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Antioxidants of Butterfly Pea Flowers on Glycemic and Antidiabetic Responses: Literature Review

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ABSTRACT

Introduction: Butterfly pea flower (Clitoria ternatea) contains antioxidants particularly anthocyanins, flavonoids, and phenolic acids that have been investigated for their potential effects on glycemic regulation and antidiabetic activity. This narrative review synthesizes findings from in vitro studies, in vivo experiments, and limited human trials to evaluate the strength of evidence supporting these effects.

Method: Literature searches were conducted using ScienceDirect, PubMed, Elsevier, and ResearchGate, and 5 primary studies that met the inclusion criteria (original research on glycemic or antidiabetic outcomes) were reviewed. The majority of available evidence originates from animal studies using diabetic rodent models, supported by several mechanistic in vitro investigations and a small number of short-term human trials.

Result: Overall, in vivo studies consistently report reductions in blood glucose, improvements in insulin sensitivity, decreases in oxidative stress markers, and protective effects on pancreatic β-cells, whereas human studies demonstrate only modest, acute improvements in antioxidant capacity without clinically significant changes in glycemic parameters.

Conclusion: This review contributes to the current literature by comparing different extract types, dosages, and highlighting anthocyanins as key bioactive compounds most frequently associated with antidiabetic mechanisms However, due to the predominance of preclinical evidence and the scarcity of robust clinical trials, the therapeutic potential of butterfly pea flower in diabetes management remains preliminary.

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1. INTRODUCTION

Butterfly pea flower (*Clitoria ternatea*) has attracted increasing scientific attention due to its rich content of bioactive antioxidant compounds, including anthocyanins, flavonoids, and phenolic acids. These compounds have been shown in several in vitro and in vivo studies to exert antioxidant, anti-inflammatory, and cytoprotective effects, which may contribute to physiological outcomes relevant to metabolic regulation. Prior investigations have reported that extracts of *C. ternatea* can reduce oxidative stress markers, modulate inflammatory pathways, and provide cellular protection in experimental models (Jeyaraj E., J., *et al,* 2022); Maneesai P., *et al,* 2021; Multisona, R., R., *et al,* 2023). Limited human studies primarily demonstrate short-term enhancement of antioxidant capacity following consumption of butterfly pea beverages, although evidence for clinically meaningful metabolic effects remains insufficient.

Several experimental studies, particularly in rodent models, have suggested that butterfly pea flower extract may influence parameters related to glucose homeostasis, including insulin sensitivity, glycemic response, and pancreatic β-cell integrity. These findings have led to the hypothesis that the antioxidant constituents—especially anthocyanins—may play a role in pathways associated with diabetes prevention or management. However, the current body of literature consists largely of preclinical work, with considerable variability in extract type, dosage, and outcome measures. Human clinical evidence is still scarce, fragmented, and limited to acute metabolic assessments rather than long-term glycemic indicators (Gunawan, O., *et al,* 2023; Widowati, W., *et al,* 2023; Widowati, W., *et al,* 2024).

Despite increasing interest in butterfly pea flower as a potential functional ingredient, there is no comprehensive narrative review that synthesizes existing in vitro, in vivo, and human evidence specifically related to its effects on glycemic regulation and antidiabetic activity. Moreover, previous studies tend to focus on individual extract types or isolated bioactive compounds without integrating findings across different research designs, making it difficult to evaluate the overall strength of evidence. This gap highlights the need for a structured synthesis that compares extract forms, identifies the role of key bioactive constituents such as anthocyanins, and critically appraises the consistency and limitations of existing studies.

Therefore, this narrative review aims to summarize and evaluate current scientific evidence regarding the antioxidant properties of butterfly pea flower and their potential influence on glycemic response and antidiabetic outcomes. By identifying research gaps, methodological inconsistencies, and limitations of the present literature, this review seeks to provide a more accurate scientific perspective and inform directions for future clinical investigations.

2. METHODS

This study employed a narrative review approach to synthesize findings related to the antioxidant properties of *Clitoria ternatea* and their effects on glycemic response and antidiabetic activity. Literature searches were conducted across four databases such as ScienceDirect, PubMed, Elsevier, and ResearchGate covering publications from 2010 to 2021 to capture contemporary evidence related to the topic.

The search strategy used the following keywords and Boolean operators: “butterfly pea flower” OR “Clitoria ternatea” AND “glycemic response” OR “antidiabetic” AND “antioxidant” AND (“anthocyanin” OR “flavonoid”). Additional manual searching of reference lists was performed to identify relevant studies not indexed under these terms. Inclusion criteria were: (1) original research articles; (2) studies evaluating antioxidant activity, glycemic response, insulin sensitivity, β-cell function, or antidiabetic effects of butterfly pea flower or

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its extracts; (3) studies using in vitro, in vivo, or human subjects; and (4) articles published in English. Exclusion criteria included: (1) review articles, conference abstracts, or non–peer-reviewed sources; (2) studies not directly assessing glycemic or antidiabetic outcomes; (3) research combining *Clitoria ternatea* with other plant extracts in a way that prevented isolated interpretation of its effects.

