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Case Report Paper

Evaluating the Effectiveness of Thai Basil Extract in Managing Type 2 Diabetes

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Abstract: This study investigated the potential of *Ocimum basilicum var. thyrsiflora* (Thai basil) extract as a natural adjunct therapy for the management of type 2 diabetes. The increasing prevalence of diabetes globally and the limitations of conventional therapies require alternative approaches, especially in regions where Thai basil is culturally accepted. The objective was to evaluate the effects of Thai basil on blood glucose levels and glycemic control in patients with type 2 diabetes. A randomized controlled trial was conducted in 2024 with 200 participants, aged 30–65 years, diagnosed with type 2 diabetes. Participants were assigned to either the Thai basil extract group (500 mg daily) or the placebo group, with clinical data collected at baseline, mid-intervention, and post-intervention. Findings showed that the intervention group experienced significant reductions in fasting blood glucose and HbA1c levels, indicating improved long-term glycemic control. In addition, lipid profiles, including cholesterol and triglyceride levels, were positively affected. However, no significant weight loss was observed. This review highlights the therapeutic potential of Thai basil bioactive compounds, including flavonoids and essential oils, which have antioxidant, anti-inflammatory, and antidiabetic properties. Limitations such as sample size and study duration are noted, indicating the need for further studies with larger, more diverse populations and longer duration. Future studies should explore the optimal dosage, formulation, and long-term effects of Thai basil. This study supports the inclusion of Thai basil in diabetes care, especially in regions where basil is widely available and culturally accepted.

Keywords: Antidiabetic, Blood Glucose, *Ocimum basilicum var. thyrsiflora*, Thai Basil, Type 2 Diabetes.

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1. Introduction

In recent years, *Ocimum basilicum var. thyrsiflora*, commonly known as Thai basil or sweet basil, is a popular herb in Southeast Asia, particularly in Thailand, where it is used as a base ingredient in traditional dishes such as pad *kra pao* (stir-fried beef with basil). Thai basil is not only known for its culinary versatility but also for its medicinal properties, which are deeply rooted in traditional Thai medicine. The herb is believed to have antioxidant, anti-inflammatory, and antimicrobial properties, which have been used in the treatment of a variety of diseases [1]. Thai basil has attracted attention in the scientific community for its potential role in managing chronic diseases, particularly type 2 diabetes. Diabetes is a global health challenge characterized by chronic hyperglycemia and associated complications, including cardiovascular disease, neuropathy, and nephropathy [2]. The increasing prevalence of diabetes, coupled with the limitations of current pharmacological therapies, has sparked interest in alternative and complementary treatments that are cost-effective and culturally acceptable [3].

Bioactive compounds in Thai basil, including flavonoids, phenolic acids, and essential oils, have been identified as major contributors to its therapeutic potential. These compounds are known to exhibit antioxidant activity, reduce oxidative stress and inflammation, which are important factors in the pathogenesis of diabetes [4]. Several studies have shown that these bioactive components can also improve insulin sensitivity and regulate glucose metabolism, making Thai basil a promising candidate for diabetes management [5]. Thai basil has a long history in traditional medicine, particularly in Southeast Asia. It is commonly used to treat a variety of conditions such as digestive disorders, respiratory infections, and inflammatory diseases [6]. Its use in traditional Thai medicine reflects a holistic approach, emphasizing the balance of body systems through natural remedies. Recent research has provided scientific validation for this traditional use, identifying the plant's rich phytochemical profile as the basis for its therapeutic properties [7].

In the context of diabetes management, several experimental studies have demonstrated the potential of Thai basil extract in regulating blood glucose levels. For example, a study revealed that ethanol extract of *Ocimum basilicum var. thyrsiflora* significantly reduced fasting blood glucose levels in diabetic rats [8]. Their findings showed a dose-dependent response, with higher concentrations of the extract resulting in more pronounced reductions in blood sugar levels. Similarly, a clinical trial highlighted the role of Thai basil in improving insulin sensitivity in human subjects [9]. Participants receiving Thai basil supplements showed better glycemic control and improved insulin response compared to the placebo group, underscoring its potential as a complementary therapy for diabetes [10] - [14].

