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THE THERAPEUTIC EFFECT OF GYMNEMA SYLVESTRE EXTRACT AGAINST HYPERGLYCEMIA: IN VIVO STUDY

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ABSTRACT

As is well known, today's population in both developed and developing nations participates in fewer physical activities. The problem of obesity is growing as a result of these unhealthy routines or a lack of physical activity, which further contributes to numerous chronic diseases including diabetes and heart disease. The positive modifications in physical activity and nutrition, such as consuming foods with a low glycemic index and high fiber content, aid in the reduction of certain chronic illnesses. In addition, incorporating functional foods into your diet is essential for achieving certain health objectives. *Gymnema sylvestre* is said to as a mystical plant. Gymnema is a special plant that has some fantastic benefits for treating diabetes mellitus. With their remarkable antihyperglycemic capabilities, the leaves stems, flowers, and fine powder of this plant have a powerful effect on elevated blood glycemic load by bringing it down to a normal range. Along with its antihyperglycemic properties, this medicinal plant was crucial in maintaining a person's excess weight and high lipid levels. *Gymnema sylvestre* leaves were used in this study to explore the herb's potential for treating hyperglycemia, and an ethanolic extract of the leaves was created specifically for this purpose. The therapeutic impact of *Gymnema sylvestre* leaves against hyperglycemia was examined in this study using both the powder and extract forms of the plant's leaves. In this study, several blood parameters were examined to see how different *Gymnema sylvestre* dosages affected the hyperglycemia-fighting ability of the herb. Selected data were subjected to various statistical analyses to determine the degree of significance.

***Keywords*:** *Gymnema sylvestre*, Gymnemic acids, Gurmarin, Hyperglycemia, HbA1c, Insulin

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1. INTRODUCTION

Traditionally, the practice of plants as a therapeutic agent is vastly used in different communities. There is an archaeological indication to suggest that plants have been thus used since primitive times. In ancient times, their extract and chemical bioactive compounds were largely used for producing drugs. In the world, nowadays there is a trend of replacement of allopathic drugs with regular food materials which have therapeutic and medicinal potential due to their bioactive compounds (Amin 2011; Kaur et al. 2022). The nutritious diet that the consumers consume in their daily lives is the secret behind a healthy lifestyle. “Let food be thy medicine and medicine be thy food” is a prehistoric saying which provides the way of being healthy. People pay more attention to the therapeutic qualities of their diet and their healthier way of living nowadays. The plants and their useful parts which have a protective potential and can give medicinal advantages in contradiction of life-threatening illnesses, are termed as nutraceutical foods (Keservani et al. 2014). Polyphenols, carotenoids, flavonoids, and saponins are examples of bioactive compounds that show antioxidant potential and are found in nature diversely (Szymanska et al. 2016).

In the body free radicals can be produced by aerobic respiration. That’s why antioxidant enzymes are released by the human body to make these dangerous free radicals neutral, side by side the person’s diet also plays a vital role in this mechanism. So, there is a dire need to improve the diet and take a diet that is antioxidant-enriched. This particular diet is required by the human body to provide a sentinel effect from the process of oxidation and hazardous free radicals (Rafat et al. 2010). If the free radicals do not make the neutral then they lead to many complications or non-communicable illnesses like cancer, dyslipidemia, and diabetes. Food plays a significant role in tackling these life-threatening disorders by providing its specific therapeutic effect (hypoglycemic, hypolipidemic, anticancer, and some other useful effects). Furthermore, a diet rich in phenolic compounds helps to reduce the amount of free radicals and oxidative stress in the body by increasing the level of antioxidants (Del Rio et al. 2013). According to the World Health Organization “the summation of the information, practices based on the

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theories and skills, beliefs and experiences of different nations, these all are aspects of traditional medicine that are used to sustain health, as well as to prevent, identify, recover or treat physical and cerebral sicknesses". In developing countries, approximately 70-95% of the population relies on folk medicine to meet their chief healthcare desires and most traditional treatments make use of plants and crude extract (Edwards et al. 2018). In current centuries, a growing awareness association has increased interest in organic effluents due to their potential health benefits among health and functional foods. According to this point of view, many plants and herbs are extensively used in the cure of diseases and disorders in different regions of the world (Zhao et al. 2017). Fenugreek (*T. graecum*), safflower (*C. tinctorius*), beans (*P. valgaris*), and breadfruit (*T. Africana*) are some examples of medicinal plants that are used generally for diabetes treatment (Moradi et al. 2018).

