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Screening of *Psophocarpus tetragonalobus* hydroalcoholic extract for antidiabetic activity on STZ induced diabetic rat model

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Abstract
Psophocarpus tetragonalobus of the Fabaceae commonly known as winged bean is a valuable crop because of its high nutritional value. The present work aims to evaluate the active potentials of different extracts of *P.tetragonalobus* along with its anti-diabetic activity on STZ induced diabetic rat model. Preliminary phytochemical investigation reported the presence of proteins, lipids, carbohydrates, phenolic compounds, glycosides, tannins and vitamins. Antihyperglycemic activity of the two doses (100mg/kg, 200 mg/kg) of hydroalcoholic pod extract was studied on normal, and streptozotocin-induced diabetic rat models. The effect of the extract on body weight and serum lipid levels was also examined. Out of the two doses of the plant extract 200 mg/kg showed a significant anti- diabetic activity and improved the body weight loss after repeated daily dose administration for 21 days. This study concludes that the hydro-alcoholic extract of *P.tetragonalobus* possesses considerable activity to reduce the blood sugar level justifying the traditional use of the plant for diabetes.

Keywords: Phytochemical study, phenolic compounds, antidiabetic

1. Introduction
Man has been utilizing spices and plant items for relieving sicknesses/messes from the very old occasions. India is advanced with assortments of both sweet-smelling and therapeutic plants which are all around recognized and categorized by the botanists, and been used as a significant source in Indian customary arrangement of medication [1].
The winged bean (*Psophocarpus tetragonolobus),* otherwise called the Goa bean, four-ridged and dragon bean, is a tropical vegetable which is broadly known, yet just developed in small scale process. This plant is an important nutritious and underutilized crop of family (Fabaceae) which meets the dietary needs of individuals and yields more measure of protein per unit zone when contrasted with other vegetable. Winged bean as most extravagant wellspring of protein and oil with the exception of from soybean and ground nut. Winged bean has high supplement content among the vegetables and all pieces of the plant are consumable.

1.1 Psophocarpus tetragonolobus
Family: leguminosae
Synonyms: winged bean, Goa bean, four-angled and dragon bean.
Kingdom: plantea
Order: fabales
Family: fabaceae, leguminosae
Genus: Psophocarpus

Fig 1: Winged bean plant and Pod

2. Materials and Methods

2.1 collection and authentication of plant material

The pods and stems parts of the plant were collected in the month of August from Kerala, Kannur district by adopting proper collection methods. It was identified and authenticated by Prof. Sreeja, Department of Biology, Sir Syed College, Kannur. Voucher specimens of the plant material have been deposited in the Department of Pharmacognosy, Crescent College of Pharmaceutical Sciences, Kannur. The collected material was shade dried, crushed and stored.

2.2 Extraction and phytochemical investigations of extracts

Extraction is the foremost step used to separate constituents from a particular drug. It is the separation of therapeutically active parts of plant utilizing particular solvents through standard techniques.[2] The reason for all extraction is to isolate the solvent plant metabolites, abandoning the insoluble cell marc (residue).The introductory unrefined concentrates utilizing these strategies contain complex blend of many plant metabolites, for example, alkaloids, glycosides, phenolics, terpenoids and flavonoids.

2.3 Preparation of plant extracts

The plant materials were dried in shade and coarsely powdered. Approximately weighed quantity of the powdered drug was extracted successively by maceration (cold) strategy with differing solvents of expanding polarity (petroleum ether (40-60°C), chloroform, hydroalcohol (70:30). After 72 hrs, 48 hrs and 24 hrs of cold maceration it was separated. The marc was dried each time before extraction with next solvent. After entire extraction process, the concentrates were focused by refining off solvents and afterward evaporated to dryness on water bath. All the concentrates were stored tightly and appropriately for fundamental phytochemical examination, acute toxicity and pharmacological screening [3].

2.4 Preliminary phytochemical screening

Plants are enriched with different variety of chemical compounds together with primary metabolites and secondary metabolites. Plant derivatives are future guarantee active ingredients for utilizing as fresh medicine or as the lead mixes for new drug medications.

Understanding of the chemical constituents of plants is attractive on the grounds that such data will be of esteem for various drug synthesis or newer chemical substances. These secondary metabolites hold many pharmacological activities and play a crucial role in curing many human diseases [3]. Phytochemical evaluation is a major tool in investigating the quality of the extracts which incorporates phytochemical screening, profiling and marker based analysis using advanced analytical performances [4]. The phytochemical analysis of all the extracts were performed according to the procedures mentioned in reference books [5, 6].

2.5 Quantitative estimation of phenolics and flavanoid phytoconstituents from extracts

Phenols comprise the largest group of plant secondary metabolites. They range from simple structures with only one benzene ring to larger molecules such as tannins, anthraquinones, flavonoids and coumarins. Phenolic compounds are commonly found in both edible and inedible plants and they have been reported to have multiple biological effects including antioxidant activity [7].

