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Original Article

Evaluation of Anti-hyperglycemic potential of *Bauhinia Tomentosa* standardized extracts in streptozotocin- induced diabetic rats

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Abstract

In India, the occurrence of diabetes mellitus is on increase and needs to be addressed properly. Herbal remedies are considered most suitable for the management of type 2 diabetes due to their traditional acceptability and availability, low costs, and fewer side effects. Traditionally *Bauhinia tomentosa* L. (Family- Fabaceae) is used in the treatment of diabetes in India. Aqueous extract and alcoholic extract (250 and 500 mg/kg) of stem were taken to evaluate the anti-diabetic activity in normal and streptozotocin (65 mg/kg) induced diabetic rats. After 21 days of oral administration of extracts resulted in the significance reduction in blood glucose level. Serum biochemistry showed that serum cholesterol, triglyceride, HDL, LDL levels were significantly decreased by both the extracts and standard drug glibenclamide (10 mcg/kg). HPLC and HPTLC analysis of alcoholic extract found to be rich in flavanoids and phenolic constituents whereas aqueous extract found to possess rich in flavanoids, phenolic constituents, tannins and glycosides. The antidiabetic activity of *Bauhinia tomentosa* L. may be attributed to its high phenolic and flavanoids constituents.

Keywords: Antidiabetic activity, HDL, HPTLC, LDL, serum cholesterol, streptozotocin, triglyceride.

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1. Introduction

Diabetes mellitus is the most common endocrine disorder. More than 100 million people are suffering from this disease worldwide. This number is expected to increase 300 million by the year 2025. More than one fifth of them are Indian. International diabetic federation declared that India was diabetic

capital of world. Synthetic drugs have major side effects and are avoided during pregnancy. Due to side effects associated with the synthetic drugs and taking natural plants safer, cost effective, traditionally used plants were explored [1, 2, 3].

Bauhinia tomentosa commonly known as yellow bell orchid tree belongs to Fabaceae family, one of the best, versatile and most commonly used household remedy for many manifestations. It contains amino acids, alkaloids, proteins, minerals, fatty acids, phyto-steroids, flavanoids, saponins, phenolic compounds, fixed oils and fats [4, 5, 6, 7, 8, 9, 10]. Traditionally the plant was used as a remedy for fever, hyperlipidemia, dysentery, diarrhea, astringent, diabetes and as remedy for snake bites [11, 12]. It is an ingredient of Ayurvedic drug *murva*. Other species of *Bauhinia* i.e. *B. forficata, B. variegata* have been reported to possess significant anti-diabetic species [13, 14]. Therefore, an attempt was made to evaluate the antidiabetic potential of stem extracts.

2. Material and Methods

2.1. Chemicals

Streptozotocin (STZ) was obtained from Sigma Chemical Co., St. Louis, MO, USA. Total cholesterol, Serum high density lipoproteins and triglycerides were assayed by using standard kits purchased from span diagnostic Ltd. India. Other chemicals of analytical grade used in the study have been obtained from laboratory of Devsthali Vidyapeeth College of Pharmacy, Rudrapur, Uttarakhand, India.

2.2. Plant Material

The stems of plant were collected in the month of September 2010 from the nursery of Rudrapur, Uttarakhand, India and was authenticated by National Botanical Research Institute (NBRI), Lucknow, India. The herbarium of the plant was prepared and deposited in herbarium of Devsthali Vidyapeeth College of Pharmacy (Varsha no. 09). The stems were washed with distilled water to remove any type of contamination and air dried.

2.3. Preparation of Extracts:

The shade dried stems were powdered in the mixer and passed through sieve. 100g of powder was extracted in a soxhlet apparatus using 70% v/v ethanol. The extract was concentrated to small volume and then evaporated to dryness. The aqueous extract was prepared in distilled water by cold maceration and evaporated to dryness. For animal study both the extracts were dissolved in 2% v/v Tween 80.

2.4. HPLC Analysis

Preparation of sample: Alcoholic extract was diluted with the ethanol in 1:10 ratio and after centrifugation used for the analysis [15, 16, 17].