3. RESULTS AND DISCUSSION

3.1. Butterfly Pea Flower Antioxidants on Glycemic Response

The following are the results of a study on the effect of Butterfly pea flower antioxidants on glycemic response.

Table 1. Study on the antioxidant effect of Butterfly pea flower on glycemic response

Study	Method	Result
Bhosale et al. (2013)	A total of 72 normoglycemic rats with fasting serum glucose (FSG) levels of 75–85 mg/dL were included. The animals were divided into four groups of six rats each: • Control: 2% acacia gum (5 mL/kg, orally) was administered. • Standard: Metformin (200 mg/kg, oral) is used for treatment. • Extract 200: administered 200 mg/kg of butterfly pea flower extract orally. • Extract 400: administered 400 mg/kg of butterfly pea flower extract orally.	The results showed that Butterfly pea flower extract had ameliorative effects on hyperglycemia and oxidative stress in diabetic rats.
Chusak et al. (2018)	Fifteen healthy males with a mean age of 22.53 ± 0.30 years and a BMI of 21.57 ± 0.54 kg/m² drank five different drinks as part of a randomized crossover study: 50 grams of sucrose in 400 milliliters of water; 1 gram of butterfly pea flower extract in 400 milliliters of water; 2 grams of extract in 400 milliliters of water; 50 grams of sucrose plus 1 gram of extract in 400 milliliters of water; and 50 grams of sucrose plus 2 grams of extract in 400 milliliters of water. Over the course of three hours, measurements were made of lipid peroxidation, insulin, uric acid, postprandial plasma glucose, and antioxidant capacity.	At 30 minutes post-consumption, plasma glucose and insulin levels were suppressed with sucrose + 1 g and 2 g extract. The extract alone did not alter fasting glucose and insulin levels. Significant increases in antioxidant capacity (FRAP, ORAC, TEAC, thiol protein) and reduced MDA levels were observed with 1 g and 2 g of extract. The extract also protected against sucrose-induced ORAC, TEAC reduction, and plasma MDA elevation.

Table 1 demonstrates how antioxidants from butterfly pea flowers reduce oxidative stress and hyperglycemia. Furthermore, despite lowering malondialdehyde (MDA) levels,

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antioxidants found in butterfly pea flowers may dramatically raise protein thiol levels, Trolox-equivalent antioxidant capacity, oxygen radical scavenging capability, and plasma antioxidant capacity.

A comparison of the two studies indicates that stronger and more consistent glycemic benefits were observed in the animal model than in humans. In the in vivo study, both hyperglycemia and oxidative stress improved substantially, likely due to the pathological state of the diabetic rats, which made metabolic responses more detectable under intervention. In contrast, the human study showed that meaningful glycemic modulation occurred only in the presence of a glucose challenge, suggesting that butterfly pea extract may influence postprandial glucose handling rather than fasting metabolic parameters. These differences highlight the influence of physiological state—diabetic versus healthy—on measurable metabolic outcomes.

Butterfly pea flower's antioxidant qualities make it a useful tool for diabetes management and for enhancing general health and wellbeing. Butterfly pea blossoms can enhance blood sugar regulation and general health when included in a balanced diet. People with diabetes may be able to better control their illness and avoid complications because to its capacity to lower inflammation and increase insulin sensitivity (Widowati, W., *et al,* 2024; Widowati, W., 2024). People may use this natural ingredient's antioxidant qualities to enhance their well-being and health objectives by incorporating it into meals or drinks. Little adjustments, such as adding Butterfly pea flower to daily routines, can have a big impact on diabetes management and general health promotion.

Anthocyanin levels may contribute to better glucose metabolism (Fallah, A. A., *et al,* 2020; Sharma, S., 2023). These substances have been demonstrated to improve insulin sensitivity in cells, which may help diabetics better regulate their blood sugar levels (Kozłowska, A., *et al,* 2024). The anti-inflammatory qualities of butterfly pea flowers may also aid in lowering the chronic inflammation linked to diabetes, hence promoting general health (Putri, T. F., *et al,* 2023). Additionally, research has shown that butterfly pea blossoms may shield the beta cells in the pancreas, which are in charge of making insulin (Bindu, J., *et al,* 2019).

Better blood sugar control and general health outcomes for diabetics may result from using butterfly pea flower in a diabetes treatment regimen. Its anti-inflammatory qualities provide extra advantages by lowering chronic inflammation, which is frequently observed in diabetics (Wang, Y., 2022). Additionally, Butterfly pea flower may contribute to maintaining insulin production due to its protective effect on pancreatic beta cells, which makes it a useful supplement to a comprehensive diabetes management strategy (Salehi, B., *et al,* 2019). People who use this natural component in addition to conventional therapies may benefit from improved long-term health and glycemic control.

