sources of bioactive compounds that are used in traditional medicine. Plants contain various phytochemicals or natural compounds that have the potential to affect various diseases in the human body. Researchers continue to develop and study natural remedies that are widely available, inexpensive, and free of side effects compared to modern medicine. The biological activity of secondary metabolite compounds such as flavonoids exhibits properties as antidiabetic, antibacterial, anti-inflammatory, anticarcinogenic, antioxidant, and anticancer. The flavonoid content can be directly related to the total phenolic content in a natural ingredient through various mechanisms, thereby providing positive effects on human health (Stompor, 2020).

Basil leaves (Ocimum basilicum) are aromatic herbs from the Lamiaceae family, also known as "holy basil," commonly found in tropical regions, including Indonesia. It is characterized by a woody stem, 30-150 cm tall, with a grooved surface and hairy, branched, green leaves. It has white flowers with a distinctive aroma and many benefits, such as the presence of metabolite compounds in the leaves, namely flavonoids, alkaloids, saponins, tannins, and phenols. In addition, the secondary metabolite compounds in basil leaves can act as antidiabetics by inhibiting the alpha-glucosidase enzyme and have antioxidant or free radical scavenging properties (Nadeem et al., 2022). Meanwhile, red ginger (Zingiber officinale), which belongs to the Zingiberaceae family, is traditionally used in various countries, especially in Indonesia. It has the potential to contain bioactive compounds such as gingerol, shagaol, geraniol, gingerenone, arcurcumene, and zingiberene. These bioactive compounds have anti-inflammatory, antipyretic, antidiabetic, antimicrobial, immunomodulatory, antihyperuricemic, and antioxidant properties (Suciyati and Adnyana, 2017). Red ginger is a plant that can grow and reproduce in loose, fertile soil and has been widely used as a spice and medicine. Shogaol is a compound resulting from the degradation of gingerol, which has a higher level of spiciness and is more stable when exposed to heat. It has anti-inflammatory properties and can increase adiponectin expression and decrease TNF (Tumor Necrosis Factor) secretion, thereby increasing insulin sensitivity and decreasing insulin resistance, which in turn lowers blood glucose levels (Srikandi et al., 2020). Given the potential of these two plants to provide synergistic effects in controlling blood glucose levels and protecting against cell damage through various complementary mechanisms of action, they can enhance the effectiveness of diabetes management, thereby reducing the single dose and toxicity risk of each ingredient (Anggraini, 2020). Therefore, the purpose of this scoping review article is to determine the potential of basil leaves and red ginger as antidiabetic agents. This article is expected to be useful as a learning resource, enrich knowledge, and serve as a basis for further research.

METHOD

Data Sources

This review uses the scoping review technique to identify literature obtained from official websites and journals regarding the potential antidiabetic activity of a combination of basil leaves and red ginger. The questions are then grouped and conclusions are drawn. The stages carried out in the scoping review were developed based on the methodological framework proposed by Arksey and O'Malley (Page et al., 2021). In this study, an in-depth analysis was conducted to identify gaps in evidence-based articles relevant to the topic raised, so that the articles used must have clear and accountable sources (Tricco et al., 2016). The information obtained in the search for reputable national and international scientific articles was conducted through a comprehensive literature search using the electronic databases Google Scholar, Science Direct, Semantic Scholar, and PubMed published in the last 10 years (2015-2025). The initial database search strategy was determined in advance according to the combination of keywords used related to the topic and title of the study, namely "basil leaves," "ocimum basilicum," "red ginger," "zingiber officinale," "phytochemistry," "diabetes mellitus," and "antidiabetic." The stages involved in this scoping review were planned and carried out in accordance with PRISMA ScR (priority reporting item for systems review and a meta-analysis extension for scoping review), namely (1) identifying the questions or objectives of the review; (2) identifying relevant articles; (3) selecting articles; (4) mapping the data; and (5) compiling, summarizing, and reporting the results. Articles that meet these criteria will be further examined regarding the potential antidiabetic activity of the combination of basil leaves and red ginger. The results will then be presented and explained in narrative form, and conclusions will be drawn (Page et al., 2021).