The HPLC analysis of alcoholic extract was carried consisting of auto sampler with UV-VIS detector with column (Phenomenox RP-C-18, 250 x 4.6 mm). The mobile phase consists of solvent mixtures of Water and Acetonitrile: Methanol (1:1v/v) in 55:45 ratio was performed using isocratic elution (0-12min) with a flow rate of 1.0 ml/min and column temperature of 30°C. The injection volume (20 µl) was taken and UV detection was performed at 254 nm. All chromatographic data were recorded and processed using Shimadzu Class VP software.

2.5. HPTLC Analysis

In the present study, Camag HPTLC system equipped with Linomat V applicator, TLC scanner 3, Reprostar 3 with 12bit CCD camera for photo documentation, controlled by WinCATS- 4 software were used. All the solvents used were of HPTLC grade obtained from MERCK. All weighing were done on Precisa XB 12A digital balance [15, 16, 17].

Alcoholic extract for analysis was prepared by dissolving the extract in alcohol after sonication used for the analysis. Aqueous extract for analysis was prepared by dissolving the water followed by sonication and centrifugation. Supernatant was used for the sampling

2.5.1. Preparation of Mobile Phase for Alcohol and Aqueous Extracts

Alcoholic extract was developed in the following two mobile phases:

I: Ethyl Acetate: Butanone: Formic acid: water [5:3:1:1]

II: Chloroform: Methanol: water [6.5:2.5:0.4]

Aqueous extract were developed in following two mobile phases:

I: Ethyl Acetate: Formic acid: Acetic acid: water [10:1.1:1.1:2.6]

II: Ethyl Acetate: Methanol: Ethanol: water [8.1:1.1: 0.4:0.8]

2.5.2. Chamber Used for Mobile Phase

Camag twin trough chamber (10 x 10 cm)

2.5.3. Chamber Saturation

Chamber saturation was done for 18h.

2.5.4. Stationary Phase

HPTLC plates silica gel 60 F 254 manufactured by E. MERCK K GaA (5 X 10 cm) were used as stationary phase.

2.5.5. Procedure

Pre-coated TLC plates were activated by heating at 120^0C for about 30 min prior to use. Alcoholic and aqueous extract (2µl) were applied in duplicate, as tracks 1-6, with a band length of 8 mm each on a pre-coated silica gel 60 F254 TLC plate, with Linomat V applicator using a hamilton syringe. The TLC plate was kept for development to a migration distance of 77 mm and scanned at 254 nm and 366 nm, band length 8 mm, slit dimension, scanning speed and source of radiation was Deuterium and Tungsten

lamps respectively. The developed plates were dried and scanned successively at wavelengths of 254nm, 366nmand 425nm, band width, slit dimension, scanning speed and the source of radiation was deuterium, tungsten and mercury. The Rf and peak area of the spots were interpreted by using software [16].

2.6. Pharmacological Activities

2.6.1. Experimental Animals

Male wistar rats (200-230 g) were collected from the Indian Veterinary Research Lab, Barielly, Uttar Pradesh, India. Before and during the experiment, rats were fed with standard diet. Animals were maintained under standard environmental conditions i.e. temperature-24.0±1.0°, relative humidity-55-65% and 12 h light/12 h dark cycle. Animals described as fasting were deprived of food and water for 16 hours ad libitum. All protocols for animal experiment were approved by the institutional animal ethical committee (CPCSEA/IAEC/2010-11/06).

2.6.2. Oral Glucose Tolerance Test

Rats were divided into six groups containing six animals in each group. All animals fasted before treatment. Group I was kept as vehicle control which received 5% Tween 80 p.o., group II received glucose only, group III received alcoholic extract 250mg/kg, group IV received alcohol extract 500 mg/kg. The rats of group V and VI received alcohol extract 250 mg/kg and 500 mg/kg only in a vehicle, respectively. The rats of group III, IV, V and VI were loaded with glucose (2g/kg, p.o.) 30 minutes after drug administration. Blood samples were collected from puncturing the retro orbital sinus just prior to drug administration, and 30, 60, 90, 120 minutes after loading glucose. Serum glucose level was measured immediately by using glucose estimation kit (Span Diagnostic Pvt. Ltd. Surat, India).