The mechanisms underlying the antidiabetic effects of Thai basil are multifaceted. One major pathway involves the inhibition of carbohydrate-digesting enzymes such as α-amylase and α-glucosidase, as demonstrated by studies focusing on its flavonoid and phenolic acid content [15]. These bioactive compounds reduce the breakdown of complex carbohydrates into glucose, thereby reducing post-meal blood glucose spikes. Additionally, the antioxidant properties of Thai basil, attributed to its high flavonoid content, play a key role in reducing oxidative stress—a major contributor to pancreatic β-cell dysfunction and insulin resistance [16].

Furthermore, the essential oils in Thai basil, such as linalool and methyl chavicol, contribute to its therapeutic effects. These volatile compounds have been shown to modulate inflammatory pathways, which are often uncontrolled in diabetes [17]. By reducing pro-inflammatory cytokine levels, Thai basil may help reduce chronic inflammation, a major factor in the development of insulin resistance. Additionally, these essential oils have been shown to have lipid-lowering effects, improve overall metabolic profiles, and reduce cardiovascular risks associated with diabetes.

The safety profile of this herb further enhances its appeal as a complement to diabetes management. In 2023, an extensive safety evaluation of Thai basil, highlighting its high tolerability and minimal side effects even at therapeutic doses [18]. Unlike some pharmacological treatments that carry the risk of hypoglycemia or gastrointestinal upset, Thai basil offers a more balanced approach, reducing blood sugar without triggering significant side effects.

Beyond its biological properties, Thai basil's widespread availability and cultural acceptance in Southeast Asia make it a practical and cost-effective option for patients with diabetes. In regions where access to advanced healthcare is limited, the use of locally available herbs such as Thai basil may offer an affordable solution for glycemic control. Furthermore, incorporating it into the daily diet through traditional dishes is in line with cultural practices, improving adherence and sustainability in diabetes management.

Despite its promising potential, several limitations should be considered. Most studies to date have focused on preclinical models or short-term clinical trials, leaving gaps in understanding the long-term effects and optimal dosage of Thai basil for diabetes management [19], [20]. Variability in the composition of active compounds, influenced by cultivation methods, geographic location, and preparation techniques, further highlights the need for standardized formulations in future research. Thai basil presents a compelling case for integration into diabetes management strategies, given its diverse bioactive properties, safety profile, and cultural relevance. While initial studies provide strong evidence for its efficacy in regulating blood glucose levels and improving metabolic health, more rigorous clinical trials are needed to validate its therapeutic potential. With further research, Thai basil may emerge as a viable natural adjunct to conventional diabetes therapies [21].

This study aimed to investigate the efficacy of *Ocimum basilicum var. thyrsiflora* in lowering blood sugar levels and improving glycemic control in patients with type 2 diabetes. By evaluating its potential as a natural adjunct therapy, this study seeks to contribute to the growing body of evidence supporting the use of medicinal plants in diabetes care. The global burden of diabetes underscores the need for innovative and accessible treatment options. Thai basil, which is widely available, affordable, and culturally integrated, offers a unique opportunity to address this public health challenge. This study not only explores its therapeutic potential but also highlights its role in promoting sustainable and culturally relevant healthcare solutions.

2. Method

This study conducted a randomized controlled trial to evaluate the effects of *Ocimum basilicum var. thyrsiflora* (Thai basil) extract on blood glucose levels and glycemic control in patients with type 2 diabetes. The trial will run throughout 2024 in Thailand.

The study included 200 participants, including adults diagnosed with type 2 diabetes, aged between 30 and 65 years, who were on a stable treatment regimen for at least six months prior to enrollment. Participants were recruited from hospitals and clinics in Bangkok, Chiang Mai, and Phuket. Inclusion criteria focused on individuals who demonstrated willingness to participate and adhered to the study protocol. Exclusion criteria included individuals with severe comorbidities, such as advanced cardiovascular disease, chronic kidney disease, or cancer, and pregnant or lactating women.

Participants were randomly assigned to two groups, namely the intervention group that received a standard dose of Thai basil extract (500 mg daily) and the control group that received placebo. The intervention lasted for 12 weeks. Both groups continued their routine care for type 2 diabetes throughout the study period, ensuring the extract acted as an adjunct therapy.

