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In-vivo Evaluation of Antidiabetic Activity of Polyherbal Extract (Allium Sativum, Ziziphus Mauritianan & Delonix Regia) In Wister Rats.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Abstract

In order to manage type-II diabetes mellitus, the current study assesses the antidiabetic potential of a polyherbal extract made of Delonix regia (flame tree), Ziziphus mauritiana (Indian jujube), and Allium sativum (garlic). Although earlier studies have demonstrated the effectiveness of these herbs alone in the treatment of diabetes, this study concentrated on their combined effects. Streptozotocin-induced diabetic Wistar rats were given different quantities of the polyherbal extract, and the results were compared to a group that received normal antidiabetic medication treatment. According to the results, the polyherbal combination considerably lowered blood glucose levels and lessened the negative symptoms of hyperglycemia. Additionally, rats treated with the polyherbal extract displayed a considerable improvement in body weight, suggesting its potential to ameliorate diabetes-related weight loss. The bioactive substances in these herbal extracts worked together to improve overall physiological function and improve glycemic management. In addition to highlighting the advantages of polyherbal formulations as an alternative to traditional treatment, this study reveals the synergistic therapeutic effects of Allium sativum, Ziziphus mauritiana, and Delonix regia in the management of diabetes.

Keywords:- Antidiabetic activity, Polyherbal extract, *Allium sativum*, *Ziziphus mauritiana*, *Delonix regia*, Type-II diabetes mellitus, Hyperglycemia.

Introduction

Nearly 6% of people worldwide suffer from diabetes mellitus, one of the most prevalent diseases, and its dynamics are fast shifting in low- and middle-income nations. The International Diabetes Federation (IDF) projects that by 2030, low- and middle-income nations will account for 80% of the world's diabetes population. According to the IDF 2011 study, there are currently 90.0, 61.3, and 23.7 million diabetics in China, India, and the United States of America, respectively. By 2030, that number might rise to 129.7, 101.2, and 29.3 million. One of the six leading causes of death worldwide, diabetes also results in several systemic problems. Alpha-glucosidase inhibitors, sulfonylureas, biguanides, and thiazolidinediones are examples of glucose-lowering medications used to treat diabetes mellitus, as is hormone treatment (insulin). Many research institutes and pharmaceutical corporations are interested in drug development to uncover molecules with strong therapeutic potential and fewer adverse events because the development of an adverse event is one of the problems in the treatment of any systemic condition. 3.47.0% of hospital admissions in the United States are caused by adverse drug reactions, which affect 102.5 percent of patients.

Numerous plants are effective in treating a range of systemic illnesses in traditional medical systems. One of the major issues facing the traditional medical system is its lack of full uniformity, although many traditional/Indigenous medical systems are more successful than the modern one. The ancient literature contains extensive documentation on the idea of polyhedral formulation. The polyherbal formulation offers more and longer-lasting medicinal potential than a single herb. To create and standardize a polyherbal formulation employing a plant with documented antidiabetic activity and assess its therapeutic benefits in rodents, the current study was designed.

Material and Method

Herbal drug material

Selection and collection: Allium sativum, Ziziphus mauritianan, and Delonix regia were collected from the local market of the Morena region.

Authentication: Identified and Authentication by Dr. M. K Gupta, Department of Botany Jiwaji University, Gwalior M.P India, and Date of Authentication 01/07/2023.

Drying: Herbal products are used to remove the water/moisture content from it by a natural process, i.e., under sunlight.

Soxhlet Extraction

Figure 1 Soxhlet Apparatus

To increase surface area, 250g of each of an Allium sativum bulb, a Ziziphus mauritianan seed, and Delonix regia leaves were dried, ground into a coarse powder, and then extracted with 60–65% ethanol using a separate Soxhlet extractor. The Soxhlet extraction method is widely utilized in the extraction of plant metabolites due to its perceived ease of usage. With this method, practically all initial and bulk extraction may be completed. The primary benefit of the Soxhlet apparatus, commonly referred to as the hot continuous extraction technique, is that it requires the least amount of solvent to achieve full extraction. A round-bottom flask, siphon tube, distillation channel, condenser, cooling water inlet, cooling water exit, heat source, and thimble make up the Soxhlet extractor system.

