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Article

The Effect of DXN Spirulina Supplements on Hba1c (Glycated Haemoglobin) Levels and Insulin Resistance in Female Diabetic Rats

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Abstract: The current research analyzed the impact of supplementation with DXN Spirulina on glucose levels, glycated hemoglobin (HbA1c), and insulin resistance. According to the results, the use of such supplements can assist in the control of blood glucose level and also decrease the severity of diabetes as a result of the presence of nutrients in these supplements, together with their anti-inflammatory and antioxidant effects. The research was conducted in an animal lab for a period of 40 days with 60 female rats aged from 12 to 13 weeks weighing from 154 to 178 grams. The animals were placed in proper cages where they were exposed to a cycle of 12 hours light and dark conditions, provided with an unlimited supply of water and a regular diet. The animals were made diabetic using alloxan at a dose of 155 mg/kg. There were three groups of animals, and there were 20 animals in each group. Group A comprised healthy controls, Group B had diabetic controls with no treatment, while Group C had diabetic animals and received a treatment using DXN Spirulina supplement at a dosage of 25 g/day. In conclusion, the dose of alloxan resulted in weight loss, high blood glucose, insulin resistance along with ulceration and hemorrhage in the pancreatic tissues, and death of beta cells. On the other hand, the experiments have shown that there was a marked enhancement in body weight gain, an increment in insulin secretion, blood glucose regulation, decrease in insulin resistance, and return to the normal pancreatic histology.

Keywords: Spirulina supplements, diabetes, alloxan, glycated hemoglobin (HbA1c), insulin resistance

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1. Introduction

Diabetes mellitus is a metabolic disorder defined by defects in insulin function or production, causing an abnormal rise in blood sugar level. Type 1 diabetes entails degeneration of beta cells of pancreas situated in the Islets of Langerhans, causing low or no production of insulin. Type 2 diabetes is mainly caused by insulin resistance in which body cells are less responsive to insulin. The onset of diabetes is affected by various factors such as obesity, genetics, and poor eating habits. Diabetes may develop at any age and during pregnancy where it is referred to as gestational diabetes, which is temporary and ends immediately after childbirth but increases susceptibility to Type 2 diabetes in future. Hyperglycemia in diabetes patients leads to gradual tissue damage in many organ systems especially the kidney, liver, and pancreas. [1] Another source of chronic diseases comes from the presence of certain diseases like cancer [2]. Diabetics and its complications account for one of the main causes of mortality and morbidity in the world; as indicated

by scientists, researchers, diabetes will be one of the top seven causes of death by 2030 [3]. Diabetes is associated with numerous vascular complications, most notably neuropathy, diabetic nephropathy, cardiomyopathy, retinal damage, gingivitis, and tooth decay [4]. Furthermore, diabetes can compromise the immune system, leaving the body susceptible to various types of bacterial infections—particularly diabetic foot infections, infections of the mucous membranes and soft tissues, and urinary tract infections [5]. The dietary patterns play a crucial role in determining the body's health status; it has been found that people with a good and well-balanced diet suffer less from diabetes due to the intake of fat and sugars, which are the major causes of type 2 diabetes [6]. The studies have shown that dietary fibers promote the growth of bacteria *Bifidobacterium* and short-chain fatty acids, thereby improving glucose levels in the blood [7]. [8]. Fiber foods are ideal ingredients that one can consume to prevent the effects of diabetes. They occur in different forms and have different roles in our body; some examples of fiber foods include leafy greens (e.g., spinach and parsley), grains (e.g., quinoa), and algae (e.g., spirulina), and they include the following: increasing the amount of antioxidants, improving the immune system, and reducing the levels of HbA1c [8]. Even though they increase gut microbiota and control the levels of blood glucose, their exact effect is dependent on the type and amount of the fiber foods consumed, as well as the overall dietary regimen being followed [9]. The spirulina algae are blue-green species, thriving in subtropical climates. Spirulina is regarded as an essential source of food due to medicinal value because it has high levels of fiber, iron, and antioxidants like phycocyanin. The phycocyanin compound in spirulina has a light absorbing substance referred to as the phycocyanobilin. The latter reduces the effects of the enzyme known as NADPH, causing oxidative stress in fat cells and leading to insulin resistance. The algae also have beta-carotene content and consist of 30 percent proteins [10]. Spirulina is noted for antioxidant and anti-inflammatory properties, enhancing the immune system and glucose control; hence wound healing in diabetic mice [11]. It has plenty of bioactive compounds that contribute to brain health and thus reduce endothelial injuries to blood vessels walls and fatigue and increase the resistance to blood clots [12]. In addition, scientific research has proved that Spirulina is capable of increasing immunity due to its ability to decrease lipid peroxidation caused by physical activity and reduce muscle inflammation and injury caused by the same activity [13]. Spirulina is also able to chelate heavy metals such as lead and improve immunity of affected people [14]. In addition, Spirulina also has a protective mechanism against rheumatoid arthritis through the prevention of production of inflammatory cytokines like TNF-α and IL-6 and by reducing oxidative stress through free radical scavenging [15].

