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ORIGINAL ARTICLE

Spirulina Platensis in the Management of Type 2 Diabetes: A Systematic Review

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ABSTRACT

Background: Diabetes, characterized by insufficient insulin production or ineffective insulin utilisation, poses serious health risks if left unmanaged, including hypertension, hyperlipidemia, and organ damage. *Spirulina platensis*, a blue-green microalgae, has garnered attention for its potential in managing metabolic disorders like diabetes. However, its impact on blood sugar control remains inadequately understood. Consequently, this review aims to explore the efficacy of *Spirulina platensis* in managing type 2 diabetes mellitus.
Methods: A systematic search of PubMed, Embase, and Cochrane databases was done to identify original research articles that were published within the last 25 years.
Results: A total of 65 articles were retrieved. Upon screening, 56 articles were excluded for not meeting inclusion criteria. The remaining 9 articles revealed promising outcomes associated with *Spirulina platensis* supplementation, including reductions in fasting blood sugar (FBS), postprandial blood sugar (PPBS), glycated hemoglobin (HbA1C), total cholesterol, triglycerides, and malondialdehyde (MDA) levels.
Conclusion: *Spirulina platensis* demonstrates potential in improving key health indicators among type 2 diabetic patients. Health practitioners should consider recommending its adjunct use alongside glucose-regulating medication for enhanced diabetes management.

BACKGROUND

Diabetes mellitus is a chronic metabolic disorder characterized by abnormal insulin production or utilization, leading to elevated blood sugar levels and subsequent metabolic dysregulation.[1] Left uncontrolled, diabetes can result in various complications, including hypertension, hyperlipidemia, and organ damage, particularly affecting the heart, kidneys, nerves, and blood vessels. With approximately 537 million adults affected worldwide, the prevalence of diabetes is projected to increase significantly in the coming years, posing a significant global health burden according to IDF Diabetes Atlas, 2021.

There are three main types of diabetes: Type 1, Type 2, and Gestational diabetes. Type 1 diabetes is caused by an autoimmune reaction that impairs insulin production and typically manifests at an early age, requiring lifelong insulin therapy for management. On the other hand, Type 2 diabetes, which accounts for 98% of global cases, results from inadequate insulin production or utilization and is often associated with lifestyle factors such as poor diet and sedentary behavior[2]. Gestational diabetes occurs during pregnancy and increases the risk of developing Type 2 diabetes later in life.

Management of diabetes typically involves dietary modifications, physical activity, and pharmacological interventions to control blood sugar levels and prevent complications. In recent years, the concept of functional foods, particularly those with potential health benefits in chronic disease management, has gained prominence. Among these, *Spirulina platensis*, a nutrient-rich microalgae, has attracted attention for its purported health-promoting properties.[3]

Spirulina, a free-floating blue-green filamentous microalgae found in alkaline water bodies, has a long history of use as a dietary supplement, dating back to ancient civilizations such as the Aztecs.[4] Recognized as one of the most nutritious foods on the planet, Spirulina is rich in protein, essential amino acids, B-complex vitamins, iron, magnesium, potassium, and antioxidants.[4] It has been hailed by the United Nations as "the best food for the future" and is officially approved by the Food and Drug Administration (FDA) as a safe supplement.[5]

Despite its nutritional benefits and widespread use, the impact of Spirulina on blood sugar control, particularly in the context of managing Type 2 diabetes mellitus, remains unclear. While some studies suggest potential therapeutic effects, others report conflicting findings, leading to uncertainty regarding its clinical use. Given the increasing popularity of Spirulina and its potential as an adjunctive therapy for diabetes,

there is a critical need for a comprehensive review of the existing evidence to elucidate its efficacy and safety in diabetes management.

Therefore, this systematic review aims to investigate the impact of *Spirulina platensis* on blood sugar control in individuals with Type 2 diabetes mellitus, providing valuable insights into its potential role as a therapeutic agent in diabetes management.

METHODOLOGY

Data Sources and Searches

A systematic search was conducted across three major databases—PubMed, Embase, and Cochrane—from January 15, 2024, to February 12, 2024. The search terms employed included "*Spirulina platensis*," "*Arthrospira platensis*" "Diabetes Mellitus," "Diabetes type 2," and "Hyperglycemia." Additionally, Google Scholar was utilized to supplement the database search.