Data Selection

In writing a scoping review, a strategy is needed for searching the literature to obtain relevant sources and data. Research questions can be formulated to facilitate the literature search process. The process of formulating research questions can be based on the PICO framework (Population, Intervention, Comparison, Outcomes) so that by using this method, the literature will be uniform according to the established criteria. Initial search for research articles was then identified whether it met the PICO eligibility criteria as follows: population: diabetes mellitus, Intervention: basil leaves and red ginger; Comparison: -; Results: there are phytochemical compounds and antidiabetic activity; Research design using laboratory, clinical, in vivo and in vitro experimental studies. The reference list was obtained through literature searches using electronic databases from the last 10 years (2015–2025) using predetermined keywords. The selected articles were then filtered based on inclusion criteria, including complete articles published in the last 10 years (2015–2025) in Indonesian and/or English, articles with full text access, research subjects were experimental animals or humans with diabetes mellitus, the intervention was basil leaves and red ginger, and the results of this study were phytochemical compounds and antidiabetic activity. Exclusion criteria included articles that were not available in full text, articles that were not relevant to the antidiabetic and/or phytochemical activities of basil leaves and red ginger, articles that used plants other than basil leaves and red ginger, articles that included scoping reviews, systematic reviews, meta-analyses, literature reviews and reviews or comments, or articles that were not fully accessible.

The literature selection stage involved selecting literature according to predetermined keywords. The literature inclusion category was articles relevant to the research problem as the main review. Therefore, further screening was conducted on 1,229 articles and resulting in a final selection of 8 articles to obtain full-text articles written in Indonesian or English. The screening was followed by reading the full text, then a critical assessment was carried out to assess the feasibility of the article, especially its suitability for the research objectives. Based on the above criteria, articles were selected for further analysis by designing a PRISMA ScR flowchart showing the process of literature search, screening, and the final results of the literature to be reviewed. In the data extraction and synthesis of the research evidence collected, this stage summarizes the data from the selected research articles into a simple table. In preparing the systematic review report, relevant references are analyzed, summarized, and organized to be reported in the form of results and discussion.