2. Materials and Methods

Laboratory Animals

A total of 60 female Wistar rats aged 12-13 weeks and weighing from 154 to 178 grams were used in this study. The subjects were housed in an environmentally controlled laboratory with a 12 hours photoperiod and unlimited access to drinking water and laboratory food. After acclimation period, the subjects were randomly divided into three treatment groups consisting of 20 subjects each, namely:

Group A: Normal healthy control group

Group B: Diabetic control group without any treatment.

Group C: Diabetic group supplemented with DXN Spirulina.

Inducing Diabetes in Animals

Diabetes was induced in female rats through the induction of alloxan at the concentration of 155 mg/kg body weight. Before the induction of diabetes, the rats were put on fasting for 24 hours and subjected to baseline measurement of their blood glucose levels. Alloxan, a chemical inducer of diabetes which causes selective destruction of pancreatic beta cells, was used to induce hyperglycemia. It was freshly prepared by

dissolving in chilled normal 0.9% saline solution at the concentration of 2-5 g/100 mL. After its administration, the blood glucose levels were checked to ensure that diabetes had been induced. The rats whose blood glucose levels were 250 mg/dL or more were regarded as having developed diabetes. Glucose was also injected to prevent mortality among the experimental animals.

Blood Analysis

After fasting for 24 hours, the experimental animals were exposed to blood sampling and harvesting of tissue for laboratory studies. Levels of glucose in the blood were measured, and blood samples were collected by way of heart puncture and placed in appropriate lab tubes for preservation and analysis. After that, the pancreas was carefully isolated and harvested and placed in formalin solution in designated glass bottles.

3. Result and discussion

Results In this experiment, the use of alloxan induced diabetes among the experimental animals. The findings revealed a marked reduction ($p<0.01$) in body weight in the experimental animals of group B after the treatment of alloxan as opposed to Group A. On the other hand, *Spirulina* proved its nutrition value by increasing the body weight of the experimental animals in group C, as shown in the chart below. Look the figure 1.

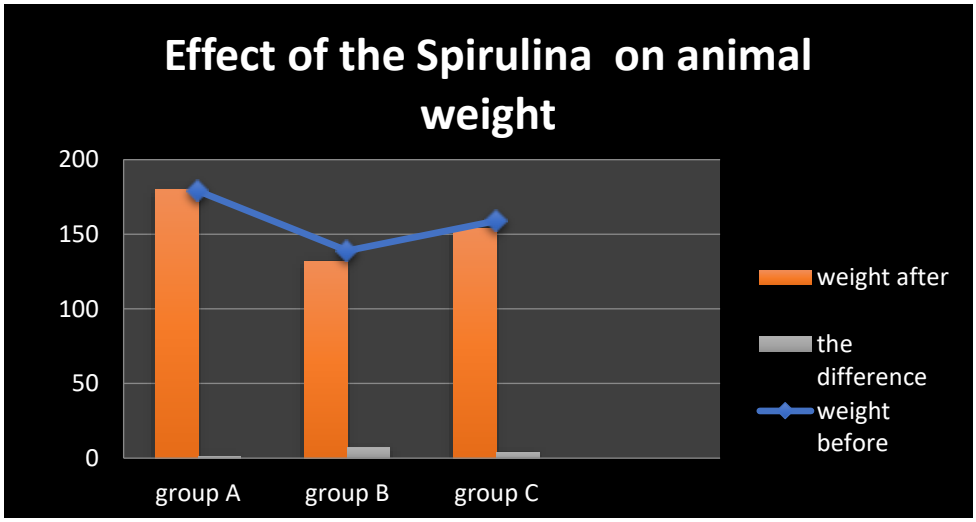

Figure 1. Effect of DXN Spirulina Supplementation on Body Weight in Female Diabetic Rats.

These findings are consistent with previous studies, in which alloxan and streptozotocin (STZ)—administered at doses of 120 mg/kg and 40 mg/kg, respectively—were used to induce diabetes in animal models, resulting in metabolic imbalance, irregular blood glucose levels, and a significant reduction in body weight [16]. Furthermore, the results indicated a statistically significant increase($p<0.05$) in blood glucose, glycated hemoglobin (HbA1c), and serum insulin resistance in Group B compared to Group A. Conversely, the consumption of Spirulina supplements helped regulate blood glucose levels and reduced both glycated hemoglobin and insulin resistance, owing to the supplement's anti-oxidative stress and antiinflammatory properties, as illustrated in Figure (2).