There are many herbs that have been studied for their hypoglycemic properties and characteristics i.e. *Gymnema sylvestre* is one of them. A woody, climbing plant *Gymnema sylvestre* with a nature of sugar killing is found to be very effective against various kinds of etiological factors related to DM like inflammation by its oral administration (Najafi and Deukule 2011). It is used for a number of major health issues primarily for cardiovascular disorders, obesity, hypercholesteremia, osteoporosis, eye problems, asthma, and snake bite in different cultures and traditions. This health assistance is helpful in controlling hyperglycemia and is regarded as a strong moderator besides insulin resistance and diabetes-induced hyperglycemia. It scavenges free radicals from the body and provides a purifying effect (Tiwari et al. 2014; Khan et al. 2029; Tran et al. 2020). It is a familiar curative plant that has an ancient history of use in homeopathic customary medication and has been widely studied for its value or efficiency in the diabetes mellitus type 2 treatment (Pham et al. 2018).

Gymnema sylvestre is a perennial climber and the superlative season for planting is June to July. It is also propagated by seeds during the period of November to December. It is indigenous to the central and Southern forests of India. In tropical and sub-tropical regions of China, Africa, Malaysia, and Sri Lanka also found. Its herbal formulations are presently used in health pills and supplements, tea bags, beverages, and confectioneries (Patel et al. 2012) *Gymnema sylvestre* is related to the family Asclepiadaceae. It has green leaves with light brown hairy stems. Leaf length is approximately 2-6 cm and width is 1-4 cm. It has normally elliptical or oval-shaped leaves in an opposed manner, follicles are terete and lanceolate up to 3 inches in height. Leaf has a little bitter and astringent taste with a characteristic odor. It also holds the notable attribute of deactivating the sense of taste for a few hours of sugary ingredients (Saneja et al. 2010). The gymnemic acid is the most significant vigorous element present in *Gymnema sylvestre* which removes free radicals and fat peroxidation. It's primarily found in the leaves and stems of the plant.

Besides the gymnemic acid, *Gymnema sylvestre* also contains saponins which are composed of triterpenoids, tannins, flavonoids, gymnemagenin, 23-hydroxylongispinogenin, gymnestrogenin, and a few dammarane derivatives as the aglycones (Porchezhian and Dobriyal, 2003). Triterpenoids have the ability to lower the cholesterol level in the blood. The therapeutic properties of *Gymnema sylvestre* and its main component gymnemic acid have been studied in the handling of cancer, arthritis, dental caries, hyperlipidemia, hepatotoxicity, and diabetes (Patel et al. 2012; Pham et al. 2018; Devangan et al. 2021). *Gymnema sylvestre* reduces high blood glucose levels through the proper mechanism. It promotes the renewal of islet cells. By stimulation, it increases insulin secretion from the pancreas. It inhibits the absorption of glucose from the intestinal tract. By increasing the activity of the enzymes responsible for the use of glucose by the insulin-dependent pathways, the use of glucose increases, an increase in the activity of phosphorylase, a decrease of the gluconeogenic enzymes and sorbitol dehydrogenase. Which leads to a decrease in the high glucose concentration in the blood (Kanetkar et al. 2007; Reddy 2022). The defect in basic nutrients like carbohydrates, proteins, and lipids metabolism is moving towards the chronic disorder "Diabetes mellitus" which is signalized by irregularly raised glucose levels (hyperglycemia), which usually indicates the combination of hereditary and environmental causes, faulty production of insulin or obstruction in insulin action (Jarald et al. 2008).