2.5.1 Estimation of total phenols

The assay relies on the transfer of reducing equivalents (electrons) from phenolic compounds to phosphomolybdic and phosphotungstic acid complexes in alkaline medium resulting in the formation of blue color complexes which were determined using spectrophotometer at 765 nm. The method makes use of Folin-Ciocalteu reagent along with a working standard gallic acid. The strength of light incorporation at that particular wavelength is proportional to the amount of phenols in the sample. The amount of polyphenols in the extract samples were assumed from a standard curve plotted for gallic acid. The substance of phenolics in extricates was expressed as Gallic corrosive acid equivalent (mg of GAE/g of concentrate).

The total phenolic content was given by the formula

$$T=C\times V\div M$$

Here T = total sum of phenolic compounds, ie mg/g plant extract, in GAE

C= the concentration of gallic acid taken from the calibration curve
V = the volume of extract in ml, *M* = the weight of plant extract in grams

2.5.2 Quantitative estimation of flavonoids
Aluminium chloride colorimetric analysis was used for flavonoids detection. It was on the principle that aluminum chloride forms acid stable complexes with the C-4 keto group or with the hydroxyl group of flavones and flavonols. Moreover, they can also form complexes with the ortho dihydroxyl position in the ring system of the flavonoids. Due to the formation of complex a yellow color is developed which can be calculated colorimetrically in spectrophotometer at 510 nm which is made to compare with quercetin which is taken as the standard. By using the standard curve the total flavonoid of extracts was obtained [9].

2.6 *In-Vivo* pharmacological investigation
The *in vivo* experiments were carried out in accordance with the CPCSEA guidelines set by Government of India. The experiments were conducted after obtaining permission from Institutional Animal Ethics Committee. The protocol for animal studies was presented before IAEC and approval was granted by the Institutional Animal Ethics Committee, Certificate number (IAEC/KMC/65/2020) by Kasturba Medical College, Manipal.

2.6.1 Animals and its husbandry
Wistar rats aged 4-8 weeks were used for the study. The animals were maintained in polypropylene cages, two animals per cage, with controlled temperature and 12 h light–dark cycle. Care was taken to maintain the room temperature of 22°C and relative humidity of 50–70% in the room. Animals had open admittance to pellet feeds.

2.6.2 Acute Toxicity Study
Toxicity investigation of the hydroalcoholic extract (PTPE) of pods was finished by standard procedure (OECD rule 425, 2001) utilizing wistar rodents to decide the protected dosing. The rats were continued fasting for the time being giving just water. The suspension of the concentrates were set up in 1% of acacia was directed orally for one rat at the breaking point portion of 2000 mg kg-1 and was watched for 14 days (with exceptional consideration for the initial 4 hrs. of organization followed by next 20 hrs.) for mortality as well as social changes, spasms etc . In the event that the rat tolerate another four animals were dosed consecutively so complete five creatures were tried. Body weight was recorded before dosing and from that point once in seven days till the finish of the analysis.Net neurotic changes were additionally seen towards the finish of investigation[8].

2.7 Experimental models in diabetes mellitus
2.7.1 Pharmacological method: STZ induced model
Streptozotocin chemically is a nitrosourea. It is obtained from the micro organism *Streptomyces achromogenes.* Its activity is by entering the pancreatic β cell through a glucose transporter 2 (GLUT2) and causes alkylation of deoxyribonucleic acid (DNA). STZ induces activation of poly adenosine diphosphate ribosylation and nitric oxide release. As a result of STZ effect, pancreatic β cells get exploited by causing necrosis. A permanent or relatively permanent hyperglycemia with STZ occurs after 24 hours.

2.7.2 Method of dose selection
Selection of dose of a particular sample can be done from the LD_{50} value obtained from toxicity studies. Based on this 1/5, 1/10, 1/15 or 1/20th dose can be taken.

2.7.3 Induction of diabetes using STZ and grouping of animals
Streptozotocin (STZ), purchased from Merck Life Science Private Limited, was administered as a solution in isocitrate buffer, as a single dose (42.5 mg/kg b.w., *i.p.*) to induce hyperglycaemia. On day 7 of STZ administration, the fasting blood glucose, from the tail tip of the animals was estimated using a commercially available glucometer. Based on the blood glucose levels, the animals were randomized into six treatment groups (STZ control, STZ + Metformin, STZ + Test1 and STZ+ Test2). Another group of animals (injected with only isocitrate buffer sans STZ) were maintained as normal control group.

2.7.4 Treatment procedure and examination of anti-glycemic strength
Test drug hydroalcoholic pod extracts of *Psophocarpus tetragonalobus* (PTPH) was formulated as suspension in carboxy-methyl cellulose (CMC) and administered once daily orally, in two doses - 100 mg/kg and 200 mg/kg body weight to the groups STZ + Test1 and STZ+ Test2, respectively.
The standard drug metformin was also prepared as a suspension in CMC and administered in a dose of 200 mg/kg body weight to the STZ + Metformin group. The STZ control group received only the vehicle (0.3% CMC suspension), whereas the normal control received only the saline. The treatments were continued for 21 days.
On day 22, all the rats were anesthetized using thiopentone sodium (25 mg/kg, *i.p.*), and blood was withdrawn by retro-orbital puncture and the blood glucose level were monitored. Histopathological studies and biochemical estimation were also carried out.