Inclusion and Exclusion Criteria

The search aimed to identify original research articles written in English and published in peer-reviewed journals published within the last 25 years.. Specifically, the search strategy targeted randomized clinical trials or controlled trial study designs comparing the use and non-use of spirulina among healthy patients with Type 2 Diabetes both male and female. The use of spirulina referred to use of any part of the spirulina algae, raw or cooked and the use of any supplement containing spirulina product. Articles not written in English or could not be fully accessed were excluded from the study.

Data Collection Process

Titles and abstracts were independently screened by two reviewers to identify potentially eligible studies. Out of the initial pool of 65 articles, 56 were excluded as they did not meet the inclusion criteria. Subsequently, the remaining nine (9) articles full texts were reviewed for final inclusion.

Ethical Considerations

Ethical considerations were thoroughly examined in each included study. Only studies that reported ethical clearance from relevant institutional review boards or ethics committees and confirmed informed consent from participants were included. The review itself adhered to ethical research practices by maintaining transparency in study selection, data extraction, and reporting, and by respecting intellectual property through proper citation of all sources.

RESULTS

The initial search yielded a total of 65 articles. After screening, 56 articles were excluded for the following reasons: 37 articles focused on animal trials, 8 were review articles, full texts could be accessed for 3 manuscripts, 3 were not in English, and 5 did not align with the clinical trial objectives. The remaining 9 articles were included in the final review and synthesis.

The included studies investigated the effects of Spirulina platensis supplementation in individuals with Type 2 diabetes mellitus, characterized by fasting blood sugar (FBS) levels greater than 126mg/dL, postprandial blood sugar (PPBS) levels above 200mg/dL, and glycated hemoglobin (HbA1c) levels exceeding 6.5%. Both male and female participants were included, and studies generally excluded individuals on lipid-lowering medications, those with diabetic complications, or those using other medicinal herbs or supplements.

The interventions across studies varied in both form and dosage. Spirulina was administered as a powder in three studies[6–8] and as tablets in six studies.[9–14] Daily dosages ranged from 800mg to 14g, and the duration of interventions spanned from 21 days to 12 weeks, with most studies maintaining a two-month intervention period[8–14] Five studies provided spirulina supplementation alongside glucose-lowering medications,[8–11,13] while three studies administered spirulina independently of such medications[7,12,14] Control groups in some studies received placebos, such as bran powder or an isocaloric diet.[6,8,9]

Regarding glycemic control, significant reductions in FBS were reported in five studies.[6,7,9,11,13] For example, Alam et al. demonstrated a significant reduction in FBS after supplementation with 7g of spirulina powder taken twice daily for 45 days[7] while Ashtiani et al. observed a reduction in FBS following the consumption of spirulina-enriched yogurt containing 4g of spirulina powder twice daily for 21 days[6]. PPBS levels were significantly reduced in three studies[7,9,13] and significant reductions in HbA1c levels were observed in two studies.[9,10]

In terms of lipid control, five studies reported significant reductions in total cholesterol (TC) and low-density lipoprotein cholesterol (LDL-C) levels[8,10,11,13,14] while four studies observed significant reductions in triglycerides (TG).[11–14] Four studies reported reductions in plasma malondialdehyde (MDA) levels, an indicator of oxidative stress.[6,8,12,14] Additionally, one study noted an increase in high-density lipoprotein cholesterol (HDL-C) levels[10].

Specifically, Parikh et al. found that 15 patients consuming 2g of spirulina daily for two months experienced non-significant reductions in FBS and PPBS but significant reductions in HbA1c, TC, and LDL-C, as well as increased HDL-C levels.[10] Lee et al reported no significant changes in plasma FBS, HbA1c, TC, LDL-C, and HDL-C in 19 patients supplemented with 8g of spirulina daily for 12 weeks, though triglycerides and MDA levels were significantly reduced.[12] Alam et al. observed significant reductions in FBS and PPBS with no significant change in HbA1c[7] while Rostami et al. reported significant reductions in TC, LDL-C, triglycerides, and MDA levels but not in FBS or HDL-C.[14]

Rezaiyan et al. found that supplementation with 20g of spirulina sauce daily for two months significantly reduced TC, LDL-C, and MDA levels, though changes in FBS and HbA1c were not significant.[8] Serban et al. reported significant reductions in HbA1c, glycemia, and TC in patients receiving 800 mg of spirulina daily for two months alongside metformin.[9] Ashtini et al. showed significant reductions in FBS and MDA with the consumption of spirulina-enriched yogurt[6]. Mani et al. observed reductions in FBS, TC, and TG with supplementation of 2g spirulina tablets daily for two months.[11] while Kaur et al. reported significant reductions in FBS, PPBS, TC, TG, and LDL-C in patients supplemented with either 1g or 2g spirulina daily for two months.[13]