In the 21st century diabetes declared the most dangerous and alarming disease that interferes with macronutrient metabolism (simple and complex proteins, SFA, USFA, and trans fats and complex carbs) and globally increasing its omnipresence (Keter and Mutiso 2012; Dong et al. 2012). DM is now categorized as the 3rd "Killer" of living creatures along with cardiovascular, coronary artery diseases, stroke, and cancer (Donga et al. 2011). Diabetes mellitus is one of the complex metabolic syndromes initially characterized by loss of glucose homeostasis, high blood lipid levels, inflammatory responses, and oxidative stress. The glucose level in the blood is maintained by the hormone insulin. Diabetes has two well-known types, diabetes type 1 and diabetes type 2. In diabetes type 1 also called insulin-dependent diabetes (IDDM) or juvenile-onset diabetes, insulin cannot be able to produced by the body in this type. In contrast, in diabetes type 2 also known as non-insulin dependent diabetes (NIDDM) or adult-onset diabetes in this type the body cannot produce an adequate amount of insulin or the body becomes resistant to insulin. The privilege of type II diabetes is 95%. Weight gain and obesity are the most common causes of type II diabetes which is recovered by altering lifestyle eating habits (Asmat et al. 2016). Diabetes is an endocrine disorder that happens due to hyperglycemia and the key reason of hyperglycemia is the

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insufficient supply of endogenous insulin. With the passage of time further leads to many complication from which are non-reversible and problematic such as cancer, heart failure, brain hemorrhage and etc. so, it is necessary to achieve and maintains a healthy life to prevent from biggest losses (de M Bandeira et al. 2013). There is a dire need to treat diabetes because it causes severe complications leading to premature death if diabetes is not treated timely. The utilization of insulin production agents and lowering serum glucose medications are involved in the treatment of diabetes (Daisy et al. 2009). The research also revealed that the production of endogenous insulin was enhanced by the oral administration of *Gymnema sylvestre* leaf extract (Pandey et al. 2011; Alam et al. 2022).

According to the WHO, the illness of diabetes affects over 228 million people. Pakistan is ranked 7th among the top 10 nations for having the most diabetes patients. In Pakistan, 14.5 million individuals will have diabetes by 2025. It has been determined that more or less 422 million locals have diabetes. In the last two years, the frequency rate has increased from 4.7 to 8.5%. In Pakistan, the prevalence of diabetes is currently 6.8% in women and 5.1% in men in municipal areas. Diabetes awareness rates in rural areas are 4.8% for females and 5.0% for males. In urban regions, hyperglycemic patients related to rural areas were 14.2% in females and 6.3% in males compared 10.9% in females and 6.9% in males (Zafar et al. 2016).

The group of gymnemic acids for humans and gurmarin for rodents are the chief bioactive elements that are found in the *Gymnema sylvestre*. Saponin and gymnenin which are the derivatives of gymnemic acid plays an important role in the reduction of plasma sugar level by initiating the utilization of glucose which is the basic energy content also they increase the production and excretion of the insulin inside the body which is the chief pancreatic hormone for the maintenance of body's glucose level (Chen and Guo 2017). A laboratory study was held on rats in which diabetes was induced by giving them an alloxan injection, these diabetic rats were administered with the dose of Gymnema *sylvestre* leaf extract of 300 mg/kg on a daily basis for one month. The concerned study shows that a momentous decrease in the ranges of elevated serum glucose is seen in rats with diabetes. The percentage reduction of 69% was recorded at the end day of dose administration (Mall et al. 2009). Diabetes mellitus is a health problem in society that over time contributes to serious impediments. Many herbs were proposed for experimental treatment of diabetes and its complications. The recommendations, however, are based in most cases on animal studies and there is insufficient clinical efficacy confirmation (Ghorbani, 2013). Diabetes is a challenging and numerous etiological metabolic disorder in which hyperglycemia and long-term complications often occur (World Health Organization, 2012). The incidence of diabetes mellitus is nearly 6% of this type 2 diabetes mellitus count at 90% in universal people. Treatment includes weight management, regular exercise or physical activity, lifestyle management, diabesity prevention, use of nutraceuticals with anti-hyperglycemic effects, and at extreme conditions use medications (Kumar and Mukkadan 2013). In this respect, the *Gymnema sylvestre* leaves have extensive therapeutic properties and the hypoglycemic effects of *Gymnema sylvestre* leaves were assessed in the present experimentation.

2. MATERIALS AND METHODS

2.1. Study Area

The experimental analysis was conducted in the Food Microbiology and Biotechnology Laboratory of National Institute of Food Science and Technology, Department of UAF. To evaluate the therapeutic effect of *Gymnema sylvestre* leaves against the complication of hyperglycemia. The leaves of *Gymnema sylvestre* (gurmar) were acquired from the local market of Faisalabad and afterward these leaves were subjected for further procedures.