2.6.3. Acute Oral Toxicity Studies

Acute toxicity studies of *B. tomentosa* extract showed that both the extracts were found to be safe up to the doses of 2500mg/kg in mice. Hence, the dose was selected as the 1/10 th dose of the safest dose [17].

2.6.4. Induction of Diabetes in Rats

Rats were made diabetic by single intraperitoneal injection of STZ (65 mg/kg), prepared in citrate buffer to pH 4.5. Three days after the administration of STZ, when the fasted blood glucose level was greater than 200 mg/ dL, rats were selected and used for the study. Blood samples were collected by retro-orbital plexus of eye. Fasting blood glucose levels and body weight were taken on 0th, 7th, 14th and 21st days with commercially available biochemical kit.

2.6.5. Estimation

Blood glucose level (BGL), Total cholesterol (TC), High density lipoprotein (HDL) cholesterol and Triglycerides (TG) were estimated using standard kits of Span Diagnostic Ltd., India.

2.6.6. Experimental Design

2.6.6.1. Assessment of normoglycemic activity in normal healthy rats

Fasted rats were divided into six groups of six rats each.

Group I: Normal control and received vehicle only

Groups II & III: Alcoholic extract (250 mg/kg & 500 mg/kg b.w.)

Group IV& V: Aqueous extract (250mg/kg & 500mg/kg b.w.)

Group VI: Glibenclamide as an aqueous suspension (500µg/kg b.w.)

After 30 min of extract administration, the rats of all the groups were orally treated with 2 g/kg of glucose. Blood samples were collected from the retro-orbital plexus just prior to glucose administration and at 0, 30, 60, 90, 120 min after glucose challenge. Plasma was separated by centrifugation and blood glucose levels were measured immediately by using Glucose Oxidase/Peroxidase (GOD/POD) method [18, 19, 20, 21, 22].

2.6.6.2. Assessment of Anti-diabetic Activity in Streptozotocin Induced Diabetic Rats

Diabetic rats were divided into 7 groups containing 6 animals each for assessment of anti-diabetic activity [22, 23, 24, 25, 26, 27, 28].

Group I: Normal Control received food and water

Group II: Diabetic Control, received 0.5 ml of 5% tween 80

Group III: Standard received Glibenclamide (100 µg/kg)

Group IV& V: Alcoholic extract treated group 250 and 500 mg/kg

Group VI& VII: Aqueous extract treated group 250 and 500 mg/kg

2.7. Statistical Analysis

The experimental data are expressed as mean + S.E.M. The difference between test and controls were evaluated by two way ANOVA followed by Dunnett's multiple comparison test. Values of $p < 0.05$ were considered statistically significant.

3. Results and Discussion

3.1. Preliminary Phyto-Chemical Analysis

Preliminary phytochemical analysis shows the presence of alkaloids, carbohydrates, phyto-sterols, phenolic compounds, flavonoids and tannins in both aqueous and alcoholic extract. [17]

Table 1. Peak table for Flavanoids profile of *Bauhinia tomentosa* stem alcoholic extract (BTSAL)

Peak	R_f	Height	Area	Assigned substance
1	0.78	62.8	4430.1	Unknown
2	0.91	32.6	937.6	Flavonoid 6 *

3.2. HPLC studies

3.2.1 Mobile Phase

HPLC studies of aqueous extract shows 14 sharp and prominent peaks. Solvents used for the study were water as solvent A and acetonitrile: Methanol (1:1) as solvent B using isocratic elution of in the ratio of 55:45. Peaks at retention time 10.45, 11.0 15.16 and 16.96 shows similarity when compared with other species [16]. HPLC studies of alcoholic extracts shows 41 sharp and prominent peaks. Peaks at retention time 10.45, 11.0 15.16 and 16.96 min. shows similarity when compared with other species [16]. (Figure 1)

