

ANTIDIABETIC ACTIVITY OF *HEMIGRAPHIS COLORATA* (WHOLE PLANT ETHANOL EXTRACT) IN STREPTOZOTOCIN- INDUCED DIABETIC RATS AND TOXICITY EVALUATION OF THE EXTRACT

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ABSTRACT

Evaluation of the efficacy of *Hemigraphis colorata* Blume [Family:Acanthaceae] (whole plant) ethanol extract in streptozotocin induced diabetic rats. Subsequently isolate the active fraction from the ethanol extract and study the acute and short-term general toxicity in male mice. The alcohol extract of the whole plant was tested for its efficacy in streptozotocin-induced diabetic rats. The extract was evaluated for its acute and short term general toxicity in male mice. The aqueous suspension of ethanol extract was successively extracted with petroleum ether, chloroform, ethyl acetate and butanol. The active chloroform and ethyl acetate fractions were subjected to qualitative chemical analysis. In streptozotocin-diabetic rats the alcohol extract (300 mg/kg) showed significant antidiabetic property as judged from body weight, serum glucose, lipids, cholesterol and urea, and liver glycogen levels. However, the extract did not significantly influence the levels of serum insulin in both diabetic and normoglycemic rats. The alcohol extract was devoid of any conspicuous acute and short term general toxicity in mice. The antihyperglycemic activity was found predominantly in the chloroform fraction of alcohol extract, which contained terpenoids, coumarins and saponins. The active fraction of *Hemigraphis colorata* leaf extract is very promising to develop standardized phytomedicine for diabetes mellitus.

Keywords: Anti-hyperglycemic activity, *Hemigraphis colorata*, Diabetes mellitus, Streptozotocin, Chloroform.

INTRODUCTION

Many plants are been used for the treatment of diabetes mellitus in folk medicine in remote villages of Kerala and Kanyakumari Districts, India. One such plant is *Hemigraphis colorata* (whole plant) which was pharmacologically evaluated for anti hyperglycemic property. The alcohol extract of the plant exhibited concentration dependent anti hyperglycemic effect in glucose loaded rats. But the extract did not show hypoglycemic effect in fasted normal rats. Streptozotocin induced diabetic animals exhibit reduced response to insulin in hepatic and peripheral tissues. Further, rats treated with streptozotocin display many of the features seen in human subjects with un-controlled diabetes mellitus. Therefore, in present study the efficacy of *Hemigraphis colorata* (whole plant, alcohol extract) was evaluated in streptozotocin diabetic rats and it was fractionated and analyzed chemically. Acute and short-term general toxicity evaluation of the extract was also carried out in male mice.

MATERIALS AND METHODS

Plants materials and preparation of alcoholic extracts

Hemigraphis colorata was collected in the month of June and July from Kerala and Kanyakumari District, India. A voucher specimen was deposited in the herbarium of TBGRI (No. 0001).

The whole plant was dried in the laboratory at room temperature and powdered in a mixer grinder. To prepare the extract 25g of the whole plant powder in 250 ml of ethyl alcohol was stirred magnetically for 4h at room temperature. The residue was removed by filtration and it was once again extracted as above and filtered. The combined filtrate was evaporated to dryness at 40-50°C under reduced pressure in a rotary evaporator (yield of ethyl alcohol extract was approximately 10%)^{1,2}.

The extract was suspended in 5% Tween – 80 and used for oral administration.

Animals

Male Wistar rats weighing 150-200g and male Swiss albino mice (25-30g) were used with the approval of the Medical College Animal Ethics Committee. Animals were fed a standard pellet (Lipton India Ltd.) and water ad-libitum and maintained at 24-28°C temperature, 60-70% relative humidity, and 12h day and night cycle. Animals described as fasted were deprived of food for 16h but had free access to water.

Animals were caged in uniform hygienic conditions and fed with standard pellet diet (Lipton, India Laboratories, Bangalore) and water *ad libitum* as per the guidelines of College Animal Ethics Committee, CPCSEA guidelines were followed [IAEC approval obtained].