2.2. Sample Preparation

Stones, dust, and straw fragments were removed from the raw material during cleaning. These leaves were thoroughly dried in a lab-scale dehydrator for 24 hours at 50°C, and they were then crushed into a fine powder in the canning hall using an electric grinder machine. The finished powder was then tested for extract preparation and biochemical characteristics. Using ethanol as the solvent and mostly according to the procedures outlined by Sheoran et al. (2015), the extract of *Gymnema sylvestre* leaves powder was made. The powder was steeped in 200mL of an 85% ethanol solution for 4 hours, following which the extract was filtered using Whatman No. 1 filter paper, and the sample was placed in a rotary evaporator to get a concentrated extract at a lowered pressure below 40°C. It was possible to acquire the semi-solid, dark-green extract.

2.3. Experimental Design

Gymnema sylvestre leaves were used in the study on male albino rats to assess their potential as a treatment for hyperglycemia. The duration of this particular research was one month.

2.4. Animal

Twelve healthy, adult, male albino rats weighing 160-180g and with the age of 2-3 months were purchased and kept in the Animal Room of NIFSAT, University of Agriculture, Faisalabad. Rats were caged individually and

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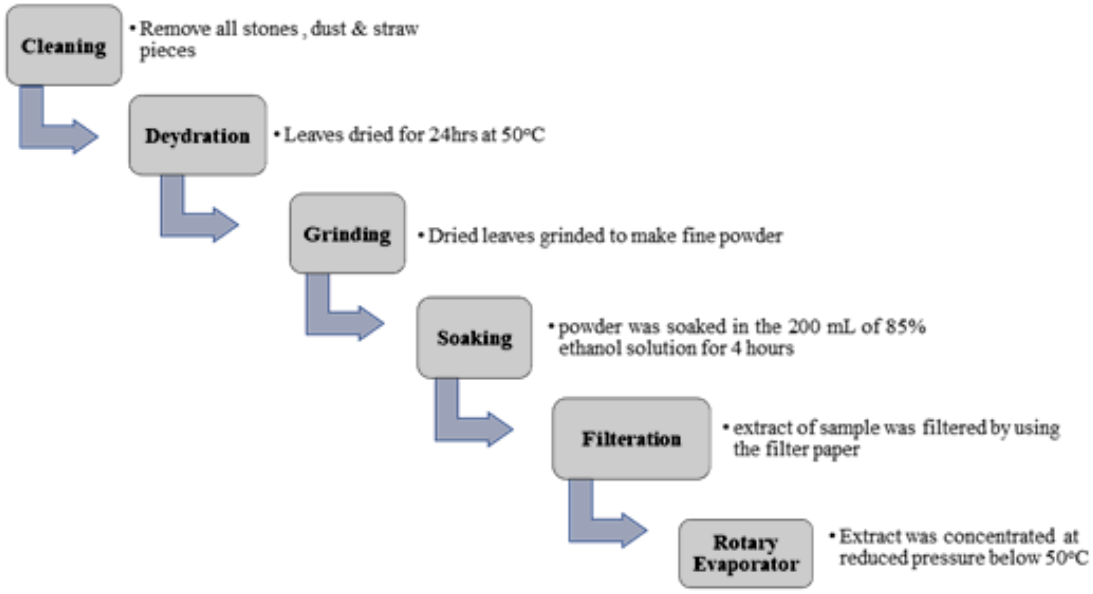
throughout the research, the optimal environmental conditions including humidity, light, and temperature were maintained. All experiments were conducted according to the ethical guidelines of International Association and the standard guidelines for animal use.



2.5. Induction of Hyperglycemia in Normal Healthy Rats

Rats were injected with 60mg/kg of streptozotocin (STZ) to cause hyperglycemia in them. Twelve rats received a total of 7.2mg of streptozotocin along with 12mL of distilled water. Streptozotocin 0.6mg and purified water 1mL were administered to each rat. And because the blood sugar levels were increased when tested by the glucometer after the medication was administered for a week, diabetes was created. When their blood glucose levels are high, rats also alter their behavior. After that, the rats were administered *Gymnema sylvestre* leaf extract and powder to see how it affected their blood glucose and insulin levels. To assess these dosages' impact on the hyperglycemic rats, they were given to rats for a month.