These findings highlight the potential of Spirulina platensis supplementation to improve glycemic control, lipid profiles, and oxidative stress markers in individuals with Type 2 diabetes mellitus, with varying degrees of effectiveness depending on dosage, duration, and form of administration. (Table 1)

TABLE 1: Summary of Study Title, Participants and Findings

Study Title/Reference	Study Description	Outcomes
Role of Spirulina in the Control of Glycemia & Lipidemia in Type 2 Diabetes Mellitus[10]	Study Area: India Study Participants Intervention 15 and Control were 15 Mean Age was: 67.2±11.5, 67.1±13.1 Duration: 2 Months Form of use; Tablet Dosage 2g/day	Significant reduction in HbA1c levels, total cholesterol and LDL-C & an increase in HDL-C. $p<.05$ Non-significant reduction in FBS & PPBS
A randomized study to establish the effects of spirulina in type 2 diabetes mellitus patients[12]	Study Area: Korea Study Participants Intervention 19 and Control were 18 Mean Age was: 52.1±2.3, 54.5±1.5 Duration: 12 Weeks Form of use; Pills Dosage 8g/day	Significant lowering of plasma triglycerides ($p<0.05$) & plasma MDA ($p<.01$) with non-significant changes in plasma levels of FBS, HbA1c, TC, LDL-C and HDL-C.
Efficacy of Spirulina (Tahlab) in Patients of Type 2 Diabetes Mellitus (Ziabetus Shakri) - A Randomized Controlled Trial[7]	Study Area: India Study Participants Intervention 30 & Control were 10 Mean Age was: 45.07±7.67, 44.0±9.39 Duration: 45 Days Form of use; Powder Dosage 14g/day	Significant reduction in FBS & 2-hour Postprandial blood glucose. $P<.003$ with no significant lowering in HbA1c $p<0.525$
Effect of Spirulina on Lipid Profile, Glucose and Malondialdehyde Levels in Type 2 Diabetic Patients[14]	Study Area: Iran Study Participants Intervention 15 & Control were 15 Mean Age was: 46.7±8.1,47.3±8.8 Duration: 2 Months Form of use; Pills Dosage 4g/day	Significant reduction in TC, LDL-C, Triglycerides and MDA p<0.01 with no significant changes in FBS and HDL.
The effect of spirulina sauce on glycemic index, lipid profile, and oxidative stress in type 2 diabetic patients: A randomized double- blind clinical trial[8]	Study Area: Iran Study Participants Intervention 20 and Control were 20 Mean Age was: 51.65±7.42, 52.9±5.5 Duration: 2 Months Form of use; Spray dried powder in sauce Dosage: 20g of sauce per day containing 2g of spirulina	Significant lowering in TC ($p<.02$) LDL ($p<.01$) & MDA($p<.001$). No significant reduction in FBS ($p<.26$) and HbA1c ($p<.75$)
The role of spirulina platensis in the control of type 2 diabetes mellitus[9]	Study Area: Romania Study Participants Intervention 15 and Control were 15 Mean Age was: 61.7±6.85, 61.6±8.90 Duration: 2 Months Form of use; Capsule Dosage: 800g/day	Significant reduction in HbA1c $p=.009$, Glycaemia $p=<.001$ and in total cholesterol $p=.004$
Effects of spirulina-enriched yogurt on FBS and MDA levels in type 2 diabetic patients[6]	Study Area: Iran Study Participants Intervention 50 and Control were 50 Mean Age was: 61.7±6.85, 61.6±8.90 Duration: 21 Days Form of use; Powder in low fat yoghurt Dosage: 100 mls yoghurt twice daily enriched with 4g spirulina powder	Significant reduction in FBS (p=0.001) and in MDA levels ($p=.001$)