RESULT

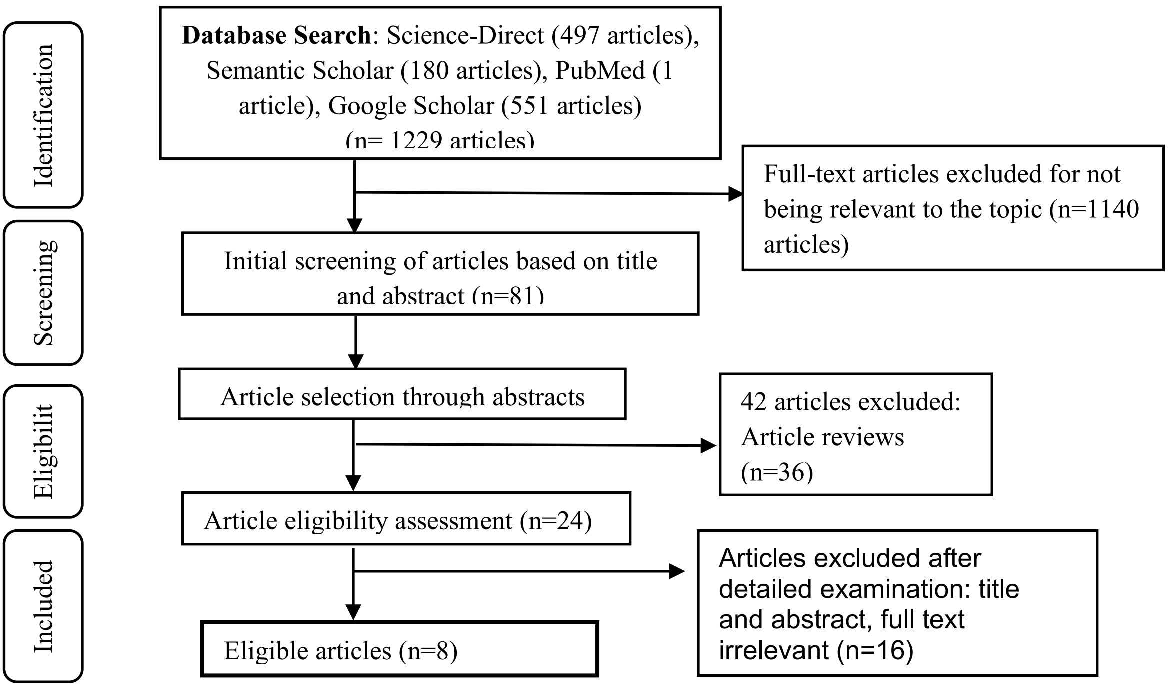

Figure 1. PRISMA-ScR diagram

This study is an elaboration of several theories and findings obtained from various sources to form the basis of the research, so that the theories found become the researcher's steps in conducting research and can better understand the issues at hand in accordance with the scientific framework of thinking. Based on the article search conducted on four databases, the selection began with reading the titles and abstracts, then articles that were not relevant to the objective review were deleted, resulting in 1229 articles. These articles were filtered and reviewed in depth to identify articles that were not relevant to the topic, duplicate articles, or articles that did not meet the inclusion criteria, resulting in a reduction of 24 articles. Next, the articles were reviewed and reassessed to consider their relevance, feasibility, clarity, and research quality, resulting in a final selection of 8 articles, the details of which are presented in (Figure 1).

Table 1.
Phytochemistry

No	Species Plant	Part Plant	Method Extraction	Solvent used	Content of secondary metabolites	References
1.	Ocimum basilicum L	Leaves basil	Maceration	Ethanol	Alkaloids, Flavonoids, Saponin and Tannin.	(Tandi *et al.*, 2021)
2.	Zingiber officinale	Red ginger	Maceration	Water	Phenolics, Tannins, Flavonoids, Saponins, Alkaloids, Glycosides, Steroids, Carbohydrates.	(Momoh *et al.*, 2022)
3.	Ocimum basilicum L	Leaves basil	Maceration	Ethanol	Flavonoids, Saponins, Tannin, Alkaloid.	(Febrianti *et al.*, 2025)
4.	Zingiber officinale	Red ginger	Infusion	Water	Flavonoids, Tannins, Saponins, Steroids, Glycosides.	(Fadhilah *et al.*, 2023)
5.	Zingiber officinale	Red ginger	Reflux	Ethanol	Alkaloids, Flavonoids, Tannins, Polyphenols, Saponins, Monoterpenes, and Sesquiterpenes.	(Herawati and Saptarini, 2020)
6.	Zingiber officinale	Red ginger	Maceration	Ethanol	Phenolics, Tannins, Flavonoids, Saponins, Alkaloids, Glycosides, Steroids, Triterpenoids	(Silvyana et al., 2024)
7.	Ocimum basilicum L	Basil leaves	Maceration	Ethanol	Alkaloids. Flavonoids, Saponins, Tannins, Steroid	(Marsila et al., 2025)
8.	Ocimum basilicum L	Basil leaves	Maceration	Ethanol	Alkaloids, Flavonoids, Phenols, Saponins, Tannins, Steroids	(Chandra et al., 2019)

Various phytochemicals have been identified as secondary metabolites in basil and red ginger leaves. Natural ingredients used in therapy are a group of secondary metabolites derived from plants. Secondary metabolites are not essential for plant growth. In general, secondary metabolites play an important role in defense against other organisms. The presence of secondary metabolites is limited to the source plant or plant strain. Compounds included in the secondary metabolite group include flavonoids and phenolic compounds. Flavonoids are found in almost all parts of plants, including roots, leaves, flowers, fruits, and seeds. Phenolic compounds are abundant in plants, especially those containing aromatic compounds with benzene and hydroxyl structures (Montané *et al.*, 2020).