This procedure involves drying, grinding, and powdering the sample into tiny particles, then placing it in a porous bag or "thimble" made of sturdy filter paper within the Soxhlet apparatus's thimble chamber. A heating source, such as a heating mantle, is used to heat the extraction solvent in a round-bottom flask. The solvent in the flask's bottom vaporizes into the condenser and then drips back into the sample thimble as a result of the heat. The extraction chamber's design allows the solvent around the sample to overflow and drip back into the boiling flask when it reaches a predetermined level.

The clear solution in the siphon tube indicates that the operation is finished when the liquid content reaches the siphon arm and is dumped into the bottom flask once more. The procedure should take about 16 hours to complete. After that, the extract was compressed until it was dry, resulting in a brownish solid. Ziziphus mauritianan yields 21.7g, Delonix regia yields 26.7g, and Allium sativum yields 28.84g. After that, the extracts were ground into a powder using less pressure. This approach has the benefit of recycling a single batch of solvent rather than passing numerous portions of heated solvent through the sample. For thermolabile chemicals, this approach is not appropriate since prolonged heating could cause the deterioration of compounds.

7.5. Preliminary Qualitative Phytochemical Screening

To identify the main chemical groups—alkaloids, sugars, glycosides, saponins, terpenoids, and sterols the subsequent extract underwent an initial phytochemical screening. Following the suggested standard technique, the initial phytochemical screening was completed as follows:

A.TEST FOR ALKALOIDS

Certain extracts were examined after being dissolved with diluted hydrochloric acid.

i. Mayer's Test

The filtrates (potassium mercuric iodide) were cleaned using Mayer's reagent. The development of a yellow precipitate indicates the presence of alkaloids.

ii. The Wagner Test

The filtrates were cleaned using Wagner's reagent (iodine in potassium iodide). The development of a brown or reddish precipitate indicates the presence of alkaloids.

iii. The Test of Dragendroff

Using a solution of potassium bismuth iodide, the filtrates were cleaned using Dragendorf's reagent. The formation of a red precipitate indicates the presence of alkaloids.

iv. Hager's Test

The filtrates (saturated picric acid solution) were cleaned using Hager's reagent. The presence of alkaloids is confirmed by the formation of a yellow-colored precipitate.

of alkaloids.

B.TEST FOR CARBOHYDRATES

Five milliliters of water were used to dissolve the residue, and it was then filtered as needed. A carbohydrate analysis was performed on the filtrate.

i. The Molisch test

After introducing a few drops of condensed sulfuric acid through the test tube's walls and treating the filtrate with two to three drops of 1% alcoholic alpha naphthol, a purple-to-violet color ring developed.

ii. Benedict's examination

0.5 mL of the filtrate was mixed with 0.5 mL of Benedict's reagent. The mixture was cooked in a boiling water pan for two minutes. Sugar is seen as a characteristic crimson precipitate.

iii. The Fehling test

One milliliter of Fehling's solution was used to wash the filtrate, which was then heated. The orange precipitate shows the appearance of carbs.

C.TEST FOR GLYCOSIDES

I. Bontrager's examination

Boil the test material with 1 milliliter of sulfuric acid for five minutes in a test bath. While the water is still bright, filter. After cooling the filtrate, add the same volume of chloroform. To separate the lowest layer of chloroform, shake it with half as much diluted ammonia. The color produced by the ammonical layer ranges from rose pink to scarlet.

ii. The Legal test

The sample solution turns blood red when an alkaline sodium nitroprusside solution is added.

iii. Test of Killer-Killani

The medication is extracted using chloroform and then dried by evaporation. To the mixture, add 0.4 mL of glacial acetic acid and a tiny bit of ferric chloride. By the side of the Test tube, pour 0.5mL condensed sulphuric acid. The acetic layer is blue.