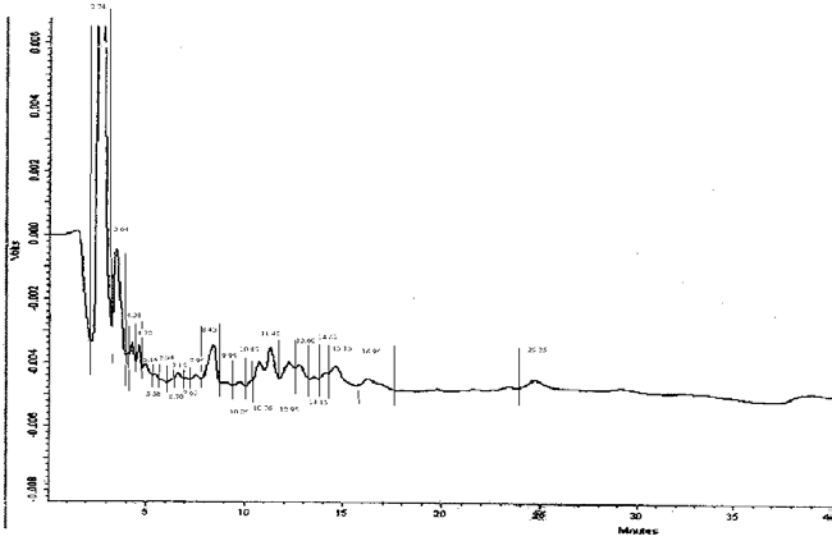

Figure 1. HPLC fingreprint chromatogram of BTSAL HPLC fingreprint profile of the BTSAL at wavelength detection at 254 nm using isocratic elution of water and [acetonitrile: methanol (1:1v/v)] (55:45) as mobile phase

Table 2. Peak table for Flavanoids profile of *Bauhinia tomentosa* stem aqueous extract (BTSAQ)

Peak	R_f	Height	Area	Assigned substance
1	0.04	125.4	3800.9	Unknown
2	0.09	77.9	2305.5	Unknown
3	0.25	59.7	23.56.0	Flavonoid 1*
4	0.46	24.3	149.4	Unknown
5	0.55	59.4	447.7	Flavonoid 2*

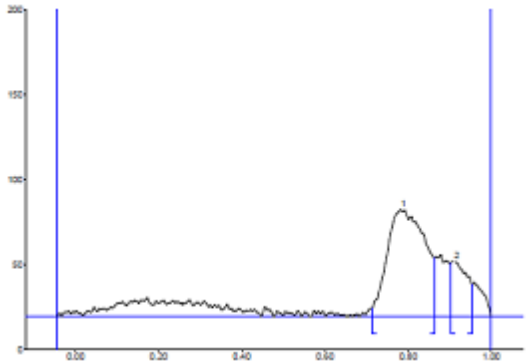

Figure 2. HPTLC fingreprint chromatogram of BTSAL. HPTLC fingreprint chromatograms showing flavanoids profile of BTSAL. Peak corresponding to R_f 0.91 showed the presence of Flavonoid 6 *[30]

3.3. HPTLC Analysis

Using mobile phase Ethyl Acetate: Butanone: formic acid: water [5:3:1:1] alcohol extract showed 2 sharp and prominent peaks with Rf value 0.78 and 0.91. The Rf value of 0.91 can be due to flavonoid 6, which was reported earlier. Using mobile phase chloroform: methanol: water [6.5:2.5:0.4] alcohol extract does not show any peak. This shows flavonoids 6 were present but cardiac glycosides were absent in the extract [17] (Table 1 and Figure 2)

Using mobile phase Ethyl Acetate: Formic acid: acetic acid: water [10:1.1:1.1:2.6] aqueous extract shows 5 prominent peaks with Rf value 0.04, 0.09, 0.25, 0.46, 0.55. Peaks with Rf 0.25 and 0.55 can be due to flavonoids 1, flavonoids 2, which were reported in the previous studies.