The studies reviewed exhibit several methodological strengths, including the use of a controlled experimental design with well-defined treatment groups in the in vivo study allowing clear comparison of treatment effects and the implementation of a randomized crossover design in the human trial, which reduces inter-individual variability and enhances internal validity. However, these strengths are accompanied by notable limitations. The animal study relied on small sample sizes and did not report randomization or blinding, reducing reproducibility and external validity. Likewise, the human study involved only 15 healthy male participants, restricting generalizability, particularly to populations with impaired glucose regulation, and assessed only short-term (3-hour) metabolic responses without examining long-term glycemic indicators such as HbA1c or insulin sensitivity. Furthermore, substantial differences in extract dosages between the animal and human

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studies complicate direct comparison of efficacy across models.

Collectively, the evidence base is constrained by several limitations. First, the majority of available data come from animal studies, restricting extrapolation to human clinical contexts. Second, extract forms and dosages differ substantially across studies, making it difficult to determine dose–response relationships or optimal formulations. Third, clinical evidence is extremely limited, with only one short-term trial available, and no long-term data assessing sustained glycemic control, β-cell function, or insulin resistance. Finally, the human study population consisted only of healthy individuals, limiting relevance to diabetic or prediabetic groups—the populations most relevant for antidiabetic interventions.

3.2. Antidiabetes Butterfly Pea Flower Antioxidants on Antidiabetic Response

The following are the results of a study on the effect of Butterfly pea flower antioxidants on antidiabetic responses.

Table 2. Study on the antioxidant effect of Butterfly pea flower on glycemic response

Study	Method	Result
Rajamanickam et al. (2015)	After an overnight fast, male Wistar albino rats weighing 200–250 g were split up into six groups, with six rats in each group: Group I: Standard control using just saline Group II: Two days of intraperitoneal alloxan-induced diabetes Group III: Glibenclamide (10 mg/kg) plus diabetes Group IV: 300 mg/kg of chloroform extract plus diabetes Group V: 300 mg/kg of ethyl acetate extract with diabetes Group VI: 300 mg/kg of methanol extract with diabetes	In diabetic rats, administering Butterfly pea flower extracts for 12 days resulted in a substantial decrease in blood glucose levels and an increase in body weight, indicating antidiabetic action.
Abhishek et al. (2015)	Male Swiss albino rats (150–200 g) were induced with streptozotocin and fasted overnight. Blood glucose was measured at 0, 30, 60, 120, and 240 minutes. Five groups of rats (five per group) were created: Group 1: Placebo, or normal control Group 2: Management of diabetes Group 3: Take 200 mg/kg of the extract orally Group 4: 400 mg/kg of extract taken orally	Methanol, aqueous, petroleum ether, and chloroform extracts of Butterfly pea flower significantly reduced blood glucose levels in streptozotocin-induced diabetic rats.

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Study	Method	Result
	Group 5: Glibenclamide (10 mg/kg), a standard medication	
Valentine et al. (2021)	A randomized post-test only control group design. 36 male Wistar rats were divided into control and treatment groups (n=18 each). Control: aquabidest + glimepiride (0.036 mg/200g BW); Treatment: Glimepiride (0.036 mg/200g BW) with butterfly pea flower extract (80 mg/200g BW) administered once daily for 60 days is the treatment.	Immunohistochemical analysis and HbA1c testing showed that combining Butterfly pea flower extract and glimepiride significantly reduced HbA1c levels in diabetic male Wistar rats.

Table 2 demonstrates that the antioxidants in butterfly pea flowers can lower HbA1c levels in diabetics while also significantly lowering serum glucose levels and increasing body weight. The three in vivo studies reviewed demonstrate consistent antihyperglycemic effects of *Clitoria ternatea* across different experimental conditions. Rajamanickam et al. (2015) reported that chloroform, ethyl acetate, and methanol extracts administered for 12 days substantially reduced blood glucose levels and increased body weight in alloxan-induced diabetic rats. Similarly, Abhishek et al. (2015) found that methanol, aqueous, petroleum ether, and chloroform extracts significantly reduced blood glucose levels in streptozotocin-induced diabetic rats within a short observation period of 240 minutes. Complementing these findings, Valentine et al. (2021) demonstrated that combining butterfly pea flower extract with glimepiride lowered HbA1c and increased β-cell expression in diabetic Wistar rats over 60 days. Compared collectively, the studies show agreement in glycemic improvement but differ in the duration of intervention, extraction methods, and outcome markers assessed—varying from acute glucose reduction to long-term improvements reflected in HbA1c. Verma et al. (2013) investigated the antioxidants in Butterfly pea flower in streptozotocin-induced diabetic mice and discovered that they had antihyperlipidemic and antidiabetic potential. They also identified a correlation between antioxidant activity in vitro and in vivo (Verma et al., 2013).