The literature data in the table above shows that basil leaves and ginger rhizomes contain various secondary metabolites, and that the extraction methods and types of solvents used can affect the results obtained. Basil leaves extracted with ethanol using the maceration method contain alkaloids, flavonoids, saponins, and tannins (Tandi *et al.*, 2021; Febrianti *et al.*, 2025). (Nadeem *et al.*, 2022). The phenolic and flavonoid compounds in basil ethanol extract act as antioxidants that can capture free radicals and inhibit carbohydrate digestive enzymes such as alpha-amylase and alpha-glucosidase (Fitriani *et al.*, 2021). Additionally, the flavonoid and phenolic compounds in basil leaves can metabolize increased glucose and stimulate beta cells in the pancreas to produce insulin, thereby lowering blood glucose levels (Dasgan *et al.*, 2022). Another mechanism of flavonoids is to prevent damage to beta cells in the pancreas through their antioxidant activity, which neutralizes or captures free radicals, allowing damaged tissue to be repaired. Meanwhile, red ginger extracted using maceration and infusion methods with water as a solvent was found to contain secondary metabolites such as phenolics, flavonoids, tannins, saponins, alkaloids, steroids, and carbohydrates (Momoh *et al.*, 2022 ; Fadhilah *et al.*, 2023). Other studies also indicate that bioactive compounds in ginger, namely flavonoids, gingerol, shogaol, and oleoresin (Sulistyoningsih *et al.*, 2018). The main compounds in ginger, which belong to the phenolic group, such as gingerol and shogaol, function as antidiabetic agents through glucose metabolism in the liver, by activating enzymes such as protein kinase by activating adenosine monophosphate, and the catalytic activity of AMPK is activated and produces energy or ATP by facilitating the catabolic pathway (Rusli *et al.*, 2022).

Table 2.
Data extraction and synthesis from research articles

No.	Title, Author, Year	Species plant	Objective Research	Extract	Study	Method	Results
1.	Qualitative and quantitative determination of secondary metabolites and antidiabetic potential of Ocimum basilicum L.leaf extract (Tandi *et al.*, 2021)	*Ocimum basilicum L.*	To determine the levels of secondary metabolites and clarify the effects of the extract on blood glucose levels and pancreatic histology in STZ-induced rats.	Ethanol	*In vivo*	Six groups of test animals were given positive control and comparison treatments.	The results of the study showed that basil leaves at doses of 400 and 800 mg/kgBW were significantly effective in reducing blood glucose levels and were able to regenerate pancreatic cells in rats, indicating that basil leaves have potential as an antidiabetic agent.
2.	Phytochemical screening, Gas chromatography : Mass spectrometry and Antidiabetic properties of the aqueous extract of ginger (Zingiber officinale) in alloxan-induced diabetic Wistar rats (Momoh *et al.*, 2022)	*Zingiber officinale*	To determine the phytochemicals, GC-MS, AAS, and antidiabetic properties of ginger extract in alloxan-induced diabetic Wistar rats.	Water	*In vivo*	Five groups of test animals were given positive control and comparison treatments for 15 days	Administration of ginger water extract at a dose of 200 mg/kgBW and 400 mg/kgBW for treatment for 15 days can reduce blood glucose levels in Wistar rats induced by alloxan and protect against DM and its complications
3.	Enhancing the antidiabetic and antimicrobial performance of Ocimum basilicum and Ocimum sanctum (L) using silver nanoparticles (Malapermal *et al.*, 2017)	*Ocimum basilicum L*	To develop and analyze the potential of AgNPs synthesized from Ocimum basilicum and Ocimum sanctum L that function as antidiabetic and antimicrobial agents	Ethanol and water	*In vitro*	Inhibitors of α-amylase and α-glucosidase	AgNPs synthesized from Ocimum basilicum extract and Ocimum sanctum L extract, as well as the crude extracts of both materials, showed a greater inhibitory effect on alpha-amylase than acarbose, indicating that Ocimum basilicum could be a candidate for natural antidiabetic therapy.