D. TEST FOR PHYTOSTEROLS AND TRITERPENOIDS

i. Burchard test by Libermann

Three milliliters of acetic anhydride and a few drops of concentrated sulfuric acid were added after one gram of extract had been mixed with a few drops of dry acetic acid. The emergence of a bluish green color indicated the presence of phytosterols.

ii. The Salkowski test

When a few drops of condensed sulfuric acid are added to the extract, the lower layer turns red, indicating the presence of steroids, and purple, indicating the presence of triterpenoids.

E.TEST FOR FIXED OILS AND FATS

Separately, two filter papers were coated with a very small amount of each extract. The formation of an oil spot on the paper indicates the presence of fixed oil. A limited number of distinct extracts were mixed with a drop of phenolphthalein and a few drops of 0.5 N alcoholic potassium hydroxide. In a water bath, the mixture was cooked for one to two hours. The formation of soap or partial alkali neutralization indicates the existence of fixed oil and lipids.

F.TEST FOR SAPONIN

i. The test for foam

In a measuring cylinder, the extracts were agitated for 15 minutes after being condensed to 20ml with filtered water. The formation of a 1 cm film of foam indicates the presence of saponins.

ii. The foam test

Half a gram of extract was mixed with two milliliters of water. If the foam that forms lasts longer than 10 minutes, saponins are present.

G.TEST FOR TANNINS AND PHENOLIC COMPOUNDS

i. Test for gelatin

The extract was treated with a 1% sodium chloride gelatin sample solution. The formation of a white precipitate indicates the presence of tannins.

ii. Test for ferric chloride

The extracts were mixed with three to four drops of ferric chloride solution. The formation of a bluish-black color indicates the presence of phenols.

H. PROTEIN AND FREE AMINO ACIDS TEST

i.Xanthoproteic examination

The extracts are mixed with a few drops of strong nitric acid. The formation of a yellow color indicates the presence of proteins.

ii. Ninhydrin test: After adding the 0.25 percent w/v Ninhydrin mixture to the extract, it was heated for several minutes. The development of a blue hue indicates the presence of amino acids.

iii. The Burette test

Equal parts of a 1% $CuSO_4$ solution and a 5% NaOH solution were added. The pink color indicates the presence of proteins and free amino acids.

I. **FLAVONOID TEST**

i.Test with an alkaline reagent

The extracts are mixed with a few drops of sodium hydroxide solution. Flavonoids are identified by their production of a bright yellow color that turns colorless when diluted acid is added.

ii. Test for lead acetate

The extracts were mixed with a few drops of lead acetate solution. The formation of a yellow precipitate indicates the presence of flavonoids.

J. LIGNIN TEST

The emergence of a red hue in an alcoholic solution with hydrochloric acid indicates the presence of lignin.

Experimental Animals

From the central animals of Shriram College of Pharmacy, Banmore, Wistar rats weighing 200–250 g of either sex were acquired. They were kept in polypropylene cages on rodent pellets at a regulated temperature of 22±2°C and acclimated to a 12-hour light/dark cycle. Food and water were freely available until two hours before the trial. The animals were maintained and cared for by the "Committee for Control and Supervision of Experiments on Animals (CPCSEA)"'s approved criteria. Two hours following the trial, food and water were made available. All animal tests were carried out in compliance with the project proposal no. The establishment's ethical committee on animal experimentation issued ref.no. SRCP/M PHARMA/IAEC/83/22-23.

Induction of Diabetes

A single dosage of Streptozocin (STZ) (60 mg/kg body weight, i.p.) 2% solution mixed in 0.9% NaCl was used to induce diabetes following a 12-hour fast. They had unrestricted access to food and water glucose solution following the injection to prevent hypoglycemic shock. After 72 hours, diabetes was found to have developed. For the experiment, rats with fasting blood glucose levels more than 200 mg/dl were chosen.