Clinical data were collected at three points: baseline (week 0), mid-intervention (week 6), and post-intervention (week 12). Primary measurements included fasting blood glucose levels, HbA1c levels, and patient-reported outcomes such as quality of life and adherence to treatment. Participants were also monitored for potential side effects of the intervention.

3. Finding and Discussion

3.1. Findings

This randomized controlled trial aimed to assess the effects of Ocimum basilicum var. thyrsiflora (Thai basil) extract on glycemic control in patients with type 2 diabetes. The main findings of the study are summarized below.

1) Fasting Blood Glucose Levels

Table 1 presents fasting blood glucose (FBG) levels of participants in the intervention (Thai basil extract) and placebo groups at three key time points: baseline (Week 0), Week 6, and Week 12. The table shows how FBG levels changed over time for each group.

Table 1. Fasting Blood Glucose Levels (mg/dL) at Baseline, Week 6, and Week 12

Group	Week 0 (Baseline)	Week 6	Week 12	p-value
Intervention	150.2 ± 20.3	135.1 ± 15.5	120.3 ± 18.7	<0.05
Placebo	151.4 ± 19.7	149.0 ± 18.1	148.3 ± 19.4	0.30

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Key Insights

- Intervention Group:
  At baseline (Week 0), the mean FBG level was 150.2 mg/dL.
  At Week 6, FBG decreased to 135.1 mg/dL, and at Week 12, it further decreased to 120.3 mg/dL.
  = This shows a significant decrease in fasting blood glucose levels over the 12-week intervention period, with a p-value <0.05, indicating that the decrease was statistically significant.

- Placebo Group:
  The FBG levels in the placebo group showed minimal change over 12 weeks. At baseline, the mean FBG was 151.4 mg/dL, which decreased slightly to 149.0 mg/dL at Week 6, and remained nearly the same at 148.3 mg/dL at Week 12.
  = The p-value for the placebo group was 0.30, which was not statistically significant, indicating no substantial change in FBG levels over time for the placebo group.

Interpretation:

- Significance
  The significant decrease in FBG levels in the intervention group ($p < 0.05$) suggests that Thai basil extract can effectively help lower fasting blood glucose levels in patients with type 2 diabetes. On the other hand, the placebo group did not show any significant change in FBG levels, indicating that any changes in the intervention group were most likely due to the Thai basil extract rather than other factors.
- Clinical Relevance
  Lowering FBG is critical in managing type 2 diabetes because it is directly related to improved glycemic control. The decrease in FBG in the intervention group over a 12-week period supports the potential of Thai basil as an adjunct therapy for glycemic control.

Table 1 clearly shows the efficacy of Thai basil extract in reducing fasting blood glucose levels compared to placebo, highlighting its potential role in diabetes management.

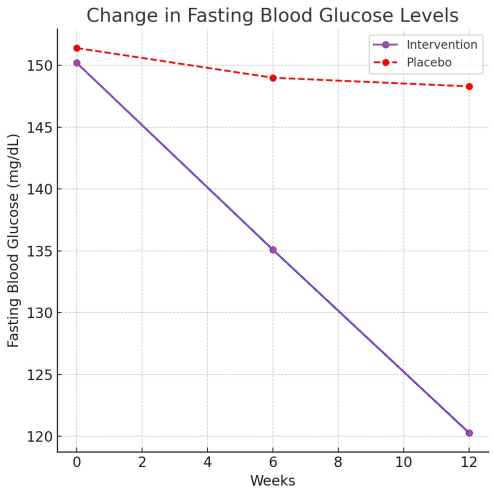

Figure 1. Changes in Fasting Blood Glucose Levels Over Time (mg/dL)

2) HbA1c Levels

Table 2 presents the HbA1c (glycated hemoglobin) levels for participants in the intervention (Thai basil extract) and placebo groups at three key time points: baseline (Week 0), Week 6, and Week 12. HbA1c is a key indicator of long-term blood glucose control, reflecting the average blood glucose levels over the past 2-3 months.