Streptozotocin-induced diabetic rats

Diabetes was induced in rats by tail vein injection of streptozotocin (50mg/kg) dissolved in normal saline (One group of 6 identical rats was kept without streptozotocin administration as normal control group I). Forty eight hours after streptozotocin administration blood samples were drawn by retro- orbital puncture and glucose levels determined to confirm diabetes. The diabetic rates exhibiting blood glucose levels in the range of 275 and 300mg/100ml were selected for the studies. These diabetic rats were sub-divided into 3 groups as follows. Group II (untreated rats) given 0.5ml of 5% Tween 80: Group III, diabetic rats given (300 mg/kg) *Hemigraphis colorata* (alcohol extract) in 0.5ml 5% Tween 80; Group IV, diabetic rats given 0.5ml of 5% Tween 80 containing glibenclamide (500 µg/kg). The dose (500µg/kg) of glibenclamide was selected based on previous reports³. The normal control group of rats (group I) were given 0.5ml of 5% Tween 80 Each group consisted of 6 animals.

The treatments were continued daily for 15 days (In the untreated control [diabetic] rats 3 animals died on the 8th day and one on the 9th day) Blood was collected by retro-orbital puncture for glucose estimation just before drug administration on days 4, 7 and 10 as described earlier^{1,2}. The animals were sacrificed after blood collection under chloroform anesthesia on 15th day and liver was removed for glycogen estimation^{1,2}.

Determination of serum insulin

To determine the effect of *H. colorata* extract on serum insulin levels 3 groups of animals were used. They were over-night normal fasted rats (group I) normal fed rats (groups II) and streptozotocin – induced diabetic rats (group III). Immediately after the collection of blood samples the extract (200mg/kg; 1 ml/rat) was administered (p.o.) One hour after the extract administration, blood samples were again collected. Serum was separated from the samples and insulin and glucose levels were determined. Insulin levels were measured by radio-immunoassay method using kits obtained from Board of Radiation and Isotope Technology (BRIT), Mumbai, India.

Isolation of an active fraction

The alcohol extract was subjected to glucose tolerance test guided fractionation. Briefly, the alcohol extract was suspended in water and successively extracted with petroleum ether, chloroform, ethyl acetate and butanol. Each fraction was dried free of solvent and the yield was determined. The dose selected for glucose tolerance test in each case was based on the yield from the alcohol extract. Since 400mg/kg body weight is double the optimum dose the yield from 400 mg alcohol extract in the case of each fraction was administered per kg. body weight.

Analysis of the active fraction: Since the activity was found in the chloroform fraction and to some extent in ethyl acetate fraction these two fractions were tested for the presence of alkaloids, coumarins, flavonoids, steroids, saponins and terpenoids following standard methods ⁴.

Glucose tolerance test

This was done as described recently. Briefly overnight fasted rats were divided into 5 groups. One group was kept as control which received 5% Tween 80 (0.5ml p.o) group 2 received petroleum ether fraction (160mg/kg) in 0.5% Tween 80 (0.5ml p.o) groups III, IV and V received chloroform fraction (25mg/kg), ethyl acetate fraction (75mg/kg) and butanol fraction (110mg/kg) respectively in 5% Tween 80 (0.5ml p.o). The rats of all the groups were loaded with glucose (3g/kg p.o) 30 min after the administration of the drug (fractions). Blood samples were collected 30, 90 and 150min after glucose loading. Serum was separated and glucose levels were measured immediately. Six rats were used in each group.

Estimation of biochemical parameters

Serum glucose was estimated spectrophotometrically using a commercial assay kit (Monozyme, India, Ltd.), 10 ml serum was used for each assay. Liver glycogen was estimated by the method of Corroll et al ⁵. Serum cholesterol ⁶ and urea ⁷ levels were determined following standard methods. Total lipid in the serum was estimated by phosphovanillin method using reagent kit (Span Diagnostic Ltd). Protein was estimated using Folin's phenol reagent by the method of Lowry et al ⁸.

Toxicity evaluation in mice

The alcohol extract was tested for its acute and short-term toxicity (if any) in mice. To determine acute toxicity of a single oral administration of the herbal drug, different doses of the drug (0.5, 1.0, 1.5 and 2 g/kg) were administered to different groups of mice (2 mice were used for each group, control mice received Tween 80). Mortality and general behavior of the animals were observed continuously for the initial 4h and intermittently for the next six hour and then again at 24h and 48h following drug administration. The parameters observed were grooming, hyperactivity, sedation, loss of righting reflex, respirator rate and convulsion.