Drug Treatment

Different drug treatment was given to different groups of rats after the induction of diabetes. The treatment includes:

i. Combination of extract in equal quantity (200 mg/kg and 400 mg/kg body wt.; orally)
ii. Glibenclamide (0.5 mg/kg body wt.; peritoneal cavity)

Grouping of Animals

The animals were divided into 5 groups, 6 in each, total no. of animals =30

Group I: Normal control (vehicle only i.e., 0.9 % NaCl).
Group II: Diabetes control (STZ induced 60mg/kg; i.p).
Group III: Diabetes induced+ standard drug (Glibenclamide 0.5mg/kg; peritoneal cavity)
Group IV: Diabetes induced+ polyherbal extract (200mg/kg; p.o)
Group V: Diabetes induced + polyherbal extract (400mg/kg; p.o)

Preparation of doses

The extracts dissolved or suspended in distilled water; their pH was brought to 7.0.

Administration of doses

Herbal extracts are administered in a single by gavages using a stomach tube.

Evaluation Parameters

i. BLOOD GLUCOSE

Except for the normal control and diabetes control groups, the treatment began on the same day and was administered orally for 21 days. Animals in groups had unrestricted access to water and a typical feed throughout this time. Estimates of blood glucose levels were made on days 0, 3, 7, 14, and 21 of the treatment. A glucometer strip and glucometer were used to estimate the glucose levels in the blood that was extracted from the tail vein. (Laboratory Jyoti Scientific).

ii. BODY WEIGHT

The body weight of rats was recorded on 0, 3rd, 7th, 14th, and 21st day of the treatment with the help of electronic balance.

Statistical Analyses

The data obtained from the different studies and the biochemical estimation is expressed as mean± SEM for each group. After this, the statistical analysis was carried out using was carried out using one-way analysis of variance (ANOVA) followed by Dennett's test using SPSS 16.0 window version. Values p> 0.05 were considered non-significant, p<0.05 as significant.

RESULTS

Table 1: Phytochemical Testing of Herbal Extracts.

S. NO.	**Test**	**Extract (ethanol)**		
		Allium sativum (bulb)	*Ziziphus mauritianan(seed)*	*Deloonix regia(leaves)*
1.	**Alkaloids**			
	Mayer's test	+	+	+
	Dragendroff's test	+	+	+
2.	**Carbohydrates**			
	Benedict's test	+	_	_
	Fehling's test	+	+	+
3.	**Proteins**			
	Biuret test	+	+	+
	Millon's test	+	+	+
4.	**Amino acids**			
	Ninhydrin test	+	+	+

	Tyrosine test	+	_	_
5.	**Glycosides**			
	Borntrager's test	+	+	+
6.	**Flavonoids**			
	Lead acetate test	+	+	+
7.	**Phytosterols**			
	Salkowski test	+	+	+
8.	**Fats and oils**			
	Solubility test	-	_	_
	Stain test	+	_	_
9.	**Phenolics and tannins**			
	Acetic acid test	+	+	+
10.	**Volatile oils**			
	Solubility test	-	-	-

(+) Indicates positive result, (–) Indicates negative result.

Table 2: Effect of Polyherbal Extract (Allium Sativum, Ziziphus Mauritianan & Delonix Regia) in different animal groups on blood glucose level.

S.NO.	Groups Treatment/ Dose	0 day (mg/dL)	After 3days (mg/dL)	After 7days (mg/dL)	After 14days (mg/dL)	After 21days (mg/dL)
I	Normal control	95.32± 1.12	94.71± 0.96*	96.08± 1.35*	96.54± 1.24*	98.92± 0.97*
II	Diabetic control (STZ induced 60mg/kg)	257.18± 2.64	279.06± 1.98	270.12± 2.54	219.37± 2.36	209.14± 1.97
III	Standard drug (Glibenclamide 0.5 mg/kg)	253.13± 3.29	200.12± 3.07*	155.43± 2.99*	118.74± 2.86*	98.16± 3.04*
IV	*Polyherbal extract* (200mg/kg)	256.16± 2.91	247.74± 2.23	208.17± 3.06	176.51± 3.27	130.36± 2.97
V	*Polyherbal extract* (400mg/kg)	249.49± 3.82	219.12± 3.54	161.75± 2.59*	130.50± 2.89*	112.69± 3.06*

Streptozocin (60 mg/kg) was administered; i.p in sterile saline, single dose 7 days before the administration of different ethanolic extracts.