No.	Title, Author, Year	Species plant	Objective Research	Extract	Study	Method	Results
4.	Potential in vitro antioxidant, anti-inflammatory, antidiabetic, and anticancer effects of arachidonic acid-elicited basil leaves (Złotek *et al.*, 2017)	*Ocimum basilicum L*	To evaluate the impact of basil leaves with arachidonic acid on the content and bioactivity (measured as antioxidant, anti-inflammatory, antidiabetic, and antiproliferative potential) of polyphenols from chemical extracts and from samples obtained after digestion (potential bioavailability)	Ethanol	*In vitro*	Inhibitors of α-amylase and α-glucosidase	The phenolic compounds found in basil leaves have the potential as bioavailable phytochemicals with high biological activity. Elicitation with arachidonic acid can increase the activity of phenolic compounds that can inhibit α-glucosidase and α-amylase, so that basil leaves have the potential to strengthen pro-health activities as an antidiabetic through this mechanism.
5.	Volatiles, phenolic compounds, and bioactive properties of essential oil and aqueous extract of purple basil (Ocimum basilicum L.) and antidiabetic activity in streptozotocin-induced diabetic Wistar rats.(Kanmaz *et al.*, 2023)	*Ocimum basilicum L.*	To determine the bioactive properties and antidiabetic activity of aqueous extract (BAE) and essential oil (BEO) from basil leaves	Water	*In vitro* and *in vivo*	α-amylase and α-glucosidase inhibitors and 6 groups of test animals were given positive control and comparison treatments.	In this study, water extract (BAE) and essential oil (BEO) from basil leaves were found to effectively inhibit α-glucosidase and α-amylase due to their active compounds such as phenolics and flavonoids, which exhibit antioxidant and antidiabetic activities. Consequently, the administration of BAE and BEO significantly reduced blood glucose levels in STZ-induced diabetic rats.
6.	Evaluation of of the combination of leaf infusion betel *(Piper betle L.)* and ginger rhizome infusion *(Zingiber officinale Rosc.)* on male Wistar rats as a model hyperglycemia (Fadhilah *et al.*, 2023)	*Zingiber officinale*	To determine the empirical effectiveness of betel leaf and ginger rhizome in lowering blood glucose levels in male hyperglycemic rats or to test their antidiabetic activity.	Water	*In vivo*	Six groups of test animals were given positive control and comparison treatments	The results of the study showed that a single dose of ginger rhizome infusion, namely 2 ml/kgBW, in male Wistar rats induced with alloxan, was effective in lowering blood glucose levels compared to the combination infusion.
7.	Effect of ginger extract on reducing blood sugar levels in glucose-induced mice.(Hadijah *et al.*, 2023)	*Zingiber officinale*	To determine the effectiveness of red ginger extract in reducing blood glucose levels in glucose-induced mice.	Ethanol	*In vivo*	Five groups of test animals were given positive control and comparison treatments.	The results of this study indicate that ginger has the potential to provide optimal results at a concentration of 5% w/v, namely a decrease in blood glucose levels in glucose-induced mice, thus proving that ginger rhizome functions as an antidiabetic agent.

No.	Title, Author, Year	Species plant	Objective Research	Extract	Study	Method	Results
8.	Effectiveness of giving red ginger extract in preventing damage to β-pancreatic cells in Wistar strain white rats (Rattus norvegicus) (Wira, 2019) .	*Zingiber officinale*	To analyze the effectiveness of ginger extract in preventing damage to pancreatic beta cells in Wistar strain white rats.	Ethanol	*In vivo*	Five groups of test animals were given positive control and comparison treatments.	In this study, administration of red ginger extract at a dose of 750 mg/kgBW was the most effective in lowering blood glucose or preventing diabetes mellitus in alloxan-induced rats.