Using mobile phase Ethyl Acetate: methanol: ethanol: water [8.1:1.1: 0.4:0.8] aqueous extract shows 8 prominent peaks with Rf 0.07, 0.13, 0.19, 0.25, .28, 0.37, 0.40, 0.62. Peaks with Rf value 0.19, 0.25, 0.37, 0.40 and 0.62 were found to be exactly same as reported earlier. Peaks corresponding to Rf 0.19 may be due to Steviosides under similar conditions as reported earlier. [17] (Table 2, 3 and Figure 3)

Table 3. Peak table for Glycosides profile of *Bauhinia tomentosa* stem aqueous extract (BTSAQ)

Peak	R_f	Height	Area	Assigned substance
1	0.07	380	8470.8	Unknown
2	0.13	75.5	1558.2	Unknown
3	0.19	65.2	2971.7	Steviosides**
4	0.25	40.7	404.8	Unknown
5	0.28	34.4	796.3	Unknown
6	0.37	39.2	972.2	Unknown
7	0.40	14.9	240.3	Unknown
8	0.62	26.8	1349.0	Unknown

**When compared in similar conditions [31]

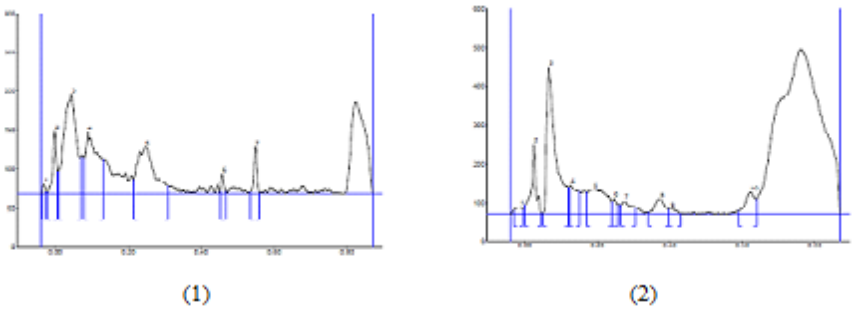

Figure 3. HPTLC fingreprint chromatogram of BTSAQ. HPTLC fingreprint chromatograms showing flavanoids and alkaloids profile of BTSAQ. Peak corresponding to R_f 0.25 and 0.55 showed the presence of Flavonoid 1* and Flavonoid 2* whereas peak corresponding to R_f 0.19 showed the presence of Steviosides**.[31]

HPLC and HPTLC analysis of alcoholic extract found to be rich in flavanoids and phenolic constituents whereas aqueous extract found to possess rich in flavanoids, phenolic constituents, tannins and glycosides. The significant anti-diabetic potential of alcoholic and aqueous extracts is due to high phenolic and flavanoid constituents by effectively reversing the levels of biochemical parameters and also improvement in body weight. HPTLC analysis of the alcoholic extract of *Bauhinia tomentosa* L was found to be rich in flavanoids and phenolic constituents whereas aqueous extract was found to be rich in flavanoids, phenolic constituents, tannins and glycosides. The significant normoglycemic, anti-diabetic potential of alcoholic and aqueous extracts in streptozotocin induced diabetic rats might be due to high phenolic as well as flavanoids constituents by effectively reversing the levels of biochemical parameters and also improvement in body weight.