Standard drug Glibenclamide (0.5mg/kg body wt. by peritoneal cavity) once a day. Ethanolic Polyherbal extract was administered orally once a day, in a single dose daily seven days after confirmation of Hyperglycaemia.

N=6 (no. of animals in each group)

A statically significance test was done by one-way ANOVA followed by Dunnett's test using the SPSS 16.0 window version.

*p<0.05 compared to the disease control group.

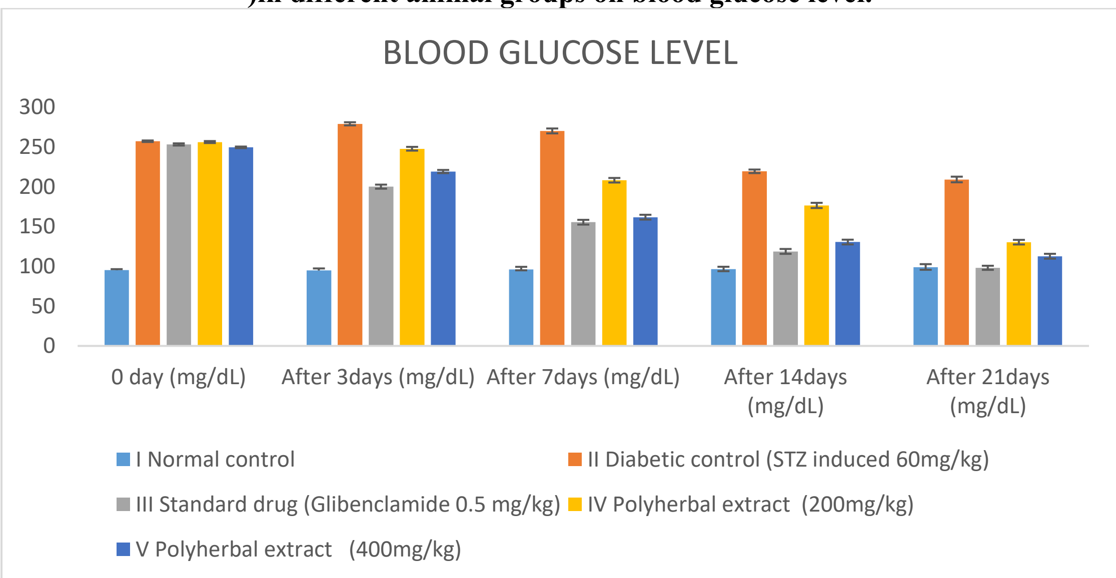
Table 3: Effect of Polyherbal Extract (Allium Sativum, Ziziphus Mauritianan & Delonix Regia) in different animal groups on body weight.

S. No.	Groups	Body weight (in grams)				
		0^{th} day	3^{rd}day	7^{th}day	14^{th}day	21^{st} day
I	Normal control	194.6±2.4	193.8±3.0	190.6±1.2*	189.5±1.3*	186.5±1.3*
II	Diabetic control	186.5±1.5	186.5±1.5	177.6±1.6*	173.7±2.6*	170.7±2.6*
III	Standard drug(0.5 mg/kg)	172.7±2.6	173.7±2.6	178.6±1.6*	186.5±1.5	190.5±1.5
IV	*Polyherbal extract* (200mg/kg)	170.7±2.6	171.7±2.6	174.6±1.6*	179.5±1.5	183.5±1.5
V	*Polyherbal extract* (400mg/kg)	170.7±2.6	174.7±2.6	178.6±1.6*	187.5±1.5	193.5±1.5

Streptozocin (60 mg/kg) was administered; i.p route in sterile saline, single dose 7 days before the administration of different ethanolic extracts.
Standard drug Glibenclamide (0.5mg/kg body wt. by peritoneal cavity) once a day.
Ethanolic Polyherbal extract was administered orally once a day, in a single dose daily,7 days after confirmation of Hyperglycaemia.
N=6 (no. of animals in each group)
A statistical significance test was done by one-way ANOVA followed by Dunnett's test using SPSS 16.0 window version.
*p<0.05 compared to the disease control group.

