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Effect of Food-based Approach with Spirulina on Blood Glucose Profile of Non-insulin Dependent Diabetics

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Abstract

A sample of 90 diabetic subjects (40–60 years) were selected from diabetic hospitals Tirupati and divided equally into three groups, namely, experimental group-1 (EG1), EG2, and control group (CG). Spirulina supplementation was given daily in the form of snack bar and capsules to EG1 and EG2, respectively, for a period of 3 months and CG was not given any supplementation. The impact of spirulina supplementation was studied on blood glucose profile of subjects before and after the study. It was observed in the present study that the mean fasting, postprandial blood glucose levels, and hemoglobin A1C were decreased significantly ($P < 0.01$) in Group EG1 and EG2 from pre- to post-intervention period. Non-significant change was observed of the subjects of CG. Hence, it is suggested that 2 g of spirulina supplementation as food-based approach can prove to be effective in management of diabetes.

Keywords: Blood glucose and hemoglobin A1C, Diabetes, Spirulina

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Introduction

Diabetes mellitus (DM) is a disease in which the body's ability to produce or respond to the hormone insulin is impaired, resulting abnormal metabolism of carbohydrates and elevated levels of glucose in the blood. In Type I, there is reduced insulin production as the beta cells are gradually destroyed and an increased peripheral resistance in the uptake of insulin. In Type II, the body produces enough insulin; however, the cells develop a condition "insulin resistance" where glucose does not move into the cells. Type II DM has been described as a modern epidemic, emerging rapidly in developing countries.[1] Type II DM is a worldwide major public health problem. It is a global crisis that threatens the health and economy of all nations, particularly developing and one of the main chronic diseases currently affecting people through socio economically and increases the risk of the future with macro and microvascular diseases.[2] Diet has been considered a possible cause of DM for centuries.[3] Total caloric intakes as well as several components of diet have been considered, including carbohydrates and fats. In recent years, functional foods have appeared as new means to help and maintain proper nutrition in patients with chronic diseases such as DM.[4]

Spirulina has received much attention as functional food regarding its association with lowering blood glucose levels, controlled cholesterol properties, and antioxidant capacity and also there is increasing scientific and clinical evidences for its role in controlling chronic diseases such as diabetes. Spirulina is blue-green algae which constitute the most remarkable concentration of nutrients. It has a unique blend of nutrients that no single plant sources can provide.[5] Today, it is used by many people who know its value as a nutrient power house. It has a high protein concentration (60–70% of its dry weight) supplying 18 of the 22 known amino acids, including all the eight essential amino acids in balanced proportion. It also contains other nutrients and over loaded with functional components, thus emerging as an important therapeutic food.[6] Spirulina has well established itself as a super food and excellent weapon against an array of nutritional deficiencies.

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In recent years, spirulina has garnered enormous attention from research fraternity as well as industries as a thriving source of nutraceuticals and pharmaceuticals. Moreover, there is plethora of unexploited novel compounds and biological activities in this alga and worth-exploring.[7] Innovative formulations are required to fortify conventional foods with spirulina. Hence, to satisfy the need of diabetic consumers a novel formulation with various functional ingredients in combination of spirulina, blue-green algae constitute plentiful bioactive components that will help to mitigate diabetes.

Hence, the present study has been undertaken to find out effect of supplementation of dietary spirulina on blood parameters of the diabetic subjects as food-based approach.

Materials and Methods

Selection of the subjects: A sample of 90 subjects ($n = 90$), aged 40–60 years belonging to middle-income group, free from other complications were selected from outpatient department of the hospitals of Tirupati. Total subjects were divided into three groups in which male ($n = 55$) and female

(n = 35) subjects were included, namely, experimental group-1 (EG1) (n = 30), EG2 (n = 30), and control group (CG) (n = 30). Collection of data pertaining to general profile of the patients, diet, biochemical and lifestyle was done through a well-structured questionnaire.

Blood Parameters

Blood analysis was done for fasting, postprandial sugar (Glucose oxidase-peroxidase method), and hemoglobin A1C (HbA1c) (Eross method) before and after supplementation for all the three groups, respectively.