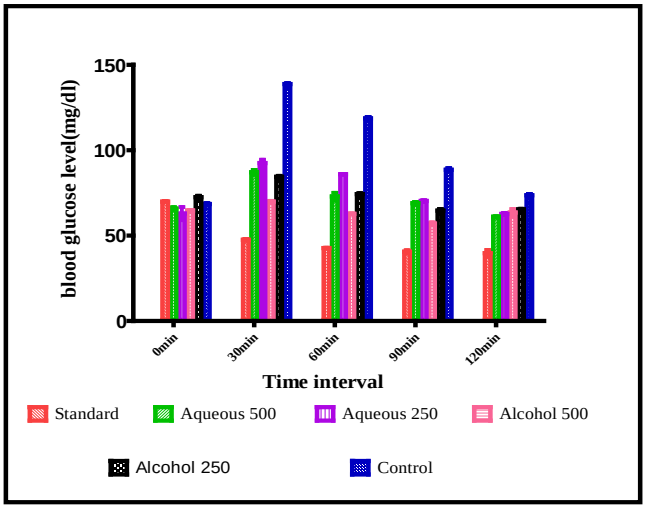

Figure 4. Normoglycemic activity of BTSAQ and BTSAL on experimental rats. Values are expressed in (mean ± SEM) obtained from each group of 6 animals. P value: [a] $p<0.05$, [b] $p<0.01$ v.s diabetic control

Table 5. Anti-hyperglycemic activity of extracts of *B. tomentosa* L on STZ induced diabetic rats.

Groups	**Fasting Glucose Level (mg/dl)**			
Treatment/Dose	0^{th} day	7^{th} day	14^{th} day	21^{st} day
Normal control	76.16 ± 5.36	75.66 ± 3.94	75.0 ± 4.96	80.0 ± 4.61
Diabetic control	220.83 ± 1.92	224.5 ± 3.69	211.33 ± 1.30	208.16 ± 1.74
Glibenclamide (10mcg/kg)	235.8±2.38	146.6 ±9.01 [b]	118.8 ± 6.73 [b]	84.5 ± 5.46 [b]
BTSAQ (250 mg/kg)	244.2 ± 4.50	195.65± 2.82	178.68 ± 1.05 [b]	116.80 ±8.42 [b]
BTSAQ (500 mg/kg)	227.5±2.54	186 ± 3.45[a]	144.32± 9.56 [b]	105.32±2.62 [b]
BTSAL (250mg/kg)	223.6 ± 2.28	182.29 ± 6.32	145.8 ± 2.42 [a]	100.42 ±2.18 [b]
BTSAL (500mg/kg)	265.14±7.56	198.08 ± 4.12[a]	148 ± 1.68 [b]	96.35±8.56 [b]

Values are mean ± SEM; n=6. P value: [a] $p<0.05$, [b] $p<0.01$ v.s diabetic control; BTSAL= *Bauhinia tomentosa* stem alcoholic extract; BTSAQ= *Bauhinia tomentosa* stem aqueous extract.

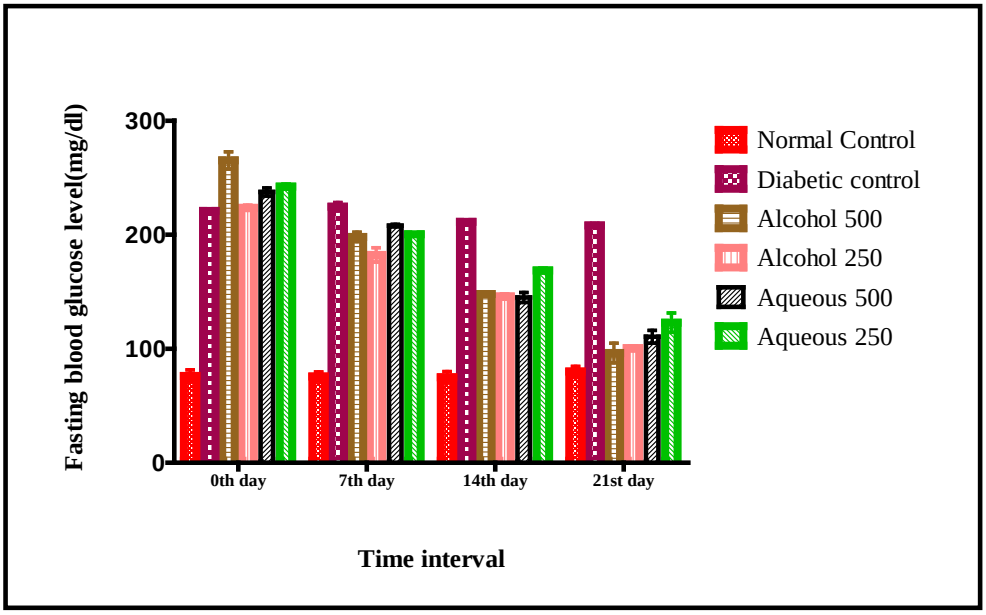

Figure 5. Effect of BTSAQ and BTSAL on Fasting blood glucose level in rats. Values are expressed in (mean ± SEM) obtained from each group of 6 animals. P value: [a] $p<0.05$, [b] $p<0.01$v.s diabetic control