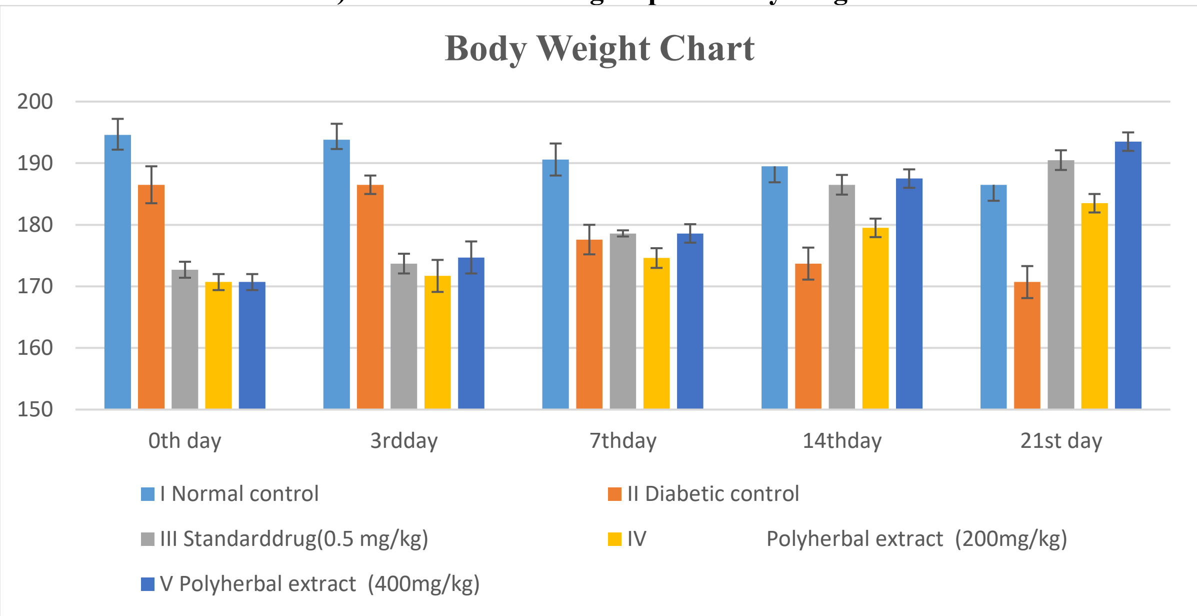
Observations

Figure 2: Effect of Polyherbal Extract (Allium Sativum, Ziziphus Mauritianan & Delonix Regia)in different animal groups on blood glucose level.



Statically significance test was done by one way ANOVA followed by Dunnett's test.
*p<0.05 compared to disease control group. Control value for Body weight -228.86±2.76 All values are MEAN± SEM of 6 animals per group

Figure 3: Effect of Polyherbal Extract (Allium Sativum, Ziziphus Mauritianan & Delonix Regia)in different animal groups on body weight.



Statically significance test was done by one way ANOVA followed by Dunnett's test *$p<0.05$ compared to disease control group.

Discussion

Hyperglycemia is the hallmark of diabetes, a chronic metabolic disease that is becoming more and more of a global health concern. Environments and genetics play a significant role in the pathophysiology of diabetes. Approximately 470 million persons worldwide had diabetes in 2022, and by 2045, that figure is expected to increase to 693 million. When diabetes develops, oxidative stress and inflammation are brought on by persistent hyperglycemia. Furthermore, because of the glucotoxicity effects, which hasten the mortality of diabetes, it is commonly linked to dysfunction and serious clinical consequences, including diabetic retinopathy, nephropathy, neuropathy, and peripheral artery disease. Therefore, reducing the production of reactive oxygen species (ROS) and managing elevated blood glucose levels are crucial for managing diabetes or reducing its consequences.