DISCUSSION

Based on the results of all the literature reviewed, basil leaves and red ginger have bioactive content through various mechanisms, both in vitro and in vivo, which have the potential to act as antidiabetic agents by inhibiting carbohydrate digestion enzymes and improving pancreatic function. Diabetes mellitus is a metabolic disorder caused by the body's inability to produce or respond to insulin in the pancreas, resulting in elevated blood glucose levels. Antidiabetic activity is the ability of a substance or compound to lower or stabilize high blood glucose levels through several mechanisms, including oral medication, herbal remedies, and insulin injection therapy (Alam et al., 2021) .

From existing studies, basil and ginger leaves have been proven to have antidiabetic effects that can control blood glucose levels. This shows the benefits of basil and ginger leaves in preventing various macrovascular and microvascular complications caused by diabetes mellitus, thereby improving the quality of life of patients (Elgebaly et al., 2019). Various metabolites found in basil leaves and red ginger, such as flavonoids, alkaloids, saponins, steroids, tannins, phenols, terpenoids, glycosides, gingerol, shogaol, and zingiberon, each have their own mechanisms or pharmacological effects in controlling blood glucose levels. Several studies have shown that basil leaves can lower blood glucose levels. A study conducted by Tandi et al., (2021) showed that administering 400 and 800 mg/kgBW of basil leaf ethanol extract significantly reduced blood glucose levels and improved pancreatic histology in male Wistar rats induced with STZ, indicating the occurrence of a protective mechanism in pancreatic beta cells.

Another study conducted by Al-Subhi and Ibrahim Wa, (2020) showed that from two basil leaf cultivars, namely Italian Genovese and Thyrsilora, in streptozotocin-induced diabetes model mice were able to reduce blood glucose levels and increase the function of the insulin hormone. This supports the role of basil leaves in various mechanisms, both through pancreatic cell protection and glucose absorption inhibition. Other studies also show results from in vitro research that basil leaf extracts in various forms, whether ethanol, water, or essential oil extracts, have a significant ability to inhibit alpha-amylase and alpha-glucosidase. The flavonoid and phenolic compounds contained in basil leaves are thought to be the main components that support this activity. Thus, basil has the potential to lower postprandial blood glucose through the mechanism of inhibiting carbohydrate digestion while providing antioxidant and anti-inflammatory protection (Złotek et al., 2017; Kanmaz et al., 2023).

The active metabolites in basil leaves have mechanisms that function as anti-diabetics, including the flavonoid mechanism, which increases insulin secretion and increases Ca2+ ion influx through calcium channels, resulting in exocytosis of insulin granules and causing insulin to be secreted into the bloodstream (Rumengan et al., 2019). The role of insulin in blood glucose regulation. Body cells depend on insulin to absorb glucose from the blood as energy, to control the body's use and storage of fat and glucose. Disrupted pancreatic beta cells result in metabolic disorders that cause excess glucose to accumulate in the blood (Nurfitri et al., 2018) . In addition, another mechanism of flavonoids is to activate nuclear factor-kB (NF-kB) and peroxisome proliferator-activated gamma receptors (PPAR-γ) by increasing glucose uptake in muscle tissue. On the other hand, the mechanism of flavonoids and phenolics in basil leaves can delay intestinal glucose absorption by inhibiting the alpha-amylase and alpha-glucosidase enzymes involved in carbohydrate metabolism, thereby reducing postprandial hyperglycemia (Ezeani et al., 2017).