2.7.5 Estimation of biochemical limits
Plasma levels of triglycerides, total cholesterol, HDL cholesterol, creatinine and blood urea nitrogen were estimated using the biochemical estimation kits from Rapid Diagnostic Pvt. Ltd (Aspen Laboratories Pvt. Ltd., Delhi, India),using a microplate spectrophotometer(Model: Epoch 2; Bio Tek Instruments Inc., Vermont, USA). LDL cholesterol was estimated using biochemical estimation kit on the fully automated clinical chemistry analyzer (Model: Mispa Ace; Agappe Diagnostics Ltd., Kerala, India).

2.7.6 Statistical Analysis
All the values are expressed as Mean + SEM. The means of treatment groups were analyzed by one-way ANOVA followed by Tukey's post hoc analysis using JASP (Version 0.13.1) Computer Software by JASP Team, University of Amsterdam, and The Netherlands. $p<0.05$ was considered statistically significant. The graphs were prepared using Microsoft Excel.

3. Results and Discussion
3.1 Extraction of the plant material
The pods of *Psophocarpus tetragonalobus* (PT) plant were subjected to successive solvent extraction using cold maceration process and the yield of extracts were calculated. The hydro-alcoholic extracts of both plant parts gave maximum yield (38.7% w/w of pod concentrate). Extraction

with solvent petroleum ether and chloroform were very less. The table below depicts the results of extraction process.

3.2 Phytochemical Screening of extracts

All the extracts were subjected to qualitative chemical test for identifying the active constituents present. All the concentrates treated gave positive result for one or more than one active elements. The extracts showed the occurrence of carbohydrates, proteins, fixed oils, glycosides, flavanoids and other phenolic principles. The results also showed that out of the three extracts, hydro alcoholic extracts of pods had almost all the active ingredients like carbohydrates, proteins, fixed oils/fats, flavonoids, tannins and other phenolic compounds.

Table 1: Preliminary Phytochemical screening of PTPE (Pod Extract)

Sl. No	Chemical tests	Pet. Ether (PTPP)	Chloroform (PTPC)	Hydro alcoholic (PTPH)
1	Carbohydrates	-	-	+
2	Proteins	-	-	+
3	Amino acids	-	-	+
4	Fixed oils/fats	+	+	+
5	Glycosides	-	+	+
6	Flavanoids	-	+	+
7	Tannins/phenolic compounds	-	+	+
8	Alkaloids	-	-	-
9	Steroids	+	+	+
10	Terpenoids	-	-	-

(+) present (-) absent

Here steroids and fixed oils were reported in all the extracts whereas alkaloids were shown absent in the extracts. The richness of fixed oils content in all the portion of solvents can be attributed to its nutritional and health promoting benefits. The extract obtained from water and ethanol (hydroalcohol) demonstrates the inclusion of all the chemical ingredients.

3.3 Assessment of total phenol and flavanoid content of chloroform and hydroalcoholic extracts.

The total phenol and flavanoid content in chloroform and hydroalcoholic extracts of PTPE were determined using Folin –Ciocalteu method and Aluminium chloride colorimetric method respectively. While comparing the two extracts the hydro-alcoholic extract of both stem and pods had more phenolics and flavanoids than chloroform extract. The results were shown in table.

Table 2: Results of Total Phenol and Flavanoid content

Type of extracts	Total phenol content	Total Flavanoid content
Chloroform	12.6mg/g	9.3mg/g
Hydroalcohol	68.9mg/g	48.3mg/g

3.4 *In-Vivo* antidiabetic activity of pt extracts

Animal study using streptozotocin induced diabetic model was carried out according to the CPCSEA guidelines using Wistar rats aging from 4-8 weeks. Caring and maintenance of the animals were done according to the guidelines issued by IAEC. Animals were maintained in polypropylene cages with proper care, bedding, food and water. In the present work the extracts which showed maximum activity in in-vitro studies were taken for in- vivo test. From the results only PTPH gave maximum activity, hence only these extracts were subjected to animal studies. In the present study two doses (100mg/kg and 200mg/kg BW) were finalized taking into consideration acute toxicity study.

3.4.1 Streptozotocin induced hyperglycemia

The antidiabetic activity of PTPH hydro-alcoholic extracts was evaluated on STZ induced diabetic rats. The initiation of diabetes with streptozotocin raised the blood glucose level significantly in experimental rats as compared to normal rats. Administration of a single dose of STZ (42.5 mg/kg b.w., *i.p.*) induced hyperglycaemia in Wistar rats.

3.4.2 Effect on Blood glucose level on STZ induced rats by PTPH extract

There was a significant increase in the fasting blood glucose levels in STZ control group compared to the normal control. After treatment for 21 days, a significant reduction in the elevated glucose levels was observed in the standard (metformin) and test PTPH at 200 mg/kg b.w administered groups.The results are presented in table.