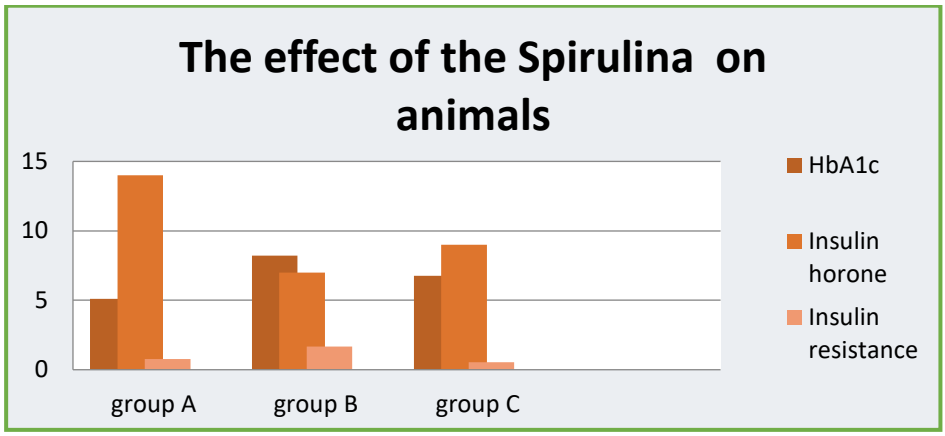

Figure 2. Effect of DXN Spirulina Supplementation on Blood Glucose, HbA1c, and Insulin Resistance Levels in Female Diabetic Rats.

These findings are consistent with a study in which the administration of a 250 mg dose of alloxan resulted in a sharp increase in blood sugar and insulin resistance, leading to the development of nodules and congestion in both the kidneys and the pancreas [17]. Furthermore, the consumption of 2–6 grams of spirulina daily for three months has been shown to reduce glycated hemoglobin (HbA1C) levels, increase high-density lipoprotein (HDL) cholesterol, and improve insulin resistance [18]. Spirulina also exerts a significant effect by inhibiting the production of nitric oxide and the synthesis of the enzyme responsible for its generation, while suppressing programmed cell death (apoptosis). This contributes to improved glucose levels, increased insulin hormone levels, and better liver enzyme markers [19]. Additionally, thanks to its anti-inflammatory and antioxidant properties, spirulina enhances brain function by providing neuroprotection [20]. This is because it enhances the levels of antioxidants— such as GSH, GPX, and SOD—while reducing malondialdehyde (a marker responsible for inflammation) and limiting the accumulation of free radicals [21]. Furthermore, microscopic examination of stained pancreatic tissue sections (at 40x magnification) revealed congestion, vacuolation, and hemorrhage within the beta cells of the Islets of Langerhans in Group B. In contrast, Group C—which received Spirulina supplementation—showed tissue that appeared nearly intact, with only negligible, minimal damage, as illustrated in the following images.

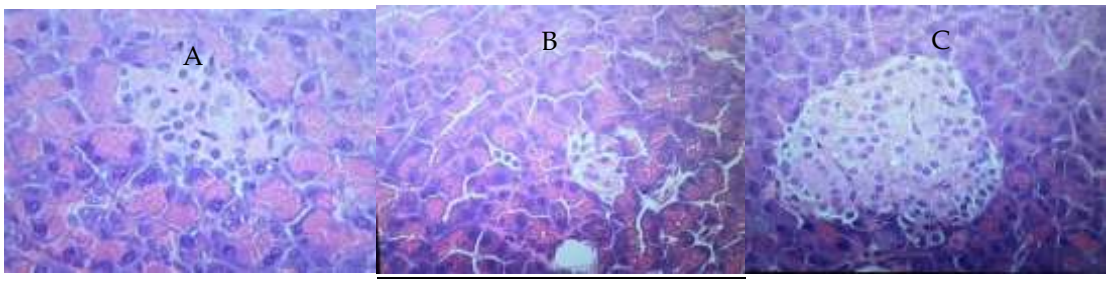

Figure 3. Histopathological Changes in Pancreatic Tissue of Healthy and Diabetic Rats Treated with DXN Spirulina Supplementation.

The results of this study correlate with other studies that employed Spirulina extract as a hydrogel in the management of inflammation in wounds and healing of the wounds of diabetic individuals. The role of Spirulina is through reduction of the burden of advanced glycation end products (AGEs), stimulation of angiogenesis, and polarizing of the macrophages from the M1 type to the M2 type [22]. In addition, studies have revealed that Spirulina aids in bone formation and osteoporosis prevention because of the increased storage of iron and vitamin D, thus stimulating bone formation in STZ-induced diabetic mice [23]. Additionally, it was noted in one research that the use of Spirulina for four months in diabetic mice helped restore the histological structure of the kidneys and pancreatic beta cells, as well as improve immunity, due to the increased antioxidants level [24].

4. Conclusion

This study demonstrates that spirulina is an ideal food for the body, as it contains all the necessary nutrients needed for its proper functioning. It contains the essential amino acids, which the body cannot produce but can consume only from outside, and that satisfy 40% of the needs of the body. In addition to this, it is also full of antioxidants like tocopherols, beta-carotene, and the pigment phycocyanin. Being a food of low glycemic index, it is prescribed for people suffering from diabetes, fatty liver, or morbid obesity.

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