To reduce the incidence of diabetes, several natural products that have been extracted from plant sources may be used as supplements or replacements since they have antioxidant action and fewer adverse effects. Consuming the aforementioned plant components may lower the incidence of chronic illnesses and prevent colon cancer, according to a prior study. The high concentration of monounsaturated fatty acids (MUFA) in these plants, particularly oleic fatty acids, may help reduce inflammation, oxidative stress, mitochondrial dysfunction, and cellular death in hepatocytes.

Due to its anti-inflammatory, antioxidant, and free radical scavenging properties, Allium sativum, Ziziphus mauritianan, and Delonxi regia have been shown in earlier research to improve immunity and decrease lipid peroxidation processes in rats with CCl4-induced liver injury. Few studies have examined the effects of dietary supplements containing Allium sativum, Ziziphus mauritianan, and Delonxi regia on gut microbiota in STZ-induced diabetes. We hypothesized its positive impact on diabetes because of its exceptional antioxidant activity. Thus, the purpose of our study was to examine the effects of this combination on STZ-induced diabetic rats.

Most mouse strains can be utilized for streptozotocin (STZ)-induced diabetic mellitus (DM), which provides a very quick and economical method that gives researchers studying DM access to a variety of genotypic and phenotypic possibilities that would not otherwise be available. Even though STZ is frequently used in small animal models, there is sometimes little and inconsistent information available about drug preparation, dosage, and administration, the severity and time to onset of DM, and any associated morbidity and death [72].

The beta cells of the pancreatic islets that produce insulin are poisoned by the broad-spectrum antibiotic STZ. It has been used experimentally in a wide range of large and small animal species and is presently utilized clinically to treat metastatic islet cell cancer of the pancreas. Over the years, a great deal of research has been done on how STZ works to deplete β cells. Although streptozotocin's cytotoxicity may be attributed to its functions as a protein alkylating agent and nitric oxide donor, it is generally believed that STZ is absorbed by the cell membrane GLUT2 glucose transporter, causing DNA alkylation and ultimately β cell death. Since STZ enters the cell through GLUT2, its harmful effects are not limited to β cells and can harm other tissues, such as the liver and kidney.

In this study, we used Streptozotocin for our experiments in the induction of experimental diabetes mellitus. For induction of experimental diabetes, 60mg/kg of Streptozotocin was injected intravenously STZ in a buffer solution with a pH of 4.0.

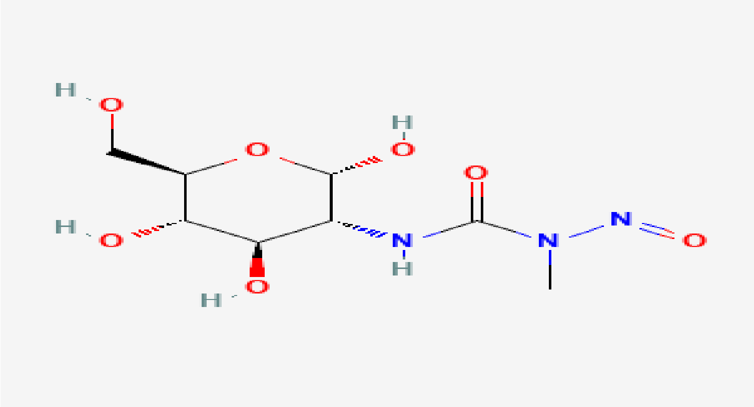


Figure 4: Chemical Structure Of STZ

Type 2 diabetes (T2D) is a long-term condition characterized by hyperglycemia, or elevated fasting blood glucose (FBG) levels. It is a chronic disorder of the metabolism of lipids and carbohydrates. Ninety percent of people with diabetes globally have type 2 diabetes. T2D has a very high rate of complications compared to other disorders, and it may even be a contributing factor to depression and Alzheimer's disease. It is widely acknowledged that the primary pathophysiology of type 2 diabetes and its consequences is caused by insulin resistance and elevated oxidative stress. The hallmarks of type 2 diabetes include a steady decline in insulin function and malfunctioning of the β-cells, which tries to make up for insulin resistance. Reduced antioxidant function and elevated free radical levels are frequently linked to type 2 diabetes.