Table 3: Effect of 21-day treatment of PTPH on fasting blood sugar levels in STZ induced hyperglycaemia in Wistar rats

Groups	Fasting blood sugar level (mg/dl) (Mean ± SEM) Day 21
Normal control	97.13 ± 3.58
STZ control	221.5 ± 20.26*
STZ +Metformin	142.33 ± 16.14$^{\#}$
STZ + Test 100	185.57 ± 8.71*
STZ + Test 200	158.17 ± 20.45$^{*\#}$

P is the projected value, $^{*}p< 0.05$ vs Normal control, $^{\#}p< 0.05$ vs STZ control

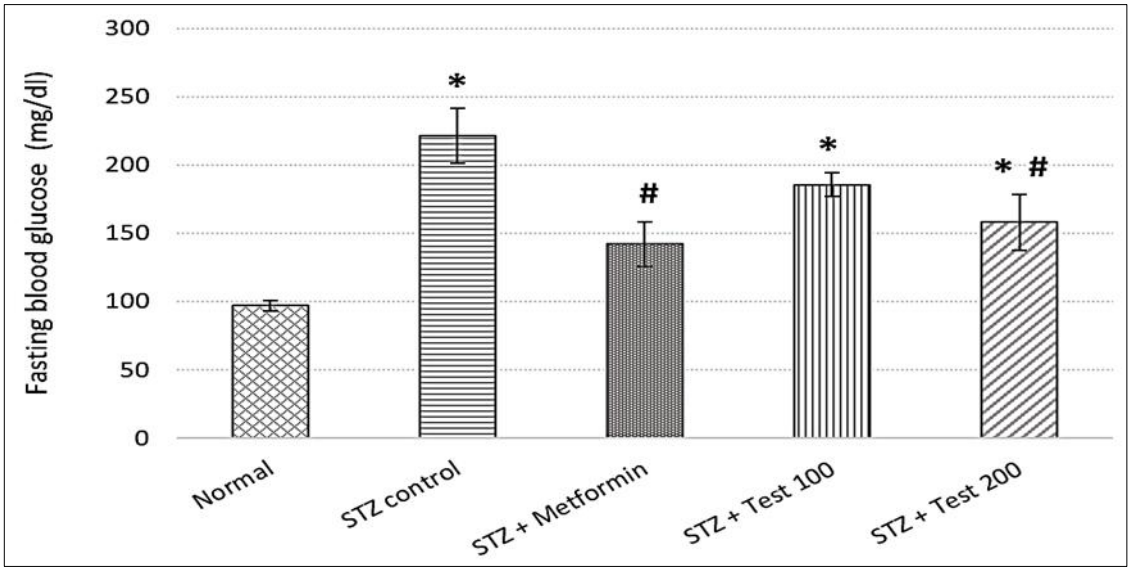


Fig 2: Result of 21 days of treatment with PTPH on fasting blood glucose in STZ-diabetic Wistar rats

All values are expressed as mean ± SEM (n = 5–6). *p<0.05 vs normal control $^{\#}p$< 0.05 vs STZ control

However, after 21 days of treatment, upon comparing the percentage change in the glucose levels with their respective day 0 levels, both the test groups showed significant reduction in comparison to STZ control group. The standard metformin significantly lowered the blood glucose level (142.33mg/dl). The samples PTPH at both doses 100mg/kg and 200mg/kg lowered blood glucose but the activity was predominant in high dose.

3.4.3 Effect of PTPH extracts on the body weight of experimental animals

STZ-produced diabetes is united with loss of weight in animals due to wasting of protein due to unavailability of carbohydrate as an energy source. Treatment of *PT* extracts for 21 days showed improved glycemic management which retains the loss of body weight. The augmented body weight might be pointed to structural protein synthesis thereby improvement in glycemic control. The influence of body weight of animals after administering with PTPH is given in Table.

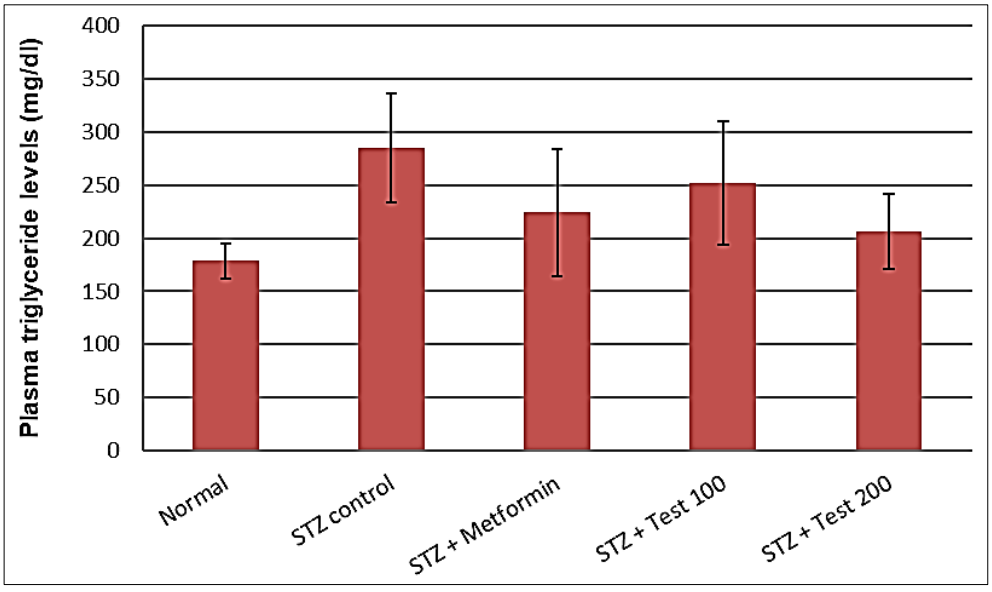
Table 4: Effect of PTPH extract on animal body weight