2.6. Efficacy Study Plan

Four groups of 3 rats each were created by dividing the 12 rats into these groups. The first group includes diabetic control rats that are hyperglycemic and are given a regular diet. In the second group of rats, which included diabetic ones, 350mg/kg of an extract from *Gymnema sylvestre* leaves was added to their regular diet. The third group, which also included hyperglycemic rats, given them an extract of *Gymnema sylvestre* leaves in their regular diet, but at a dose of 450 mg/kg. The fourth group of rats, which also included hyperglycemic rats, was fed a 25mg/day powder made from the leaves of *Gymnema sylvestre*. Over the course of a month, these hyperglycemic rats were fed. Weekly blood tests were conducted during this time to track how dosages affected the rats' blood sugar and insulin levels.

Table 1: Treatment plan for *Gymnema sylvestre* leaves dosage to rats

Groups	Treatments
G1	Hyperglycemic rats + normal diet (diabetic control group)
G2	Hyperglycemic rats + 350 mg/kg *G. Sylvestre* leaf extract
G3	Hyperglycemic rats + 450 mg/kg *G. Sylvestre* leaf extract
G4	Hyperglycemic rats + 25mg/day *G. Sylvestre* leaf powder

2.7. Blood Glucose Level

Glucose level of blood was noted by using the method of Rachh et al. (2010) at about every 7th day. The blood samples were collected from the hyperglycemic rats by puncture of the tail vein to check the effect of doses on these hyperglycemic rats. From the blood, the glucose level was noted with the help of a glucometer.

2.8. Serum Insulin Level

In each experimental study group from each group of rats, the serum was obtained by using the method of Ahn et al. (2011) and these rats were evaluated for insulin levels.

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2.9. HbA1c Test

The GOD-PAP method was used to estimate the HbA1c level to check the glucose level in the body of hyperglycemic rats according to the method described by Mostafa et al. (2018).

2.10. Efficacy Study

This study was accomplished to elucidate the therapeutic effect of *Gymnema sylvestre* leaves against hyperglycemic conditions in rats. Rats have been used to evaluate different specific variables because they have functional closing conditions used to impersonate human reactions. In this current examination, the rats were distributed into 4 groups, each group carried 3 rats this one group was the diabetic control group (G_1), and the other three groups were fed with different doses of *Gymnema sylvestre* leaves extract and powder (G_2, G_3, and G_4). The blood glucose, serum insulin, and HbA1c levels were checked after every 7th day.

2.11. Statistical Analysis

The obtained data for each parameter was analyzed statistically to determine the level of significance and means comparison by using the method of Mason et al. (2003).

3. RESULTS AND DISCUSSION

3.1. Blood Glucose

Gymnema sylvestre leaf powder and an ethanolic extract were utilized in the current experimental work to regulate the blood glucose levels of hyperglycemic rats. The statistical findings addressing the impact of treatments and time intervals on blood glucose levels are available in (Table 2). The findings of this investigation showed that treatments and intervals had a substantial impact on blood glucose concentrations. A very substantial interaction was also seen between the treatment intervals and blood glucose concentrations.

Table 2: Treatment means of blood glucose (mg/dL) treated with various doses of *Gymnema sylvestre*

Treatments	Days				Mean
	7	14	21	28	
G1	174.7±1.5	180.7±2.5	191.0±2	202.7±4.26	187.3a
G2	189.0±2	152.0±3	122.67±2.51	105.3±2.1	142.3b
G3	196.0±2	139.0±3	116.00±2	98.0±2	137.3c
G4	182.0±2	153.7±2.5	131.00±3	109.0±2	143.9b
Mean	185.4a	156.3b	140.17c	128.8d	

Mean±SD bearing alphabets in a row or column differ significantly (P<0.05).