Basil leaves also contain alkaloids that activate the glucose transporter type 4 (GLUT4) translocation cycle, inhibit dipeptidyl peptidase-4, 5'-adenosine monophosphate-activated protein kinase, and inhibit protein tyrosine phosphatase (PTP) 1B. Saponins work by preventing carbohydrate absorption in the intestines by inhibiting the enzymes alpha-amylase and alpha-glucosidase, which metabolize carbohydrates. Inhibition of these enzymes results in increased peripheral glucose uptake and increased tissue insulin receptor sensitivity. Tannin content can also alter the enzymes that break down glucose, thereby reducing carbohydrate absorption in the intestine and helping to regenerate damaged pancreatic beta cells and inhibit adipogenesis (Xu et al., 2018; Kumar et al., 2019; Rasouli et al., 2020) .

Red ginger contains various bioactive compounds, primarily gingerol, shogaol, and zingiberone, which have pharmacological effects that are antioxidant, anti-inflammatory, and antipyretic, thereby effectively lowering blood glucose levels. Research conducted by Momoh et al. (2022) showed that ginger water extract administered for 15 days at a dose of 200-400 mg/kgBW can lower blood glucose levels in alloxan-induced rats and provide a protective effect against diabetes complications. Other studies (Hadijah et al., 2023; Wira, 2019) show that red ginger ethanol extract at an optimal dose of 750 mg/kgBW effectively lowers blood glucose levels while preventing damage to pancreatic β-cells. This confirms that red ginger works not only as a glucose-lowering agent but also as a protector of pancreatic tissue through its antioxidant mechanism. The bioactive compounds found in red ginger are gingerol, paradol, and shogaol. Their mechanism of action helps metabolize glucose in the liver by activating several enzymes such as adenosine monophosphate-activated protein kinase, which subtly affects the balance within cells, and by activating AMPK catabolic activity, which facilitates the catabolic pathway in the production of energy (Rusli et al., 2022) .

From these comparisons, it is evident that basil leaves and red ginger have different mechanisms of action that complement each other. Basil leaves predominantly work by inhibiting the enzymes α-amylase and α-glucosidase through carbohydrate metabolism in the intestine and regenerating the pancreas, while ginger works to improve insulin sensitivity and protect pancreatic β cells. Therefore, these two plants have the theoretical potential to be combined and provide a synergistic effect, namely lowering blood glucose levels while improving pancreatic function. However, evidence or research testing the combination of basil and red ginger extracts in diabetes models has not yet been found.

The limitations of the existing literature are the dominance of in vivo studies using animal models, while clinical studies in humans are very limited. In addition, research related to the interaction between basil leaves and red ginger with commonly used antidiabetic drugs needs attention to prevent the possibility of unwanted interactions. Variations in extraction methods, types of solvents, and different doses can affect the results, making it difficult to generalize the findings. Therefore, further research with standardized designs, long-term toxicity tests, and controlled clinical trials in humans is urgently needed. This evidence provides opportunities for further research into the development and utilization of the combination of these two plants, basil leaves and red ginger, as a safe and effective complementary therapy for diabetes mellitus patients.

CONCLUSION

Based on the literature review conducted, it can be concluded that through various mechanisms, basil leaves and red ginger have potential as antidiabetic agents. Both plants are easily found and contain various metabolic compounds such as flavonoids and phenolics like gingerol and shogaol. The mechanisms underlying the antidiabetic activity of these compounds include protecting the body from free radicals, reducing the activity of enzymes that break down carbohydrates, improving the body's ability to respond to insulin, and helping to regulate glucose metabolism in the blood. This shows that both plants, when used separately, can have a consistent effect in lowering blood glucose levels and improving metabolic parameters in both in vivo and in vitro studies. However, scientific evidence regarding the combination of these two plants is still unavailable, so the potential benefits of combining them cannot yet be empirically proven. Therefore, basil leaves and red ginger have the potential to be developed into antidiabetic phytopharmaceuticals, and further research is needed to confirm their efficacy, dosage standards, and long-term safety, including clinical trials in humans, before they can be widely applied as complementary therapy alternatives.

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