3.4. Effect of Extract on Blood Glucose Level in Normoglycemic Rats

Table 4 & Figure 4 showed the results of the effects of two doses (250mg/Kg and 500mg/Kg) of the alcoholic extract of *Bauhinia tomentosa* L, glibenclamide and control groups on streptozotocin induced diabetic rats. The animals treated with dose of 250 and 500 mg/kg of alcoholic extract produced a fall of 37.08 and 33.35% respectively, after 2 hours of extract administration. The hypoglycemic effect was moderate after 1 h of the extract administration at both the doses of extract.

3.5. Effect of Extract on Fasting Blood Glucose (FBG) and Lipid Profile in Streptozotocin Induced Diabetic Rats

Table 4 & Figure 4 showed the results of

Table 6. Effect of extract on lipid profile (mg/dl).

Groups	Parameters	0 day	7th day	14th day	21st day
NC	TC	68.54 ±3.04	63.25 ±1.55	72.65 ±3.24	69.35±1.25
	TG	82.36 ±5.04	118.45±4.12	92.35± 1.05	121.36±2.01
	HDL	35.62±4.23	38.25 ±2.53	40.47±2.76	36.58±2.53
	LDL	27.89±4.56	23.15±2.04	26.37±1.61	25.52±3.28
Diabetic control (STZ)	TC	148.48±9.45	167.46±3.63	127.58±2.63	144.79±11.25
	TG	254.39±7.28	343.16±6.35	305.56±2.94	269.30±13.59
	HDL	24.85±1.47	17.29 ±5.09	21.068±1.98	22.69±2.58
	LDL	84.25±5.68	78.36±3.73	72.23±2.21	110±10.60
Standard (Glibenclamide)	TC	169.21±7.72	156.56±8.11	139.48±6.98	112.69 ± 2.65
	TG	237.5 ±4.63	202 ± 2.08	154.25± 1.02	144 ± 6.54
	HDL	36.78±3.52	34.26±4.08	38.07±5.41	31.44 ±11.45
	LDL	114.17±4.36	86.39±6.58	59.68±5.86	49.62±7.72
BTSAL (250 mg/kg)	TC	182 ± 6.05	174.34 ± 8.18	147.08±4.94	131.74±3.71
	TG	227.38±4.53	198.68 ± 2.78	176.63±1.18	148.41±8.92
	HDL	34.73±6.48	32.25±1.54	32.17±2.76	29.74±7.78
	LDL	108.36±11.42	97.18±8.16	82.73±3.16	78.24±1.88
BTSAL (500 mg/kg)	TC	168.47±3.04	146.51±6.37	137.58±5.86	129.46±4.37
	TG	196.54±5.91	182.73±4.76	163.57±11.84	137.71±2.34
	HDL	32.58±1.08	34.07± 1.14	30.34±3.62	35.42±6.27
	LDL	127.66±1.67	104.26±12.64	92.64±7.21	67.39±9.58
BTSAQ (250 mg/kg)	TC	154.34±8.59	138.63±7.64	129.23±6.72	116.48±5.54
	TG	204.76± 1.13	187.18±3.72	169.32± 9.24	152.31±4.36
	HDL	28.62±4.32	27.44±10.74	27.16±6.24	29.61±7.45
	LDL	98.38±3.69	84.75±5.63	65.15±11.82	57.38±14.21
BTSAQ (500 mg/kg)	TC	174.73±1.87	167.29±3.38	146.68±11.84	136.52±5.14
	TG	184.24±2.17	159.81±7.13	138.37±6.24	127.81±6.93
	HDL	30.14±1.08	35.27±3.46	34.26±4.87	34.64±2.39
	LDL	114.64±3.62	107.74±10.63	87.29±5.63	76.18±13.22