Continue

TABLE 1: Continued

Study Title/Reference	Study Description	Outcomes
Studies of the long term effects of spirulina supplementation on serum lipid profile and glycated proteins in NIDDM patients[11]	Study Area: India Study Participants Intervention 15 and Control were 7 Mean Age was: 47.8±2.35, 53.4±2.32 Duration: 2 Months Form of use; Tablets Dosage: 2g/day	Significant reduction in FBS ($p<0.01$), total cholesterol ($p<.01$) and in triglycerides ($p<.05$)
Effect of supplementation of spirulina on blood glucose and lipid profile of the non-insulin dependent diabetic male subjects[13]	Study Area: India Study Participants Intervention 20 and Control were 20 Mean Age was: 46.3±1.7, 45.9±1.6, 47.6±1.5 Duration: 2 Months Form of use; Capsules Dosage: 1g/day for group 1 & 2g/day for group 2	Significant reduction in FBS, PPBS, TC, TG and LDL-C ($p=.01$)

DISCUSSION

This systematic review assessed the impact of *Spirulina platensis* on various health indicators in Diabetes type 2 patients, including FBS, PPBS, HbA1C, Total Cholesterol and MDA levels.

The studies considered for this review were randomized controlled trials, a study design whose results are reliable.

Effects on Glycemic Control

In studies assessing FBS, significant reductions were observed in five out of the nine studies reviewed. For instance, Alam et al.[7] demonstrated a significant decrease in FBS after administering 7g of spirulina powder twice daily for 45 days. Similarly, Ashtiani et al. [6] reported a reduction in FBS following supplementation with 4g of spirulina daily for 21 days. This observed reduction in FBS could be attributed to spirulina's fiber content, approximately 10%, which slows down digestion and reduces the influx of glucose into the bloodstream.[4] Importantly, the reduction in FBS was sustained over time, indicating a physiological effect rather than a transient one.[10]

Regarding PPBS, only two studies showed significant reductions, possibly attributed to spirulina's rich protein content. Peptides and polypeptides released during protein digestion stimulate insulin production, enhancing glucose absorption.[7,13] Spirulina, being a protein-rich source, may have contributed to the observed reductions in PPBS when consumed before meals.[4]

In terms of HbA1c, studies have reported mixed findings. A study involving type 2 diabetic patients supplemented with 2g of spirulina daily for 2 months showed a significant reduction in HbA1c levels.[9] Similar results were observed by Kaur et al. [13] in patients supplemented with 1g or 2g of spirulina daily for the same duration. However, Hamedifard et al. [15] suggested that shorter durations of spirulina consumption (less than 12 weeks) or lower dosages (less than 4g) may not significantly impact HbA1c levels.

Effects on Lipid Control

Spirulina has emerged as a promising dietary supplement for managing diabetes, not only for its effects on glycemic control but also for its potential to regulate lipid levels, thereby mitigating the risk of cardiovascular complications. Several studies have demonstrated the beneficial impact of spirulina on lipid profile parameters in individuals with type 2 diabetes.

For instance, supplementation with 4g of spirulina daily for 2 months resulted in a significant reduction in total cholesterol, low-density lipoprotein cholesterol (LDL-C), and triglyceride levels in 15 newly diagnosed type 2 diabetes patients.[14] Similarly, in another study involving 40 patients supplemented with 2g of spirulina daily for the same duration, significant improvements in lipid parameters were observed.[8]

The lipid-lowering effects of spirulina may be attributed to its rich content of Gamma linoleic acid (GLA), an essential fatty acid known for its hypocholesterolemic properties.[4] GLA has been shown to dissolve fat deposits, thereby contributing to the improvement of the lipid profile and reducing the risk of cardiovascular diseases. Significant reduction in MDA levels could be as a result of phycocyanin in spirulina, which acts as an antioxidant thus reducing lipid peroxidation.[6]

Moreover, the magnitude of improvement in lipid concentrations appears to be inversely associated with baseline levels.[12] reported that individuals with higher baseline levels of total cholesterol and triglycerides experienced greater reductions in lipid concentrations following spirulina supplementation. This observation was consistent with the findings of Rostami et al. [14] and Rezaiyan et al. [8], further supporting the potential of spirulina in lipid management among individuals with type 2 diabetes.

CONCLUSION

Dosages of 2g of *Spirulina platensis* daily given over a duration of at least 2 months had promising results

especially on lipid control. However, when 8g of spirulina ptimal dosages, duration of supplementation, and long-term effects on HbA1c levels.

These findings also underscore the multifaceted benefits of spirulina in diabetes management, highlighting its potential not only in glycemic control but also in improving lipid profile parameters, thus addressing key risk factors for cardiovascular complications.

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