Butterfly pea flowers may also help diabetics become more insulin sensitive, which may help them better control their blood sugar levels, according to some research (Widowati, W., *et al,* 2024). Since increasing insulin sensitivity is essential to controlling type 2 diabetes, this might be especially helpful for those who already have the disease. Furthermore, the antioxidant qualities of butterfly pea flowers could aid in preventing the harm brought on by elevated blood glucose levels, a typical issue for diabetics (Gunawan, O., *et al,* 2023). All things considered, butterfly pea flower has great promise as a natural therapy for diabetes; nevertheless, further investigation is required to ascertain how best to use it in a regimen.

Anthocyanin is one of the main substances in butterfly pea flowers that has antidiabetic qualities (Netravati, *et al,* 2022; Maneeratanachot, S., *et al,* 2024). One kind of flavonoid that has been demonstrated to enhance insulin sensitivity and lessen inflammation in the body is anthocyanins (Kozłowska, A., *et al,* 2024). Because of these qualities, they are especially advantageous for people with type 2 diabetes as they can help control blood sugar levels and guard against the consequences of the condition. Furthermore, anthocyanins have antioxidant properties that might lessen the harm that elevated blood glucose levels can have to cells and tissues (Randeni, N., *et al,* 2025; Gonçalves, A. C., *et al,* 2021). Overall, Butterfly

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pea flowers' promise as a natural treatment for diabetes is further supported by the presence of anthocyanins.

Butterfly pea flowers' anthocyanins have been linked to improved insulin sensitivity, which is important for people with type 2 diabetes, according to studies (Widowati, W., *et al,* 2024). Additionally, anthocyanins can help lower blood sugar levels and lower the risk of complications from diabetes by improving the body's response to insulin. Butterfly pea flower has shown promise in the treatment of diabetes and may be a safe and healthy substitute for prescription drugs. More research on the possible medicinal benefits of the anthocyanins found in butterfly pea blossoms may result in the creation of fresh diabetic treatment alternatives.

Methodologically, the reviewed studies have several strengths. Rajamanickam et al. (2015) employed clear group stratification, including standard control, diabetic control, and multiple extract-based treatment groups, enabling robust comparison of extract effects across solvent types. Abhishek et al. (2015) strengthened internal validity by using multiple extract types and standardized glucose measurements at several time points, while Valentine et al. (2021) incorporated histological and biochemical analyses, providing mechanistic insight into β-cell protection and long-term glycemic control. However, all studies exhibit notable limitations, including small sample sizes (typically 5–6 rats per group), lack of reported randomization and blinding, and reliance on rodent models, which may limit reproducibility and external validity. Additionally, the heterogeneity in extract preparation—ranging from petroleum ether to methanol, chloroform, or aqueous extracts—complicates direct comparison of efficacy and raises concerns regarding the consistency of bioactive compound profiles.

Overall, the available evidence is constrained by several limitations. The studies are exclusively conducted in animal models, making it difficult to extrapolate findings to human populations with metabolic disorders. There is limited understanding of the pharmacokinetics, bioavailability, and standardized dosing of *Clitoria ternatea* extracts across different preparations. The variability in induction methods of diabetes (alloxan vs. streptozotocin) further introduces biological variability that may affect the comparability of outcomes. Moreover, markers of long-term glycemic control (such as HbA1c) were assessed in only one study, while others focused solely on acute glucose changes, hindering conclusions about long-term therapeutic potential. These gaps highlight the need for well-designed, standardized, and clinically relevant human studies to validate the promising preclinical findings.

4. CONCLUSION

Based on the evidence synthesized from multiple in vivo studies and one small-scale human trial, butterfly pea flower (*Clitoria ternatea*) extract demonstrates potential to lower blood glucose levels, improve insulin-related parameters, and enhance antioxidant capacity. These effects are supported by mechanistic findings from in vitro studies, particularly highlighting the role of anthocyanins and other phenolic compounds. However, the current body of literature remains limited in several important ways. Most available studies were conducted in animal models, with considerable variability in extract types, dosages, and outcome measures. Human evidence is scarce, short-term, and insufficient to determine clinically meaningful benefits. Furthermore, the lack of standardized extraction methods and limited evaluation of bioavailability restricts the comparability and translational relevance of existing findings. Future research should prioritize well-designed, long-term clinical trials in populations with impaired glucose metabolism, alongside efforts to standardize extract composition and dosage. Additional studies investigating the pharmacokinetics and bioavailability of key bioactive compounds are also needed to clarify their therapeutic potential. Until such evidence becomes available, the use

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of butterfly pea flower extract for diabetes management should be considered exploratory.

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