Value expressed as Mean ± S.E.M (n=5); p=P<0.001, q=P<0.01, r=P<0.05 significant from normal control group; a=P<0.001, b=P<0.01 and c=P<0.05 significant from diabetic control group; TC – Total cholesterol; TG – Triglyceride; HDL – High density lipoprotein; LDL – Low density lipoprotein; BTSAL= *Bauhinia tomentosa* stem alcoholic extract; BTSAQ= *Bauhinia tomentosa* stem aqueous extract; NC= Normal control.

effect of extract on fasting blood glucose and lipid profile in streptozotocin induced diabetic rats. The FBG level were tested on 0, 7th, 14th and 21st days after treatment. Normal control rats there was no change in FBG levels where as in diabetic control rats the FBG levels rises gradually. Alcoholic and aqueous extracts at both the doses (250 and 500 mg/kg) were shown significant reduction in blood glucose levels on diabetic rats on 21st day.

From glucose tolerance test, it was confirmed that both the extracts have shown reduction in blood glucose level after 2 hours of oral administration. The hypoglycemic effect me be due to increased secretion of insulin from β cells of pancreas i.e. pancreatotrophic action or due to regeneration of pancreatic cells that were partially distroyed by STZ [23].

The post-treatment levels of total cholesterol, HDL cholesterol, LDL cholesterol and triglyceride of the treated group were significantly lesser than the pretreatment levels. A fall of 28% in TC, 67% in LDL cholesterol and 29% in TG levels was observed in diabetic rats after 21 days of extract treatment. There was an increase of 20% in HDL cholesterol in the treated diabetic groups (Table 6 and Figure 6). This would definitely reduce the incidence of coronary events, which is the major cause of morbidity and deaths in diabetic subjects [24, 25].

Phyto-chemical investigation of *B. tomentosa* extracts revealed the presence of phenolic, flavonoids, tannins, sterols and saponins. It is well known that certain flavonoids and phenolic compounds exhibit hypoglycemic activity and

Table 7. Determination of body weight (g)

Groups	0 day	7th day	14th day	21st day
NC	250±14.05	256.56±8.46	264.66±6.84	280±13.57
Diabetic control (STZ)	266.47±4.47	240.63±7.98	210.53±10.27	186.15±3.37
Standard (Glibenclamide)	267.85±14.68	271.63±9.86	275.71±12.56	292.37±8.03
BTSAL (250 mg/kg)	257.44±7.62	232.76±9.50	226.86±11.47	204.17±14.65
BTSAL (500 mg/kg)	254.30±5.17	238.73±8.89	240.67±12.63	243.56±6.59
BTSAQ (250 mg/kg)	276.66±10.41	263.53±12.47	257.65±7.22	273.47±10.12
BTSAQ (500 mg/kg)	284.14±13.08	260±9.28	273.77±5.66	283.40±3.73

Value expressed as Mean±S.E.M (n=5); p=P<0.001, q=P<0.01 significant from normal control group; a=P<0.001 and b=P<0.01 significant from diabetic control group, BTSAL= *Bauhinia tomentosa* stem alcoholic extract; BTSAQ= *Bauhinia tomentosa* stem aqueous extract.

also for their ability to regenerate beta cell of pancreas. Further sterols have also shown decrease in blood sugar levels of experimental animal models [10 & 29]. Thus, the significant anti-diabetic effect of alcoholic and aqueous extract of *B. tomentosa* may be due to the presence of above phyto constituents or their synergistic action. [26, 27, 28, 29, 30].

4. Conclusion

The results showed that both the extracts possess significant antidiabetic activity. Further research is ongoing on the isolation and in detail mechanism of action at cellular and molecular levels. These extracts also showed improvement in the parameters like body weight, lipid profile and other biochemical parameters.

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