Supplementation of Spirulina

Dietary spirulina was supplemented to the EG1 as a food-based approach. A snack bar of 50 g with two pieces (25 g each) was supplemented to the subjects and instructed to take the diabetic snack bar in the midmorning around 11 O' clock as snack every day without skipping regularly. Another diabetic snack bar was asked to take in the evening as snack at the tea time around 4 O' clock regularly without fail. Spirulina capsules were procured from local ayurveda shop and supplemented for the EG2. Two capsules per day were given to the subjects and instructed to take one capsule in the morning and another capsule in the night regularly without fail. Supplementation was carried out for a period of 3 months. The supplementation process was monitored regularly during the intervention period for each diabetic subject carefully. All the 30 diabetics irrespective of the treatments were asked to follow the regular diet and medication as usual in their daily life. No intervention was given to this CG.

Statistical Analysis

The data were analyzed with the help of various simple statistical stools such as mean and standard deviation and "t" test was applied to test and their statistical significance was done using a statistical program of SPSS version.21on all parameters.

Results and Discussion

In the present research, the mean fasting, postprandial, and HbA1c levels before and after supplementation of diabetic subjects were collected, analyzed, and discussed as follows.

Fasting Blood Glucose (FBG)

The results of the present study in Table 1 and Figure 1 revealed that the FBG levels of diabetics (138 ± 18.39 and 128.08 ± 11.76 in male and female, respectively) during pre-intervention period were found to be significantly reduced after 90 days of spirulina diabetic snack bar supplementation (122.21 ± 14.48 and 111.0 ± 14.48 in male and female, respectively) in EG-I. The difference was statistically significant at $P < 0.01$ level. Similar results were noticed in diabetic subjects supplemented with spirulina capsule in the EG-II. The FBG levels of diabetic subjects were greatly reduced from pre-intervention period to post-intervention (135.02 ± 18.22 and 132.33 ± 10.89 to 119.31 ± 14.33 and 123.12 ± 9.81 in male and female, respectively) with statistical significance at $P < 0.01$ level. No significant difference was observed in CG from pre- (146.10 ± 25.29 and 135.12 ± 10.27 in male and female, respectively) to post-intervention period (141.43 ± 25.29 and 130.12 ± 9.76 in male and female, respectively).

Postprandial Blood Glucose

The postprandial blood glucose levels of diabetic subjects in EG-I during pre-intervention (210.33 ± 28.99 and 212.12 ± 39.45 in male and female, respectively) were found to be significantly reduced after diabetic snack bar supplementation (165.56 ± 25.35 and 175.58 ± 32.11 in male and female, respectively). The difference was statistically significant at $P < 0.01$ level. Similar results were noticed for EG-II in male and female diabetic subjects from pre-intervention period (197.45 ± 23.31 and 190.03 ± 14.86, respectively) to post-intervention period (171.28 ± 24.77 and 175.50 ± 18.38, respectively) in postprandial blood glucose with a statistically significance. Where as no significant difference was observed for postprandial blood glucose levels in CG from pre (206.17 ± 22.83,179.24 ± 17.82 in male and females respectively) to post intervention period (202.37 ± 22.76,172.09 ± 15.49 in male and female diabetics respectively).

A number of independent preclinical and clinical studies support the antihyperglycemic activity of spirulina.[8-10] These observations led us to contemplate the study to evaluate the efficacy of spirulina diabetic snack bar in the management of Type 2 diabetes in human subjects.

The data on biochemical parameters, that is, FBG, postprandial glucose, and glycosylated hemoglobin in pre- and post-intervention period were presented in Table 1 and Figure 1. From the data, it is evident that there was a significant reduction in blood glucose profile of the diabetics from pre- to post-intervention period in EG-1 and EG-II except CG. The reducing FBG levels from pre--to post intervention period were more in EG-I, who were supplemented with diabetic snack bar, compared to sprirulina capsule. The reduction in food-based approach can be attributed to the absorption and possible role of the additional factors present in diabetic snack bar, other ingredients such as fiber, poly peptides, and peptides could also played a synergetic role. Similar findings were reported by[8] with 2 months supplementation of spirulina capsules at 2 g/day showing appreciable and improved long-term glucose regulation. A statistically significant reduction of FBG levels was also observed with spirulina supplementation of two capsules (each capsule of 500 mg glasco brand) for 90 days in male non-insulin dependent diabetic patients.[11,12] The study reported that spirulina supplementation to healthy elderly people with normal FBG brought a significant reduction in mean FBG from 105.1 mg/dl to 100.0mg/dl. On the contrary, the spirulina supplementation in patients with Type 2 diabetes in this study did not result any reduction in the plasma levels of FBG, HbA1c, and insulin. The subjects in this study were Type 2 DM patients with FBG >126 mg/dl.