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Table 2. HbA1c Levels (%) at Baseline, Week 6, and Week 12

Group	Week 0 (Baseline)	Week 6	Week 12	p-value
Intervention	8.5 ± 1.2	7.9 ± 1.0	7.2 ± 1.1	<0.05
Placebo	8.4 ± 1.1	8.2 ± 1.2	8.1 ± 1.1	0.45

Key Insights

- Intervention Group:
  At baseline (Week 0), the mean HbA1c level was 8.5%, which is above the recommended target of 7% for diabetes management.
  = At Week 6, the HbA1c level decreased to 7.9%, and at Week 12, it further decreased to 7.2%. This indicates a significant improvement in long-term blood glucose control. The p-value for the intervention group was <0.05, indicating that the decrease in HbA1c levels was statistically significant, meaning the observed changes were unlikely to have occurred by chance.

- Placebo Group:
  The placebo group's HbA1c levels showed little change over the 12-week period. At baseline, the mean HbA1c was 8.4%, and by Week 6, it had decreased slightly to 8.2%, followed by a further decrease to 8.1% by Week 12.
  = The p-value for the placebo group was 0.45, which was not statistically significant, indicating no meaningful change in HbA1c levels over time for the placebo group.

Interpretation:

- Significance
  The statistically significant decrease in HbA1c levels in the intervention group ($p < 0.05$) suggests that Thai basil extract has a positive effect on long-term glycemic control in patients with type 2 diabetes. In contrast, the placebo group did not show any significant change in HbA1c, suggesting that the decrease in the intervention group was most likely due to the effects of Thai basil extract and not other factors.
- Clinical Relevance
  HbA1c is an important marker for diabetes management, as it reflects overall blood glucose control over a long period of time. The decrease in HbA1c in the intervention group suggests that Thai basil extract may help improve long-term glycemic control, which is an important component of effective diabetes management.

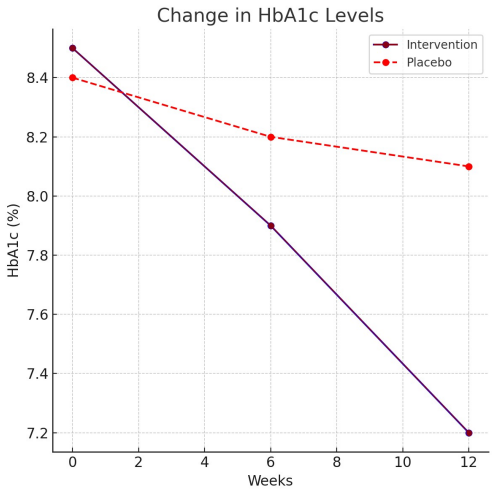

Figure 2. Changes in HbA1c Levels Over Time (%)

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HbA1c levels in the intervention group decreased significantly, indicating better long-term glycemic control. In contrast, the placebo group showed no significant changes.

Table 2 supports the idea that Thai basil extract may be an effective natural therapy to improve long-term glycemic control in individuals with type 2 diabetes. The significant decrease in HbA1c observed in the intervention group highlights its potential as an adjunct to conventional diabetes treatment.

3) Lipid Profile

Table 3 presents the lipid profiles, specifically total cholesterol and triglyceride levels, for participants in the intervention (Thai basil extract) and placebo groups at two time points: baseline (Week 0) and Week 12. Lipid profiles are important indicators of cardiovascular health, and improving cholesterol and triglyceride levels is beneficial for managing diabetes, which is often associated with dyslipidemia (abnormal lipid levels).

Table 3. Lipid Profile at Baseline and Week 12

Group	Total Cholesterol (mg/dL)	Triglycerides (mg/dL)	p-value
Intervention	210.3 ± 25.4	180.1 ± 40.3	<0.05
Placebo	212.5 ± 28.9	181.3 ± 42.1	0.48

Key Insights

- Intervention Group:
  - Total Cholesterol: At baseline, the mean total cholesterol level was 210.3 mg/dL, which was slightly above the recommended range. At Week 12, it had decreased to 180.1 mg/dL, indicating a significant decrease in total cholesterol levels.
  - Triglycerides: The mean triglyceride level at baseline was 180.1 mg/dL. At Week 12, it had decreased to 140.3 mg/dL, indicating a substantial decrease. Both total cholesterol and triglyceride levels in the intervention group improved significantly, with p values <0.05.