Groups	Body weight in grams Day 0	Body weight in grams Day 21
Normal	203.32±1.32	216.76±1.52
STZ control	190.2±1.46	169.45±1.02
STZ+ Metformin	185.43±0.82	206.71±1.12
PTPH (100mg/kg)	198.56±1.02	204.90±0.92
PTPH (200mg/kg)	189.0±1.12	195.32±1.21

All datas expressed as mean ± SEM

3.5 Evaluation of serum lipid parameters on stz injected hyperglycemic rats

Administration of PTPH extract for 14 days slightly reduced the level of serum total cholesterol and while slightly increasing the triglyceride, HDL cholesterol level compared to the diabetic control, but the effect was not found to be statistically significant. The levels of total serum cholesterol, triglycerides, total lipids, LDL-cholesterol which are in fact increased in diabetes can be maintained with PT extracts. Besides, its hypolipidemic effect possibly will signify its defensive mechanism in opposition to atherosclerosis.



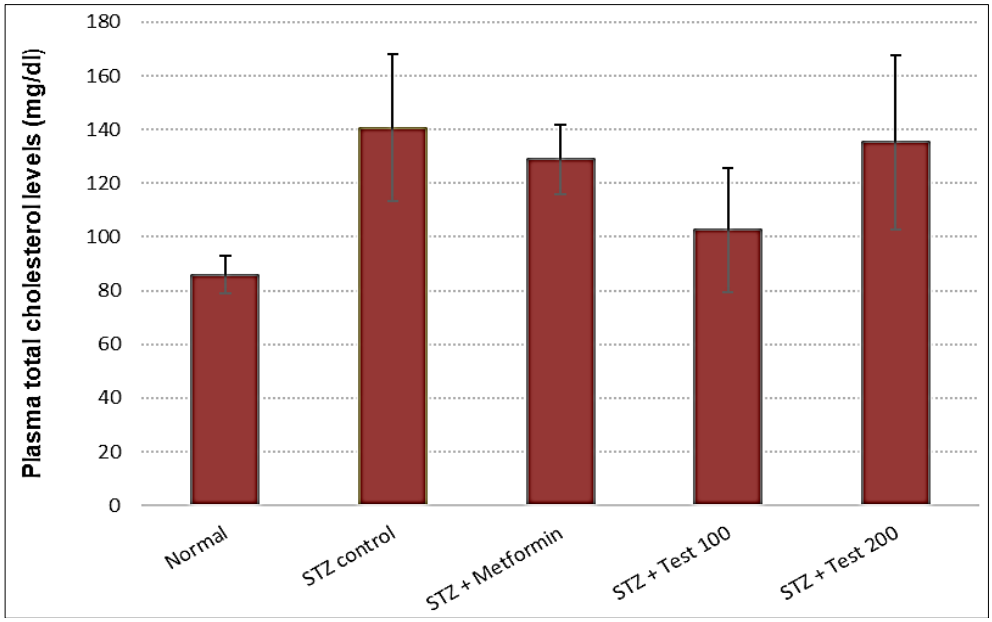


Fig 3: Effect of 21-day treatment of PTPH on Triglyceride levels and total cholesterol levels in STZ-induced hyperglycaemia in Wistar rats. All values are expressed as mean ± SEM (n = 6–8).

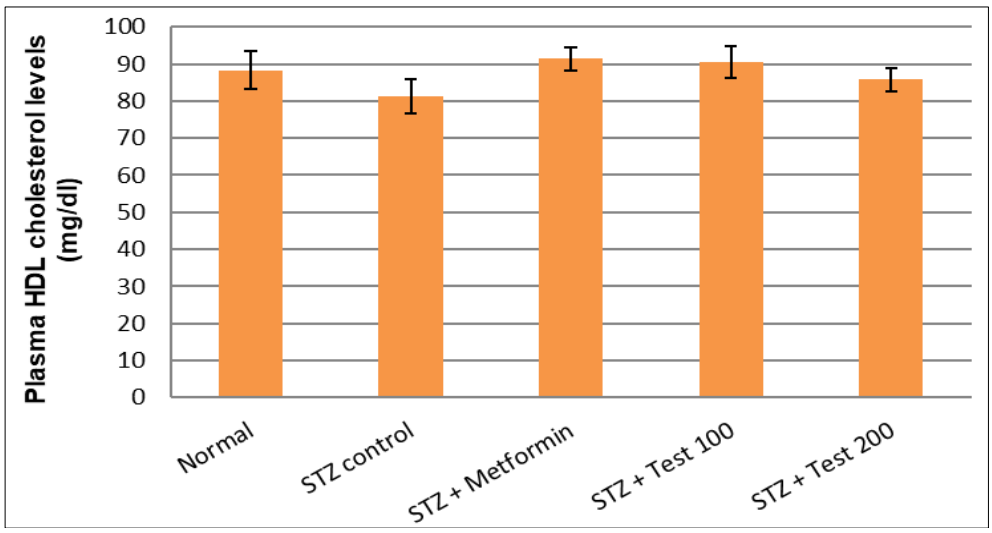


Fig 4: Effect of 21-day treatment of PTPH on HDL cholesterol levels in STZ-induced hyperglycaemia in Wistar rats. All values are expressed as mean ± SEM (n = 6–8).