In support of the present study[10] shown blood glucose lowering effect of spirulina supplementation in 60 male diabetic subjects, at 1 g and 2 g/day daily doses for a period of 2 months. The results indicated that the mean fasting and postprandial blood glucose levels decreased significantly ($P = 0.01$) from 178.4 and 242.7 g/dl to 149.3 and 212.4 g/dl, respectively, in EG-1 (2 g) and from 157.6 and 238.7 g/dl to 123.2 and 193.7 g/dl, respectively, in EG-2 (2 g), after the supplementation.

The treatment with spirulina in diabetic rats increased the hexokinase activity and decreased the glucose-6-phosphatase activity. Spirulina has a beneficial effect on plasma insulin and

Table 1: Blood glucose profile and HbA1c profile of diabetics during pre and post intervention.

Parameter	*Gender*	*n*	*Experiment Group (EG-I)*		*t-test P-value*	*Experiment Group (EG-II)*		*t-test P-value*	*Control Group (CG)*		*t-test P-value*
			Pre-intervention	*Post-intervention*		*Pre-intervention*	*Post-intervention*		*Pre intervention*	*Post intervention*	
FBG	Male	18	138.00±18.39	122.21±14.48	2.862 (0.007**)	135.02±18.22	119.31±14.33	2.875 (0.007**)	146.10±25.29	141.43±20.84	0.605 (0.110@)
	Female	12	128.08±11.76	111.00±14.48	3.885 (0.000**)	132.33±10.89	123.12±9.81	2.177 (0.037*)	135.12±10.27	130.12±9.76	1.223 (0.234@)
PPBG	Male	18	210.33±28.99	165.56±25.35	4.9419 (0.000**)	197.45±23.31	171.28±24.77	3.264 (0.002**)	206.17±22.83	202.37±22.76	0.500 (0.620@)
	Female	12	212.12±39.45	175.58±32.11	3.0477 (0.004**)	190.03±14.86	175.50±18.38	2.130 (0.045*)	179.24±17.82	172.09±15.49	1.049 (0.306@)
HbA1c	Male	19	9.19±0.88	7.11±0.64	8.332 (0.000**)	7.33±0.54	6.48±0.36	5.7089 (0.000**)	8.00±1.05	7.98±1.03	0.059 (0.953@)
	Female	11	8.88±0.70	7.64±0.48	4.845 (0.000**)	7.20±0.33	6.58±0.35	4.2740.000**	8.64±0.79	8.62±0.74	0.061 (0.952@)

*Significant at 0.05 level (*P*<0.05), **Significant at 0.01 level (*P*<0.01), @: Not significant, FBG: Fasting Blood Glucose, PPBG: Postprandial blood glucose