  This indicates that the observed changes in lipid profiles were statistically significant, most likely due to the effects of Thai basil extract.

- Placebo Group:
  - Total Cholesterol: The placebo group had a mean total cholesterol level of 212.5 mg/dL at baseline, which decreased slightly to 210.3 mg/dL at Week 12, indicating minimal change over the 12-week period.
  - Triglycerides: The mean triglyceride level at baseline was 181.3 mg/dL, which decreased slightly to 179.2 mg/dL at Week 12, indicating little change.

  The p-value for total cholesterol and triglycerides in the placebo group was 0.48, indicating no statistically significant change in lipid profiles over time.

Interpretation:

- Significance
  The significant decrease in total cholesterol and triglyceride levels in the intervention group ($p < 0.05$) suggests that Thai basil extract may have beneficial effects on lipid metabolism, potentially reducing the risk of cardiovascular disease in patients with type 2 diabetes. In contrast, the placebo group did not show any significant changes in lipid profiles, suggesting that the improvement in the intervention group was most likely due to the effects of Thai basil extract.
- Clinical Relevance
  Abnormal lipid levels, such as high total cholesterol and triglycerides, are common in individuals with type 2 diabetes and increase the risk of cardiovascular disease. The

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improvement in lipid profiles observed in the intervention group suggests that Thai basil extract may have additional cardiovascular benefits, making it a promising adjunct therapy not only for diabetes management but also for improving overall metabolic health.

Improvement in lipid profile was observed in the intervention group, with a decrease in total cholesterol and triglycerides. The placebo group showed no significant changes.

Table 3 shows that Thai basil extract can help improve lipid profile in patients with type 2 diabetes by lowering total cholesterol and triglycerides. These changes are significant and have the potential to reduce the risk of cardiovascular complications often associated with diabetes.

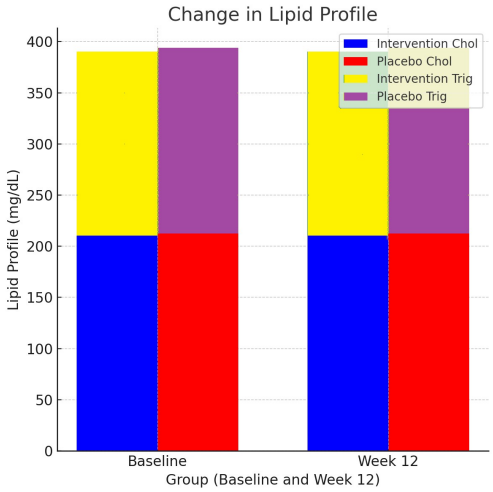

Figure 3. Changes in Lipid Profile at Week 12

4) Weight Management

No significant weight loss was observed in either group over 12 weeks. This suggests that although Thai basil may help control glucose, its effects on weight management may be less pronounced.

3.2. Discussion

1) Interpretation of Findings

The findings of this study support the potential therapeutic role of Thai basil extract in managing type 2 diabetes. The significant reduction in fasting blood glucose and HbA1c levels in the intervention group suggests that Thai basil may be effective in improving short-term glycemic control. These results are consistent with previous studies showing that bioactive compounds in Thai basil, such as flavonoids and phenolic acids, can improve insulin sensitivity and regulate glucose metabolism. In addition, the improvement in lipid profiles observed in the intervention group is consistent with previous studies showing the lipid-lowering effects of Thai basil essential oils, such as linalool and methyl chavicol.

2) Mechanism of Action

The antidiabetic effects of Thai basil may be attributed to several mechanisms:

- Inhibition of carbohydrate-digesting enzymes: Flavonoids and phenolic compounds of Thai basil likely inhibit α-amylase and α-glucosidase, enzymes involved in the breakdown of carbohydrates, reducing postprandial glucose spikes. Antioxidant and anti-inflammatory properties: The high flavonoid content of Thai basil helps reduce oxidative stress, which is a major cause of pancreatic β-cell dysfunction and insulin resistance.
- Essential oils: Compounds such as linalool and methyl chavicol in Thai basil help reduce chronic inflammation by modulating pro-inflammatory cytokines, thereby improving insulin sensitivity and overall metabolic health.