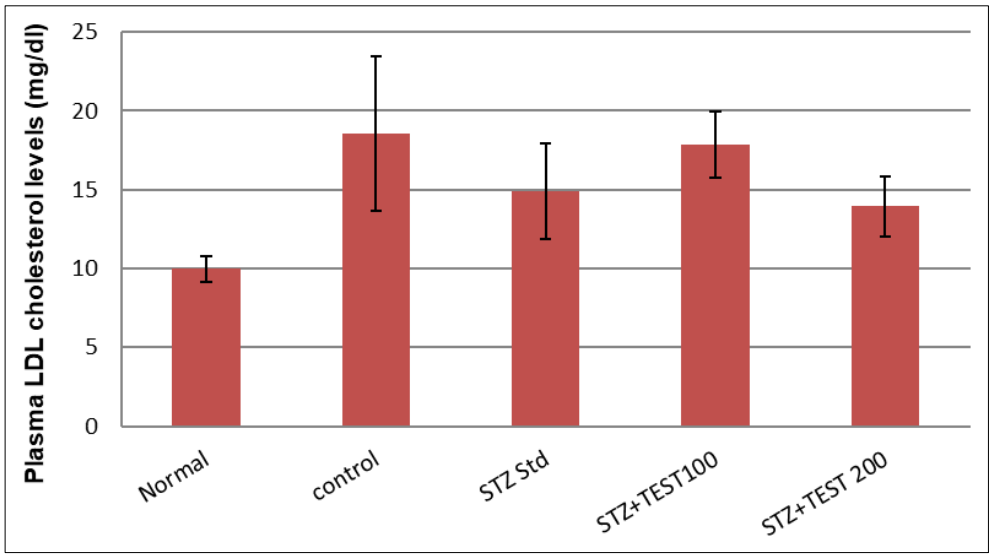


Fig 5: Effect of 21-day treatment of PTPH on LDL cholesterol levels in STZinduced hyperglycaemia in Wistar rats. All values are expressed as mean ± SEM (n = 6–8)

3.6 Effect of PTPH extract on creatinine and urea levels in STZ-induced Hyperglycaemia in Wistar rats

There was a significant increase in plasma levels of urea in the STZ control group compared to normal animals. It was shown as 70.16± 15.44 whereas the extract PTPH did not exhibit much difference in their range (45.18±5.39). Treatment with the test extract (PTPH) at both the doses - 100 mg/kg and 200 mg/kg b.w., significantly reduced the elevated creatinine levels compared to STZ control group.

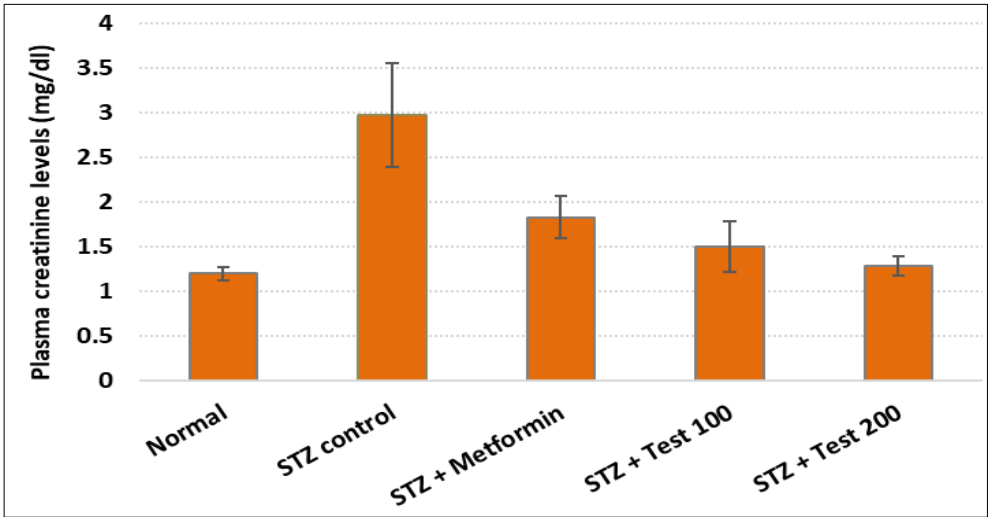


Fig 6: Effect of 21-day treatment of PTPH on plasma levels of Creatinine All values are expressed as mean ± SEM (n = 5–6). *p< 0.05 vs. Normal control, #p< 0.05 vs. STZ control