Medicinal plants with minimal side effects have been used for hundreds of years as part of traditional treatments for people with type 2 diabetes. Medicinal plants have been crucial to the development of novel drugs in recent years. Metformin, the most popular anti-T2D medication, was first created from Galega officinalis, a medicinal plant that has been used for several centuries to treat diabetes. The limonene and flavonoids found in the aforementioned plants, which are cultivated all over the world, have anti-inflammatory and anti-tumor properties that make them useful for ethnomedical purposes. Because of their ability to scavenge radicals in vivo, natural antioxidants derived from plants are gaining more attention. The type of plants and the extraction technique determine which bioactive ingredients are extracted from different plants.In this study, I justify the effect of the polyherbal extract on diabetes induced by STZthe anti-diabetic and antioxidant effects of the extract were examined by performing experiments in rat models of T2D.

There are several classes of oral antidiabetic medications on the market at the moment. These medications would be divided into three categories based on their antidiabetic properties: insulin sensitization, insulin secretion, and extra-pancreatic insulin release. In addition to these effects, medications also dramatically lower the level of glycated hemoglobin. The most commonly administered oral hypoglycemic medication is glibenclamide. Chemically, 5-chloro-N- [2- [4-cyclohexyl carbamoyl sulfamoyl) phenyl] ethyl]-2-methoxy benzamide is a sulfonylurea molecule that increases insulin release from beta cells by acting as either pancreatic or extra pancreatic. In hyperglycemic circumstances, glibenclamide works by promoting the generation of insulin from the pancreatic beta cells already present.

It exhibits extrapancreatic effects in addition to this direct activity. This medication attaches itself to the sulfonylurea receptor 1 (SUR 1), which is a regulatory subunit of the beta cells' ATP-sensitive potassium channels (KATP). This inhibition opens the voltage-dependent calcium channels and depolarizes the cell membrane. It causes beta cells' intracellular calcium concentration to rise, which in turn triggers the release of insulin. Therefore, in clinical diabetes, the single medication glibenclamide decreases hepatic glucose synthesis and increases insulin secretion. According to one study, in streptozotocin (STZ)-diabetic rats, sulfonylureas increased the production of insulin from the pancreatic beta cells that were already present. Additionally, this substance shows neuroprotective effects on the neurons in the brain's hippocampus regions.

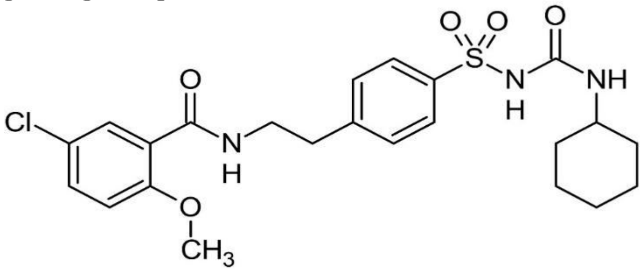


Figure 5. Chemical Structure of Glibenclamide

Conclusion

The anti-diabetic qualities of polyherbal extract (Allium sativum, Ziziphus mauritianan, and Delonix regia) were evaluated in this study. Both herbal treatments are beneficial in treating diabetes, according to numerous research. We used combination dosages and compared the results with a standard group in order to examine the combined effects of both herbal drug extractions on type-II Diabetes Miletus. Our results showed how well this test chemical combination worked against diabetes and the negative symptoms of high blood glucose that go along with it. Furthermore, as the animals were treated with the test drugs, their body weight increased.

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