To study short-term toxicity, 3 groups of mice each containing 6 male mice (20-25g, body weight) were used. Group I was kept as control and group II and III received 300 and 600 mg/kg alcohol extract respectively in 5% Tween 80. The drug was administered daily for 14 days (p.o). Control group received 5% Tween 80 in an identical manner.

The behaviour of the animals was observed daily for 1h in the forenoon (10 to 11 AM) for 14 days. Initial and final body weights, water and food intake state of stool and body temperature were observed. The animals were killed on the 15th day. Hematological and serum protein glutamate pyruvate transaminase (GPT), glutamate oxaloacetate transaminase (GOT), urea, cholesterol and alkaline phosphatase were determined. Liver, spleen, kidneys and brain were dissected out and observed for pathological and morphological changes. Weights of these organs were determined.

Hemoglobin was measured using hemoglobinometer with comparison standards. GPT and GOT were measured by the method of Reitmant and Frankel ⁹ and alkaline phosphatase by the determination of hydrolyzed phenol with antipyrine ¹⁰. The peritoneal macrophages and total leucocytes were counted as described elsewhere ¹¹.

Statistical Evaluation

Statistical evaluation was done using one-way analysis of variance (ANOVA) followed by Dunett's test, except for data in Table 4 which were evaluated using Student's 't' test (400 mg/kg drug treated group was compared with control). AP value <0.05 was considered significant.

RESULTS

Effect of the herbal extract on streptozotocin induced diabetic rats: The alcoholic extract exhibited antidiabetes properly in streptozotocin induced diabetic rats as evident from serum glucose and hepatic glycogen levels. The effect of extract on body weight and liver glycogen content in the streptozotocin-induced diabetic rats is given in Table1 in the untreated control (diabetic) group out of the 6 animals 3 died of diabetes on the 8th day and one died on the 9th day. The body weight was slightly increased in the normal control rates compared to initial body weight whereas in the diabetic control rats there was a significant decrease in the body weight (of the 2 animals which survived up to the 15th day). Glibenclamide (500 µg/kg) as well as the herbal extract (200 mg/kg) treatment significantly prevented this reduction in body weight.

Although there is a Marginal reduction in the weight of animals in these groups, compared to initial body weights, it fell short of statistical significance. However, the reduction in body weight was significant when compared to the final weight of normal control rats (Table 1).

As shown in Table 1 in the untreated diabetic rats serum levels of total lipids, cholesterol and urea were significantly increased. These complications of diabetes were attenuated with the administration of the alcohol extract. The effects of the standard drug (glibenclamide) on serum urea, total lipid and cholesterol in the diabetic rat were comparable to those of the herbal extract.

Values in parentheses represent % change (loss or gain) in body weight compared to initial body weight. Herbal drug or Glibenclamide was administered daily for 14 days and the animals were sacrificed on the 15th day. For glucose estimation blood was collected just before the drug administration on the 1st day and 1h after the drug administration on the 4th 7th and 10th day

There was a marked reduction in liver glycogen level (in 15 days) in streptozotocin diabetic animals. The herbal extract treatment remarkably attenuated this reduction in glycogen content. This effect of the herbal drug (200mg/kg) is equal to, if not better than, that of glibenclamide (500 µg/kg).

The effect of the herbal drug on serum glucose levels in streptozotocin induced diabetics rats is shown in Table 1. The initial blood glucose levels of the diabetic rats are shown in Table 1. The initial blood glucose levels of the diabetics rats selected for the study were in the range of 280 to 300 mg/100 ml. In the untreated control (diabetic) rats the blood glucose levels increased to 410 mg/100 ml on the seventh day. Thereafter, 4 animals died in this group, and the glucose levels on the 10th and 15th day in the two animals, which survived, were 360 and 362 mg/100ml respectively. In the herbal drug treated rats, the blood glucose levels steadily decreased and it was 118 mg/100 ml on the 15th day. Thus the drug treatment restored the serum glucose levels almost nearer to normal values. The effect of the herbal drug is comparable to that of glibenclamide (a standard drug).