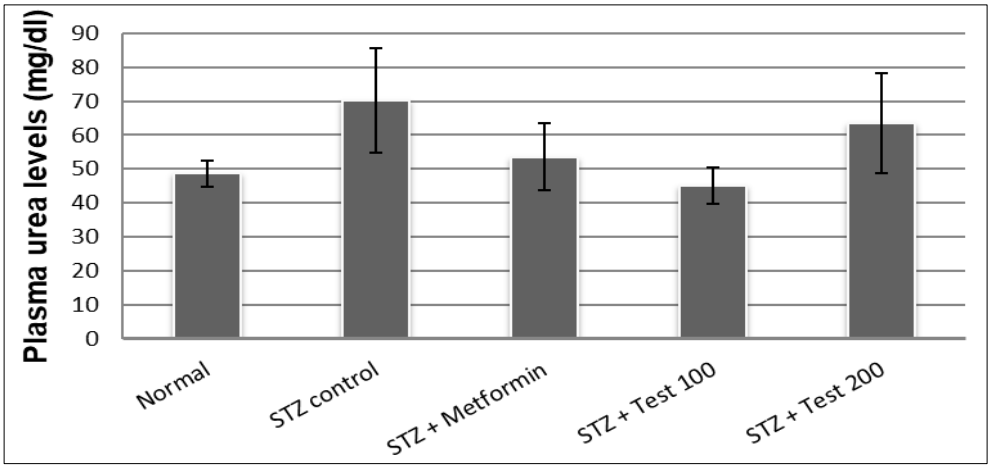


Fig 7: Effect of 21-day treatment of PTPH on plasma levels of urea. All values are expressed as mean ± SEM (n = 5–6). *p< 0.05 vs. Normal control, #p< 0.05 vs. STZ control

3.7 Effect of 21-day treatment of PTPH on the histology of pancreas in STZ-induced Hyperglycaemia in Wistar rats

In normal animals, H&E staining of sections of pancreas showed lobules separated by connective tissue septae. The lobules consist of exocrine acinar cells. The endocrine islets of Langerhans were embedded within the acinar cells.

In STZ control, there was severe/complete loss of islets. Inflammatory infiltrates were observed and the acini showed disrupted tissue architecture indicating severe damage to the islet cells.In the standard treatment (metformin 200 mg/kg), there was an increase in the number of islets of Langerhans compared to the STZ control. The number of cells in each islet and the size of islets were more. Mild inflammation was observed in the sections.

Treatment with hydroalcoholic pod extract of *Psophocarpus tetragonalobus* (PTPH) at 100 mg/kg showed a slight increase in the number of islets of Langerhans. They were also bigger in size compared to the STZ control group. Also, mild inflammation was observed in the section. However, at 200 mg/kg, the test extract showed a higher number of islets, with increase in the size, indicating reduction in STZ induced damages. The number of cells in each islet was also increased compared to the STZ group.

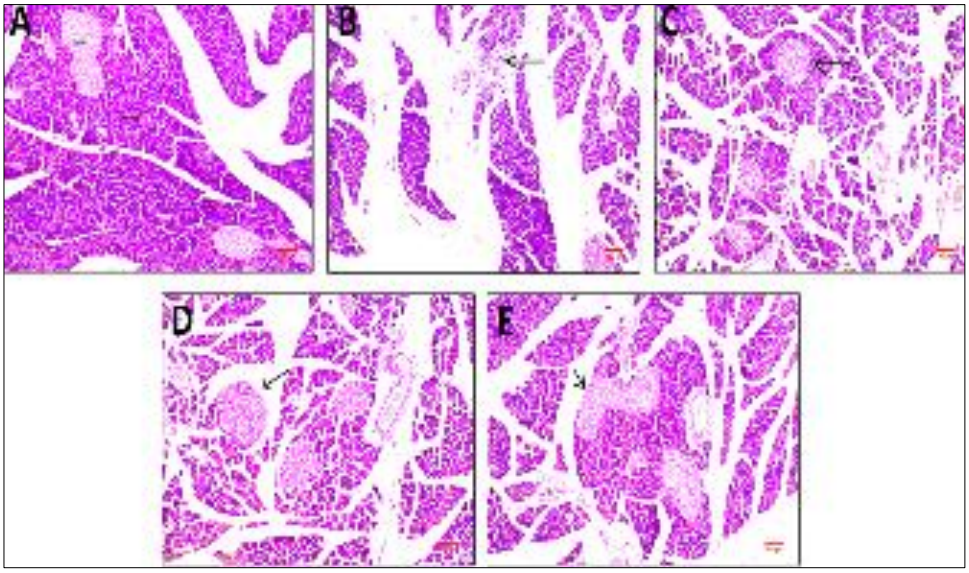


Fig 8: Photomicrograph of rat pancreas showing the effect of PTPH on STZ injected diabetic rats.

(A)Normal control- acini and islets are seen; (B) STZ control-marked reduction in islet number and an area of inflammation is shown; (C) STZ + metformin–reduced number and size of islets; (D) PTPH (100) – areas of inflammation and islets shown; (E) PTPH (200) -increased number and size of islets observed.

4. Discussion

Diabetes mellitus (DM) is a persistent problem coming about because of various elements in which a relative insufficiency of insulin or its dysfunction happens. Diabetes mellitus is one of the significant danger factors for the occurrence of multiple disorders such as hepatic damage, nephrotoxicity, inflammation, cancer, cardiovascular disorders, neurological disorders, immune impairment, hypertension, weight, smoking and dyslipoproteinemias. Hyperinsulinemia and hyperglycemia may upgrade the creation of free extremists and prompt oxidative pressure that may likewise add to expanded danger in diabetes [9].