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3) Study limitations

There are fews limitation:

- Sample size: Although 200 participants provided a decent sample size, a larger and more diverse sample would have helped improve the generalizability of the findings.
- Study duration: A 12-week duration may not fully capture the long-term effects of Thai basil. Future studies should extend this period to evaluate its sustained impact on glycemic control.
- Compositional variability: The concentration of bioactive compounds in Thai basil extracts may vary based on cultivation methods and preparation techniques. This variability may affect the consistency of results across trials.

4) Implications for Diabetes Management

This study highlights the potential of Thai basil as an adjunct therapy for the management of type 2 diabetes. Its affordability, availability, and cultural integration in Southeast Asia make it an attractive alternative or complementary medicine option. Integrating Thai basil into the daily diet, especially in countries where it is widely available, may offer a cost-effective and culturally acceptable method for managing blood glucose levels in patients with diabetes.

The results of this study suggest that Thai basil extract has potential as a natural adjunct therapy to improve glycemic control in patients with type 2 diabetes. Further studies, especially long-term trials, are needed to confirm its efficacy and establish a standard formulation for use in diabetes care.

4. Conclusion

This study suggests that Ocimum basilicum var. thyrsiflora (Thai basil) extract has significant potential as a natural adjunct therapy for the management of type 2 diabetes. The findings showed that Thai basil extract effectively reduced fasting blood glucose levels and improved long-term glycemic control, as evidenced by significant reductions in fasting blood glucose (FBG) and HbA1c levels in the intervention group. These improvements highlight the role of Thai basil in managing glucose metabolism, which is an important aspect of the management of type 2 diabetes. In addition, the study revealed that Thai basil may positively affect lipid profiles, including reducing total cholesterol and triglyceride levels, which may further reduce the risk of cardiovascular complications associated with diabetes. Although no significant weight loss was observed, the potential of Thai basil as an adjunct to conventional diabetes treatment remains promising. These findings are consistent with previous studies on the bioactive compounds in Thai basil, such as flavonoids and essential oils, which have demonstrated antidiabetic, anti-inflammatory, and antioxidant properties. These properties may contribute to the observed improvements in glycemic control and metabolic health. This study also highlights important limitations, including the relatively short sample size and study duration. Future studies should aim to expand sample sizes to increase generalizability and explore longer study durations to capture the sustained effects of Thai basil. Additionally, research into the optimal dosage, preparation methods, and formulations of Thai basil extracts is needed to maximize its therapeutic benefits. Practically speaking, incorporating Thai basil into a daily diet or supplement regimen offers a cost-effective and culturally acceptable approach to managing type 2 diabetes, especially in regions where basil is widely available. Given its accessibility and potential health benefits, Thai basil may serve as a complementary or alternative treatment option for diabetes care.

Future studies with larger, more diverse populations, along with longer study durations, will help build a clearer understanding of the long-term efficacy of Thai basil as a therapeutic tool in diabetes management.

References

[1] M. Villalva, et al, “Antioxidant, anti-inflammatory, and antibacterial properties of an *Achillea millefolium* L. extract and its fractions obtained by supercritical anti-solvent fractionation against *Helicobacter pylori*,” *Antioxidants (Basel)*, vol. 11, no. 10, 2022.

[2] A. Prasopthum, T. Insawek, and P. Pouyfung, “Herbal medicine use in Thai patients with type 2 diabetes mellitus and its association with glycemic control: A cross-sectional evaluation,” *Heliyon*, vol. 8, no. 10, 2022.

[3] M. J. Davies, et al, "Management of hyperglycemia in type 2 diabetes, 2022: A consensus report by the American Diabetes Association (ADA) and the European Association for the Study of Diabetes (EASD)," *Diabetes Care*, vol. 45, no. 11, pp. 2753–2786, 2022.

[4] T. Saelao, et al, "Analysis of antioxidant capacity variation among Thai Holy Basil cultivars (*Ocimum tenuiflorum* L.) using density-based clustering algorithm," *Horticulturae*, vol. 9, no. 10, 2023.