Table 1: Effect of *Hemigraphis colorata* (Whole plant ethanol extract) on body weight liver glucose urea, total lipid, cholesterol and protein in streptozotocin induced diabetic rats

Group	Body weight (g)		Liver glycogen (mg/g wet tissue)	Serum glucose (mg/dl)					Blood			
	Initial	Final		Day					Urea (mg/dl)	Total Lipid (mg/dl)	Cholesterol (mg/dl)	Protein (g/dl)
	(1 st day)	(15 th day)	(15 th day)	1	4	7	10	15	(Day 15)			
Normal control	210.9	216.4	49.0	86.0	89.3	87.3	88.0	86.0	28.0	291.0	100.0	6.03
	+3.6	+3.4	+2.5	+3.2	+4.0	+5.5	+5.1	+3.9	+3.5	+7.0	+5.7	+0.79
Diabetic Control (5% Tween 80.p.o)	215.3	185.6	5.3	292.0	367.2	410.0	360.0	361.0	42.0	400.0	148.0	5.02
	+4.0	+5.7	+1.0	+6.3	+7.9	+12.0	+16.0	+11.3	+7.1	+8.9	+12.7	+1.09
Diabetic + <i>C.asiatica</i> (200mg/kg.p.o)	209.2	204.5	42.0	283.0	211.0	160.0	130.0	119.0	32.0	326.0	98.0	6.08
	+3.0	+4.8	+2.8 ^a	+8.3	+8.9 [#]	+7.9 [#]	+6.8 [#]	+3.8 [#]	+2.8 ^b	+5.2 ^b	+6.9 ^b	+0.74 ^b
Diabetic+Glibenclamide (500µg/kg. p.o)	217.8	202.6	40.6	286.0	206.0	166.0	128.0	114.0	31.5	315.0	110.0	6.08
	+5.4	+5.5	+3.6 ^a	+5.8	+103 [#]	+8.4 [#]	+8.7 [#]	+4.1 [#]	+2.7 ^b	+5.7 ^b	+6.8 ^b	+1.03 ^b
		(6.4)*										
F	22	104.5	1601	1048	1413	583	833	83	102.4	27.2	1.03	
df	3.16	3.16	3.20	3.20	3.20	3.16	3.16	3.16	3.16	3.16	3.16	3.16
P	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.01	<0.01	<0.01	NS

Values are mean \pm SD; n=6 in each group except in diabetic control group where n=2 on the 10th and 15th day (3 animals died on the 8th day and 1 died on the 9th day). *P<0.01 (compared to diabetic control or normal control); #P<0.001 (compared to diabetic control or normal control); ^aP<0.01 (compared to normal control) and ^aP<0.001 (compared to diabetic control). ^bP<0.01 (compared to diabetic control). NS not significant).

Effect of the extract on serum insulin levels

The serum insulin levels at 0 and 1 h after the extract administration is shown in Figure 2. The extract (200 mg/kg) did not significantly influence serum insulin levels in fasted normal rats, fed normal rats and streptozotocin diabetic rats.

Isolation of an active fraction

Successive extraction of the aqueous suspension of alcohol extract with solvents resulted in petroleum ether, chloroform, ethyl acetate and butanol fractions. The yields of different fractions as a % of alcohol extract were as follows: Petroleum ether, 39; chloroform, 7; ethyl acetate, 15; butanol, 23; water (remaining), 10 (values are averages of 3 separate determinations). As shown in

figure 3, when different fractions were tested for their anti hyperglycemic activity using glucose tolerance test in normoglycemic rats, the chloroform fraction was found active at 25 mg/kg level. Ethyl acetate fraction also showed activity to a lesser extent at 75 mg/kg level. The petroleum ether and butanol fractions were inactive.

Qualitative tests for the presence of various classes of compounds showed the presence of coumarins, terpenoids and saponins in the chloroform fraction. This fraction was devoid of alkaloids, steroids and flavonoids. Coumarins, terpenoids and flavonoids (but, not saponins) were detected in the ethyl acetate fraction. This fraction was also devoid of alkaloids and steroids. Thus both chloroform and ethyl acetate fractions contained terpenoids and coumarins.