The findings of diabetic rats receiving various treatments are shown in Table 2 with regard to blood glucose levels (mg/dL). According to the findings, *Gymnema sylvestre* leaves significantly lowered the blood sugar levels of hyperglycemic rats. The diabetes control group (G1) had the lowest blood glucose reading at the beginning of the study, which was 174.671.52mg/dL. While the G3 group had the highest blood glucose level (196.002mg/dL), G2 and G4 had the next-highest levels (189.002 and 182.002mg/dL, respectively). The results demonstrated that the blood glucose levels of the rats reduced over time when they were fed *Gymnema sylvestre* leaf extract and powder. At the study's conclusion, the G3 (450mg/kg leaves extract) and G4 (25 mg/day leaves powder) groups had the lowest blood glucose levels, with values of 98.002 and 109.002mg/dL, respectively (Fig. 1). G2 (350mg/kg leaves extract) and G3 (450mg/kg leaves extract) had the highest values. In contrast, the G1 (diabetic control group) had the highest blood glucose level, which was 202.674.16mg/dL. With these findings, it was determined that *Gymnema sylvestre* leaves significantly (P<0.001) lower blood glucose levels than did G2 and G4. In contrast, G3 had a greater influence on blood glucose levels than G2 and G4, however, the effects were not statistically significant (Fig. 1). These findings are consistent with research by Mall et al. (2009) in which rats were given an extract of *Gymnema sylvestre* leaves, which reduced blood sugar levels by 45%. In contrast, Shanmugasundaram et al. (2006) who investigated the effects of *Gymnema sylvestre* leaf powder on rats likewise noticed a lowering tendency in the blood glucose level of rats. According to the findings, the blood glucose level was reduced by 28%.

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3.2. Serum Insulin

The ethanolic extract and powder of *Gymnema sylvestre* leaves were used in the current experimental study to increase the level of serum insulin in hyperglycemic rats. In (Table 3) the statistical results are accessible regarding the level of serum insulin influenced by treatments and time intervals. The results which were obtained from this study indicated a significant effect (P<0.001) on the serum insulin concentrations of treatments and time intervals. The interactive impact on serum insulin concentrations and the intervals of treatment also showed a very significant impact.

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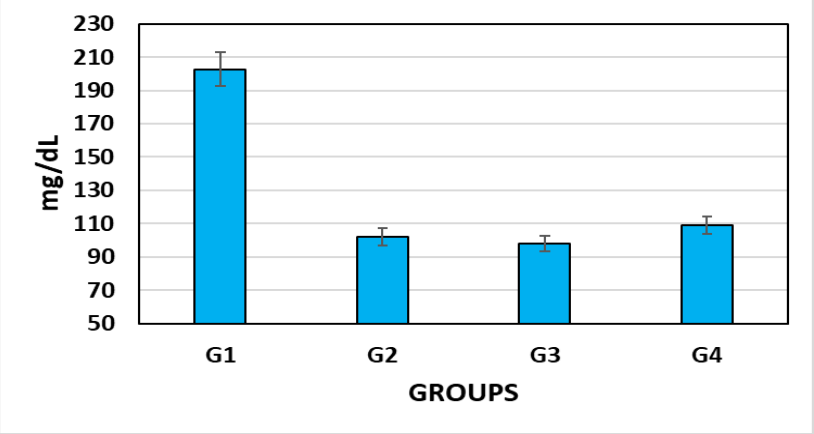

Fig 1: Comparative effect of treatments on Blood Glucose level of rats.

Concerning the serum insulin level (IU/mL), the results are set in (Table 3) of diabetic rats for different treatments. From the results, it is depicted that the leaves of *Gymnema sylvestre* had a significant effect on the serum insulin level of rats with hyperglycemia. In diabetic conditions, the serum insulin level becomes low. At the initial stage, the value of serum insulin level was noted in G_1 (diabetic control group) that was 1.970±0.16IU/ml. The highest serum insulin level noted in the G_3 was 2.080±0.17IU/mL followed by G_4 and G_2 that was 1.637±0.22IU/mL and 1.487±0.29IU/mL respectively. When the rats were fed with the extract and powder of the *Gymnema sylvestre* leaves the results showed that the serum insulin level of rats was increased with the passage of time. At the final stage of the study, the highest value of serum insulin level was noted in G_3 (450mg/kg leaves extract) which was 18.503±0.68IU/mL followed by G_2 (350mg/kg leaves extract), and G_4 (25mg/day leaves powder) that was 15.297±0.61IU/mL and 12.890±0.55IU/mL, respectively. The lowest serum insulin level was noted in the G_1 (diabetic control group) which was 0.527±0.19IU/mL (Fig. 2). These results concluded that the *Gymnema sylvestre* leaves have a significant impact on the serum insulin level by increasing it but on the comparison, the G_3 showed a higher effect on the serum insulin level than G_2 and G_4. Shanmugasundaram et al. (1990) conducted a research study where the rabbits were fed with the *Gymnema sylvestre* extract then the results showed an increase in the serum insulin level with the regeneration of islets of the pancreas. Whereas, in the hyperglycemic rats the serum insulin level was raised by 23% from the baseline values during the trial period stated by Nagy et al. (2012).