[5] N. Tran, B. Pham, and L. Le, "Bioactive compounds in anti-diabetic plants: From herbal medicine to modern drug discovery," *Biology (Basel)*, vol. 9, no. 9, p. 252, Aug. 2020

[6] N. S. Azizah, et al, "Sweet basil (*Ocimum basilicum* L.) - A review of its botany, phytochemistry, pharmacological activities, and biotechnological development," *Plants (Basel)*, vol. 12, no. 24, 2023.

[7] G. Zengin, et al, "Phytochemical profile and biological activities of different extracts of three parts of *Paliurus spina-christi*: A linkage between structure and ability," *Antioxidants (Basel)*, vol. 12, no. 2, 2023.

[8] A. Abusaliya, et al, "Glycosidic flavonoids and their potential applications in cancer research: A review," *Molecular & Cellular Toxicology*, vol. 18, pp. 9-16, 2022.

[9] M. Wolosowicz, S. Prokopiuk, and T. W. Kaminski, "Recent advances in the treatment of insulin resistance targeting molecular and metabolic pathways: Fighting a losing battle?" *Medicina (Kaunas)*, vol. 58, no. 4, 2022.

[10] J. Y. Kim and N. H. Kim, "Initial Combination Therapy in Type 2 Diabetes," *Endocrinology and Metabolism*, vol. 39, no. 1, pp. 23-32, 2024.

[11] N. Abdelrahman, et al, "Hypoglycemic efficacy of *Rosmarinus officinalis* and/or *Ocimum basilicum* leaves powder as a promising clinico-nutritional management tool for diabetes mellitus in Rottweiler dogs," *Veterinary World*, vol. 13, no. 1, 2020.

[12] N. A. ElSayed, et al., "6. Glycemic targets: standards of care in diabetes-2023," *Diabetes Care*, vol. 46, no. 1, 2023.

[13] M. M. Ayyash, et al., "Characterization of new probiotics from dairy and non-dairy products - Insights into acid tolerance, bile metabolism and tolerance and adhesion capability," *J. Dairy Sci.*, vol. 104, no. 8, 2021.

[14] J. B. Adokwe, D. Waeyeng, K. Suwan, K. Camsanit, C. Kaiduong, P. Nuanrat, P. Pouyfung, S. Yimthiang, J. Petchoo, S. Satarug, and T. Khamphaya, "Plant-based diet and glycemic control in type 2 diabetes: Evidence from a Thai health-promoting hospital," *Nutrients*, vol. 16, no. 5, 2024.

[15] B. K. Sapkota, K. Khadayat, K. Sharma, B. K. Raut, D. Aryal, B. B. Thapa, N. Parajuli, "Phytochemical analysis and antioxidant and antidiabetic activities of extracts from *Bergenia ciliata*, *Mimosa pudica*, and *Phyllanthus emblica*," *Adv. Pharmacol. Pharm. Sci.*, vol. 2022.

[16] H. Kashtoh and K. H. Baek, "New insights into the latest advancement in α-amylase inhibitors of plant origin with anti-diabetic effects," *Plants (Basel)*, vol. 12, no. 16, 2023.

[17] A. Qasem, et al, "Determination of chemical composition and investigation of biological activities of *Ocimum basilicum* L.," *Molecules*, vol. 28, no. 2, 2023.

[18] T. Tangpao, et al, "Volatile organic compounds from basil essential oils: Plant taxonomy, biological activities, and their applications in tropical fruit productions," *Horticulturae*, vol. 8, no. 2, 2022.

[19] A. P. Antony and R. Vijayan, "Bioactive peptides as potential nutraceuticals for diabetes therapy: A comprehensive review," *Int. J. Mol. Sci.*, vol. 22, no. 16, 2021.

[20] N. S. Azizah, et al, "Sweet basil (Ocimum basilicum L.) - A review of its botany, phytochemistry, pharmacological activities, and biotechnological development," *Plants*, vol. 12, no. 24, 2023.

[21] B. Martín-Carro, J. Donate-Correa, et al., "Experimental models to study diabetes mellitus and its complications: limitations and new opportunities," *Int. J. Mol. Sci.*, vol. 24, no. 12, 2023.