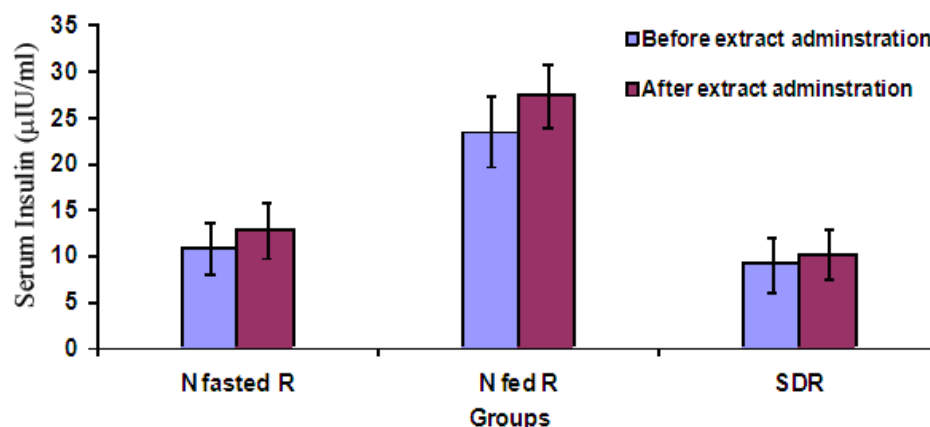


Fig. 2: Effect of *Hemigraphis colorata* (Whole plant ethanol extract) on serum insulin levels in rats

N fasted R- Normal fasted Rats; N fed R- Normal fed Rats; SDR- Streptozotocin Diabetic Rats

Insulin values at one hr after drug administration are not significantly different compared to respective 0h (before drug treatment) values. N=6 in each group.

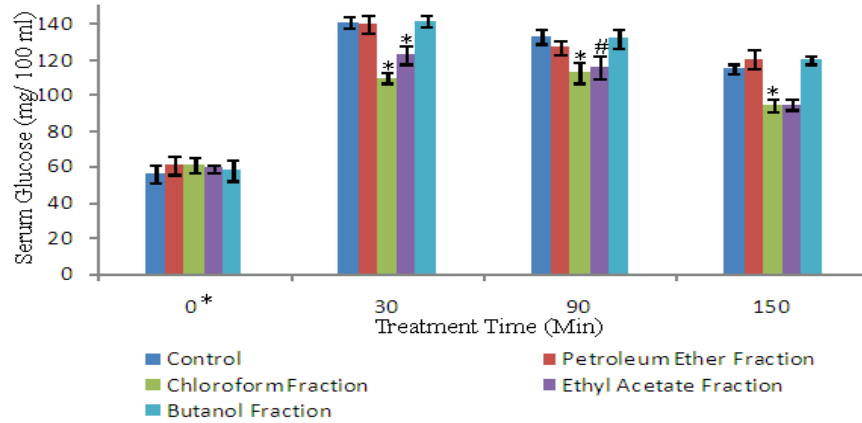


Fig. 3: Effect of different fractions of alcohol extract *Hemigraphis colorata* (Whole plant) on glucose tolerance in normal fasted rats^a.

^aThe rats of all groups were loaded with glucose (3g/kg.p.o) 30 min. after the herbal drug (fraction) administration (p.o)

The doses selected for various fractions are based on their relative amounts present in 400mg alcohol extract (200 mg/kg is known as optimum dose)

0* -Serum glucose level just prior to herbal drug administration

Values are mean +SD. n=6 in each group

*P<0.001 (compared to control value); #P<0.01 (compared to control value)

Toxicity evaluation

In the acute toxicity study, the alcohol extract of *Hemigraphis colorata* did not show any mortality up to a dose of 2g/kg body weight in male mice. Even at this high dose there was not gross behavioural changes.

Daily feeding for 14 days with the alcohol extract (300 or 600 mg/kg) did not result in any change in general behaviour of the animals. Body temperature and state of the stool were also not

influenced by the drug treatment. Body weight, weight of liver, kidneys and spleen and food and water intake were not significantly altered by the drug administration (data not shown).