Table 3: Treatment means of Insulin (IU/mL)

Treatments	Days				Mean
	7	14	21	28	
G_1	6.2800±0.01	5.2767±0.09	4.3833±0.07	3.5433±0.04	4.8708d
G_2	6.1767±0.01	5.7333±0.09	6.3667±0.09	7.4000±0.06	6.4192b
G_3	6.1633±0.06	6.8433±0.08	7.6567±0.11	8.7967±0.07	7.3650a
G_4	6.2233±0.11	4.7500±0.08	5.5233±0.22	6.3400±0.11	5.7092c
Mean	6.2108b	5.6508d	5.9825c	6.5200a	

Mean±SD bearing alphabets in a row or column differ significantly (P<0.05).

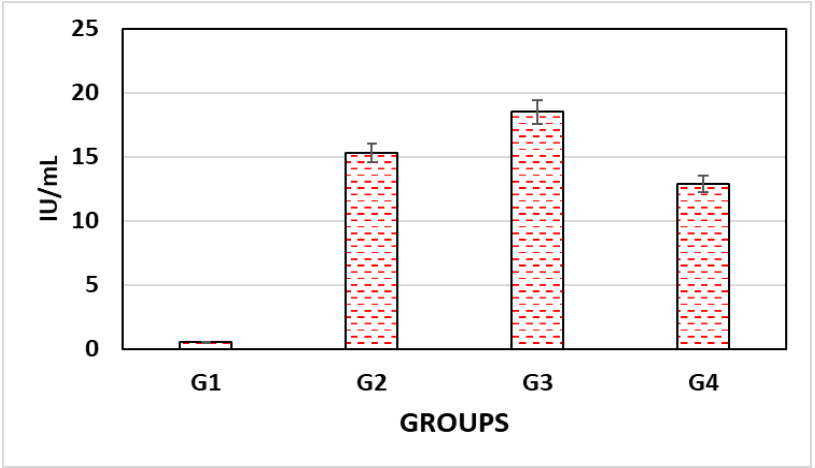

Fig 2: Comparative effect of treatments on Serum Insulin level of rats at the initial level.

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3.3. HbA1c Level

The statistical findings of the hyperglycemic rats were displayed in Table 4, where the data demonstrated that the hyperglycemic rats showed significant results when fed with various dosages of the ethanolic extract and powder from *Gymnema sylvestre* leaves according to the treatments and time intervals. The findings of this investigation showed that therapy and time intervals had a substantial impact (P<0.001) on the HbA1c concentrations. The interaction between the treatment intervals and the blood insulin concentrations also had a very big effect. The outcomes of diabetic rats receiving various treatments are shown in (Table 4) with regard to the HbA1c level (%). According to the findings, *Gymnema sylvestre* leaves significantly lowered the HbA1c levels of hyperglycemic rats. The serum insulin level falls under diabetes circumstances. At the beginning, G1 (the diabetes control group) had the highest HbA1c level, which was 8.320±0.21%. The highest HbA1c levels were found to be 7.957±0.14%, 8.243±0.10%, and 7.673±0.13% in the G2, G3, and G4, respectively. The findings of the experiment indicated that the rats' HbA1c level increased over time when they were fed *Gymnema sylvestre* leaf extract and powder. The lowest HbA1c level was found in G3 (450mg/kg leaves extract), which was 4.463±0.28% at the end of the trial and was followed by G2 (350mg/kg leaves extract) and G4 (25mg/day leaves powder), which were 4.850±0.09% and 5.240±0.1%, respectively (Fig. 3). The largest HbA1c level, however, was 11.827±0.13% in the G1 (diabetes control group). Based on these findings, it was determined that *Gymnema sylvestre* leaves significantly raise HbA1c levels, while G3 exhibited a higher influence than G2 or G4 on this metric. In a research study carried out by Kumar et al. (2010), rats were administered an extract of *Gymnema sylvestre*, and the findings revealed a substantial drop in HbA1c levels. While the HbA1c level in the hyperglycemic rats was 15% lower than the baseline levels over the trial time examined by Daisy et al. (2009).