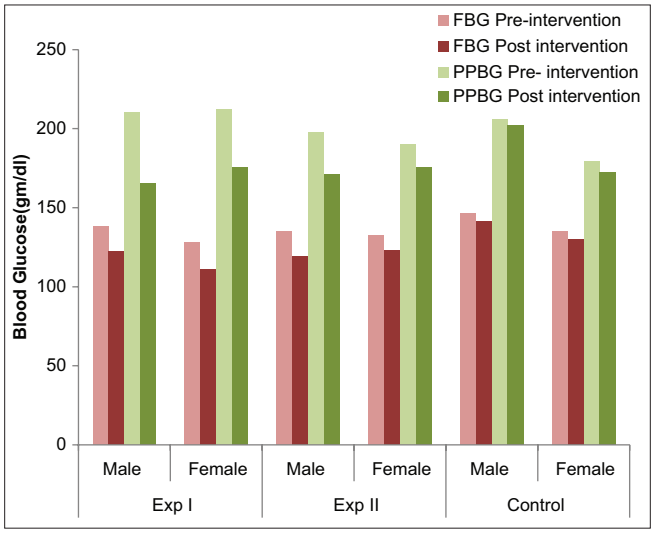

Figure 1: Hemoglobin A1C profile of diabetics during pre- and post-intervention

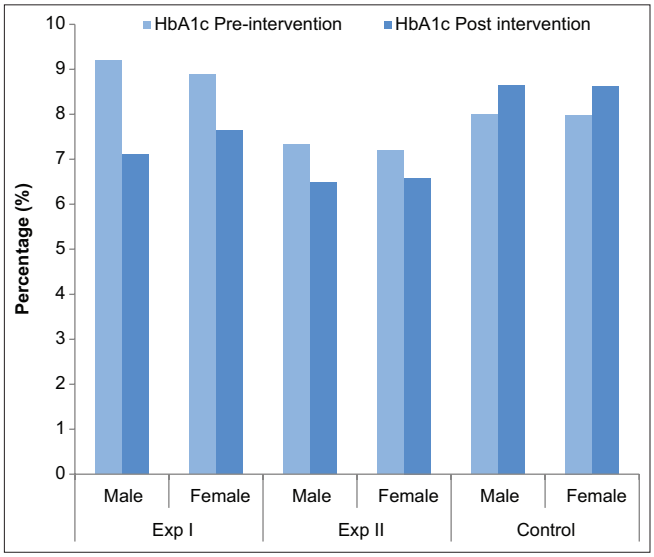

Figure 2: Blood glucose profile of diabetics during pre- and post-intervention

C-peptide.[13] In a study measuring the effect of blue-green algae on glucose levels in diabetic rats and mice, the water soluble fraction is found to be effective in lowering the serum glucose level at fasting as well as on glucose loading.[14,15]

HbA1c

The diabetics in EC-I show a significant reduction ($P < 0.01$) in HbA1c from pre- (9.19 ± 0.88 and 8.88 ± 0.7 in male and female, respectively) to post-intervention (7.11 ± 0.64 and 7.64 ± 0.48 in male and female, respectively) period. In EG-II, the HbA1C of the diabetics was reduced from pre- (7.33 ± 0.54 and 7.20 ± 0.33 in male and female, respectively) to post-intervention (6.48 ± 0.36 and 6.58 ± 0.35 in male and female, respectively) which was statistically significant ($P < 0.01$). There was no improvement in HbA1c status of diabetics in CG. The results also show that no

significant difference in HbA1C levels from pre- (8.00 ± 1.05 and 8.64 ± 0.79) to post-intervention (7.98 ± 1.03 and 8.62 ± 0.74) period in CG.

A significant reduction of HbA1c level was observed in male and female diabetic patients supplemented with diabetic snack bar in EG-I. At initial level, HbA1c was at elevated levels as shown in Table 1 and Figure 2; but after spirulina snack bar supplementation, a significant reduction was observed. However, a fall in HbA1c level was also observed in EG-II but not as prominent and significant as in EG-I by the end of the intervention period. These changes in HbA1c level reveal a favorable response to spirulina snack bar supplementation compared to spirulina capsule. No significant changes in HbA1c were noticed in CG.

The difference in values of glycosylated hemoglobin from pre- to post-intervention period was statistically significant at $P < 0.01$ and $P < 0.05$ level for EG-I and EG-II, respectively. In the present study, when observed the blood glucose profile of different groups, only the EG controlled their HbA1c levels (<7.0%), whereas the CG was not (<9.0%). Hence, from the data, it can be suggested that the blood glucose levels can be controlled with the supplementation of dietary spirulina.

The rate of formation of HbA1c is proportional to glucose level, and therefore, the diabetics have a higher proportion of HbA1c than do normal individuals. The level of HbA1c reveals the integral of blood glucose concentration over a period. Therefore, the outcome of the present study has two positive effects of supplementation of spirulina diabetic snack bar, the first one is that it monitors and controls the blood glucose levels and second by having effect on the long-term metabolic control of glucose.

Earlier studies[11] demonstrated the control of blood glucose levels by supplementing spirulina capsule (500 mg) twice per day for 90 days. There was a significant decrease of HbA1c level from 9.7 to 7.9 with difference of 13% in spirulina supplemented group, with a $P < 0.001$. This study correlates with the present study establishing the fact that the management of blood glucose levels in the long-term can be achieved by spirulina supplementation.

Research study found that HbA1c levels were significantly reduced by antioxidant supplementation, suggesting that antioxidants may have some benefit in protecting the complications of diabetes. Spirulina is a "micro vegetable" that can provide some of the antioxidants needed.[16] Many studies also revealed that antioxidants such as carotenoids in fruits, vegetables, and spirulina have a synergistic effect.[17]

The results of the present study inferred that there was a significant decrease in blood glucose levels and HbA1c of both the EGs as compared to CG due to spirulina supplementation on diabetic subjects.

Conclusion

From the measure of above discussion, spirulina supplementation after 90 days intervention proved a significant benefit on diabetic subjects in controlling and managing their disease. Hence, the present research clearly reveals that spirulina as food-based approach showed a positive impact on diabetics.

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