Hemoglobin content, total leucocyte count, serum urea, cholesterol, total lipid, glutamate pyruvate transaminase, glutamate oxalate transaminase and alkaline phosphatase were unchanged by the treatment (Table 4). However, the number of peritoneal macrophages was marginally increased by the drug at 400mg/kg (Table 4)

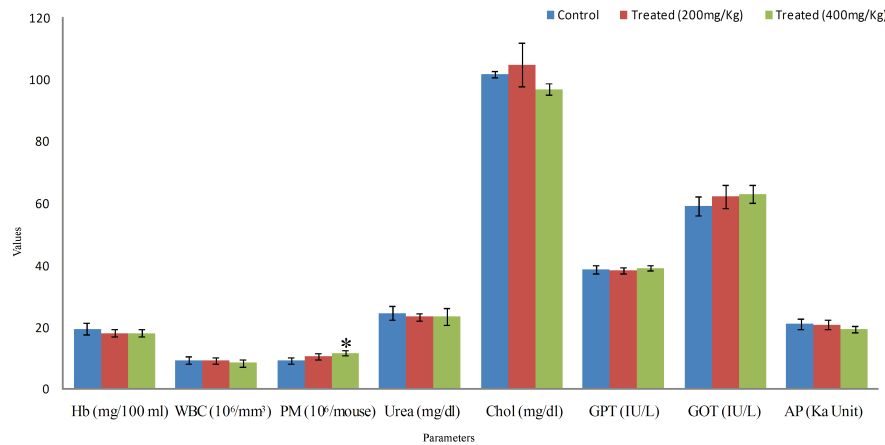


Fig. 4: Effect of short term (15 days) *Hemigraphis colorata* (alcohol extract) administration on the hematological and serum biochemical parameters of male mice.

Values are mean + SD, n=6, P<0.5 compared to control (Student's 't' test)

The herbal drug was administered daily (p.o) for 15 days.

Hb- Haemoglobin, WBC- White blood Cells, PM- Peritoneal Macrophages, Chol- Cholesterol, GPT – Glutamate pyruvate transaminase, GOT – Glutamate oxalate transaminase, AP – Alkaline phosphatase

Insulin and sulfonylurea drugs (eg. glibenclamide) cause hypoglycemia when taken in excessive doses and overt hypoglycemic is the most worrisome effect of these drugs. However, another group of OHAs, biguanides do not cause hypoglycemia even

when taken in excessive doses¹³. From the results it clearly shows that *H. colorata* did not cause hypoglycemic effect. One of the biguanides, metformin is currently a top selling OHA in USA^{12,13}. Metformin does not stimulate insulin secretion and acts by reducing

hepatic glucose production through inhibition of gluconeogenesis and, to a lesser extent, by enhancing insulin sensitivity in the tissues. In the present study, like Metformin, *H. colorata* extract did not influence serum levels of insulin in diabetic as well as normoglycemic rats. Further, like metformin the extract reduced serum lipids. Detailed studies are in progress in this laboratory to understand the mechanism of action of the herbal drug¹⁴.

C. auriculata aqueous leaf extract *C. auriculata* leaf extract at 400 mg/kg dose daily for 21 days exhibits anti-atherosclerotic role in the diabetic state and it indicates toward the notion that extract may help to prevent the progression of cardiovascular diseases¹⁵.

Ginger extracts could be used as a nephro-protective supplement particularly to reverse diabetic-induced complications (Gt, 200 mg/kg b.w. orally/30 days), Ethyl acetate fraction reduced triglyceride level by 43.82% and 42.01% in normal and STZ-diabetic rats respectively¹⁶.

In the present study, an active chloroform fraction has been isolated from the alcohol extract of *H. colorata* which is very effective at a dose of 25mg/kg as against 200 mg/kg of original alcohol extract. It is likely that the active principle(s) could be one or more terpenoids and /or coumarins. Studies are in progress to identify the active principles.

The whole plant of *H. colorata* is ground into a paste with water and used for diabetes mellitus in remote villages in Kanyakumari and Trivandrum districts in folk medicine without any known or recorded adverse effects. Such herbal drugs may be used directly for clinical trials. However, when an extract or active fraction is used it is better to evaluate for possible toxicity. In this connection, in the present study the alcohol extract was evaluated and it did not exhibit any toxic symptoms in the limited toxicity evaluation in male mice. A perusal of literature shows that studies were not carried out on this plant with regard to other pharmacological properties and phytochemistry. In the present study at 400mg/kg level the extract increased the number of the peritoneal macrophages. Since macrophages have crucial roles in immune function, further studies are warranted in this area.