There are different herbs which are being utilized for the treatment of diabetes mellitus, from which only some have been assessed according to the advanced arrangement of medication. From these plants just plant extricates have been arranged and assessed for its hypoglycemic movement. The greater part of plants revealed as hypoglycemic agents appear to act legitimately on pancreas and invigorate insulin discharge in the blood and some by other mechanisms. Chemical constituents of these plants are known to have wide scope of therapeutic properties and are available in plant source as vitamins, minerals, phenolics, lignans, flavonoids, carbohydrates, triterpenes, and tannins. These active markers are involved in regulating many pharmacological action including antidiabetic and antioxidation.

The aim of the research was to know the antidiabetic activity of *Psophocarpus tetragonalobus* plant by screening the extracts of plant parts with different known models and to find out the most potent extracts with greatest activity. Extracts of petroleum ether, chloroform and hydroalcohol of both PT pods were procured by macerating successively with the solvents and then evaporating to get the crude extract. The extracts were further taken for preliminary chemical examination to establish the occurrence of various classes of phyto constituents. PTPH showed the existence of carbohydrates, proteins, lipids, glycosides, flavanoids and phenolic compounds, steroids, vitamins and tannins.

Evidence from literature surveys suggests that all these chemical constituents within the plants can contribute to various therapeutic actions including antidiabetic, hepatoprotective, antioxidant properties [10]. Henceforth, keeping all this observation, studies was more focused on PTPH and PTSH and evaluation of hypoglycemic, and antioxidant potential was done.

Anti diabetic investigation of PTPH was performed using STZ injected diabetic rat model. Prior to the studies Acute Toxicity study of the fractions were done as per OECD guidelines 423. The extracts did not give any sort of visible toxicity or mortality in treated group up to a dose of 2000mg/kg B.W. Streptozotocin - initiated hyperglycaemic has been depicted as a valuable test model to contemplate the movement of hypoglycaemic agents. Streptozotocin specifically pulverizes the pancreatic insulin emitting β-cells, leaving less dynamic cells and bringing about a diabetic state [11]. The phytochemical screening indicated the presence of flavonoids, tannins, phenolics and vitamins. These mix particularly flavonoids and phenolics have been accounted for to improve insulin discharge and search free extremists that are created during diabetic state [12].

Administration of a single dose of STZ (42.5 mg/kg b.w., *i.p.*) significantly elevated the fast blood glucose levels in Wistar rats. Treatment with metformin (200 mg/kg) and test extract (PTPH) at a dose of 200 mg/kg significantly reduced the elevated blood sugar levels in the animals. When the means of percentage change in blood sugar values (day 21 with respect to day 0 of treatment) were compared, both the doses of PTPH extract had better shown significant reduction in the glucose levels than PTSH portion.

Streptozotocin-produced diabetes is portrayed by a severe failure in body weight [13]. The decrease in body weight can be because of the degradation of structural proteins, as they are well recognized to offer the body weight. Another reason can be the increase in muscle wasting [14]. Previous reports show that protein synthesis is decreased in all tissues due to decreased production of ATP and absolute or relative deficiency of insulin. Even though there was an elevation in plasma TG, TC, HDL, and LDL cholesterol levels, of the STZ administered group compared to the normal animals, the difference was not statistically significant. None of the

standard or test groups showed any significant effects. The diabetic groups treated with test extracts demonstrated a huge abatement in the decrease of creatinine. Histopathological perceptions uphold the hypoglycaemic reports. Organization of STZ achieved degenerative changes in the histopathology of pancreas when contrasted with normal group.

In this way, the counter action against diabetic of PT extracts may be because of sterols, fatty acids, proteins, carbohydrates, flavonoids, phenolics, vitamins and tannins. This may be achieved through numerous multiple or combined mechanisms like searching and attacking free radicals, ROS [15]; serious and reversible hindrance of pancreatic α-amylase and film bound intestinal α-glucosidase chemicals; improving glucose resistance by bringing down basal and postprandial plasma glucose; by diminishing hepatic glucose creation which diminishes intestinal retention of glucose; improving insulin affectability by expanding fringe glucose take-up and use; strong agonist for the PPAR γ receptors; communicating with K+ ATP channel on pancreatic β-cells and invigorating insulin emission from pancreas [16]. Resistance against diabetes and its treatment by PT extracts has been reported for the first time. Further, research should be done to normalize the particular mechanism of activity of every dynamic constituent.

5. Conclusion

The conceivable mechanism however not explored in this investigation might be ascribed to the capacity of the concentrate to potentiate insulin emission from pancreatic beta cells or sharpening insulin receptors [17]. The presence of flavonoids and phenolics mixes along with other components in the concentrate might be liable for this perception.

6. Future scope of the study

As very few research datas are available related to this particular plant further detailed molecular and mechanistic studies may be undertaken in future. Effort can be put on to discover more therapeutic activities including hepato protective effect as the PTPH showed significant lowering in the creatinine range in STZ treated groups. Additionally focus can be made to expand variant types of formulation containing these dynamic principles and assess them with their efficacy.

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