Tabe 4: Treatment means of HbA1c (%)

Treatments	Days				Mean
	7	14	21	28	
G_1	8.320±0.21	9.860±0.17	10.830±0.5	11.827±0.13	10.209a
G_2	7.957±0.14	5.980±0.12	5.257±0.08	4.850±0.09	6.011c
G_3	8.243±0.10	5.723±0.08	4.980±0.13	4.463±0.28	5.852c
G_4	7.673±0.13	6.297±0.15	5.767±0.10	5.240±0.10	6.244b
Mean	8.0483a	6.9650b	6.7083c	6.5950c	

Mean±SD bearing alphabets in a row or column differ significantly (P<0.05).

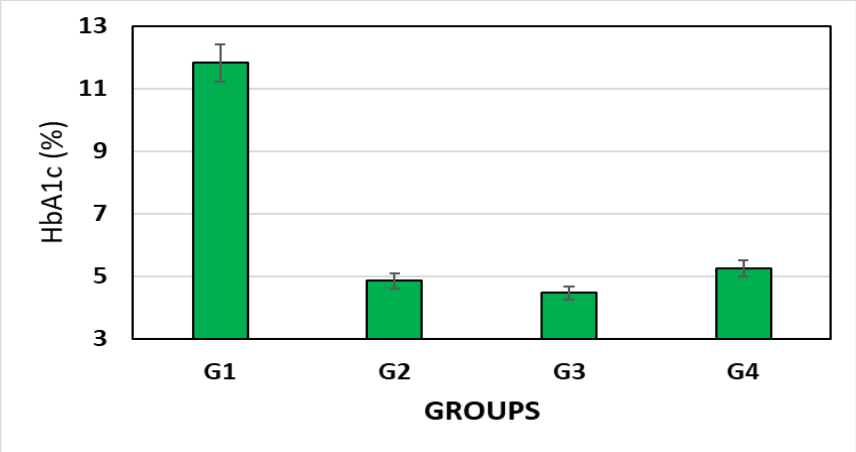

Fig 3: Comparative effect of treatments on HbA1c level of rats.

4. Conclusion

Diabetes mellitus is one of the complicated metabolic syndromes and is initially characterized by oxidative stress, inflammation, loss of glucose homeostasis, and elevated blood lipid levels. The hormone insulin regulates the amount of glucose in the blood. Blood glucose levels that are too high are a result of impaired insulin production and action, which causes glucotoxicity. *Gymnema sylvestre* (gurmar) leaves were employed in this investigation in a variety of dosages and formats. *Gymnema sylvestre*, a woody, climbing herb, is reported to be particularly efficient against a variety of etiological variables associated with DM, such as inflammation, when taken orally. *Gymnema sylvestre*, a woody, climbing herb, is reported to be particularly efficient against a variety of etiological variables associated with DM, such as inflammation, when taken orally. After conducting this experimental study, researchers came to the conclusion that the *Gymnema sylvestre* plant is magical because it has beneficial effects against hyperglycemic conditions and aids in the production of insulin while lowering blood

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glucose levels to those that are within the normal range, which is 98.002 mg/dL in rats fed with 450mg/kg of leaves extract, 105.3mg/dL in rats fed with 350mg/kg of leaves extract. According to all of the study's findings, ethanolic extract at a dosage of 450mg/kg had a stronger anti-hyperglycemia impact. *Gymnema sylvestre* leaves significantly affect the amount of serum insulin. When *Gymnema sylvestre* extract was used, the results revealed that the regeneration of pancreatic islets led to a rise in blood insulin levels. The results revealed that the HbA1c level of the rats rose over time when they were fed *Gymnema sylvestre* leaf extract and powder.

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