The restorative effect of insulin was prevented by Brefeldin A, suggesting that insulin induced TRPV1 receptor trafficking to the terminal membrane. Central vagal circuits critical to the autonomic regulation of metabolism undergo insulin-dependent synaptic plasticity involving TRPV1 receptor modulation in diabetic mice after several days of chronic hyperglycemia¹⁷.

Pet-ether and ethyl acetate fractions of *C. cordifolia* have potentiality effect against diabetes¹⁸.

Oxidative stress defense mechanisms in the heart tissue are fairly efficacious against oxidative injury by the treatment with aqueous extract (AE) of *Pimpinella tirupatiensis* (Pt) tuberous root (750mg/kg/b.w./day). AE may provide a useful therapeutic option in the reversal of oxidative stress induced cardiac dysfunction in diabetes mellitus¹⁹.

U. rigida has antidiabetic and antihyperlipidemic effects and improves oxidative stress in diabetic rats. *U. rigida* might have a potential use as a protective and/or therapeutic agent in diabetes mellitus²⁰.

Catalpol increased glucose utilization through increase of β -endorphin secretion from adrenal gland in STZ-diabetic rats²¹.

Centaurium erythraea treatment exerts a therapeutic protective nature in diabetes by decreasing oxidative stress and pancreatic β -cells' damage which may be attributed to its anti oxidative potential²². (Sefi M, et al, 2011).

Antioxidants activity of triterpenes, alkaloids and flavonoids of *H. integrifolia* plant, which is known to quench the free radicals by maintaining antioxidants levels. Considering the antioxidant property of *H. integrifolia* the bioactive compounds derived from this plant can be supplemented with anticancer and anti oxidative stress medicines and thus additional studies are underway to isolate and characterize the plant active ingredients that contributes to its

preventive effects on both anticancer and oxidative stress induced Diabetes²³.

Many thiazolidinedione and their derivatives serve as basic pharmacophore for various biological profiles i.e. antidiabetic, anticancer, antimalarial, aldose reductase and anti-inflammatory. New series of thiazolidinedione with higher biological activity was synthesised. screening of antidiabetic activity²⁴.

Some studies have reported that *Selaginella involvens*, a fern possess high antioxidant and anti fungal properties^{25, 26}. Various extracts of *A leptopus*, showed significant antibacterial, anti fungal and anti thrombin activity²⁷. The wound healing activity of ethanol extract of *Terminalia avicennioides* root bark was evaluated in two wound models (excision and incision). It was found that the extract provided wound contracting ability, wound closure, and decrease in surface area of wound, tissue regeneration at the wound site and reduced days of healing which were significant level. This data is useful in treating fungal infections which occur in diabetes and also to treat diabetic foot ulcers²⁸. Hence there is an urgent need to evaluate *H. asiatica* antioxidant and anti fungal properties

CONCLUSION

According to present study for evaluation of toxicity determination of LD₅₀ value, it is now acceptable to limit the study with an acute toxicity test using several doses including reasonably high doses of the drugs. In the present study, acute toxicity was tested up to a high concentration of 2 g/kg (ten times more than the therapeutic dose). Even at this dose the herbal extract did not exhibit any sign of toxicity. Since the main purpose of the preliminary acute toxicity study is to get some idea on conspicuous behavioral changes and death, if any, only 2 animals were used for each group considering Institute Animal Ethics Committee views to minimize the use of animals.

In the untreated streptozotocin diabetic mice (control group) only 2 animals survived till the end of the experimental period (15 days).

However, there was no mortality for eight days in this group. The glucose values were recorded for this period. The serum glucose, lipid and cholesterol values for the 2 rats are in agreement with those expected for streptozotocin diabetic rats¹⁴. Further, the individual value for the parameters studied did not differ much between these two rats in the same group. Therefore, in substance the small n in the diabetic control group does not affect the interpretation of the data in present case.

Development of phytomedicines is relatively inexpensive and less time consuming. It is more suitable to our economic conditions. However, ecotype and genotype variations, seasonal variations, etc. in efficacy and safety have to be addressed in phytomedicine development.

Hemigraphis colorata is a herb which grows as a shrub. It can be easily cultivated. Therefore, there cannot be shortage of raw materials for phytomedicine development.

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