IJPSR (2015), Vol. 6, Issue 8 **(Research Article)**

INTERNATIONAL JOURNAL OF PHARMACEUTICAL SCIENCES AND RESEARCH

Received on 26 December, 2014; received in revised form, 14 February, 2015; accepted, 28 May, 2015; published 01 August, 2015

CASSIA TORA SEEDS EXTRACT REGULATES LIPID METABOLISM IN ALLOXAN INDUCED DIABETIC RATS

Vishnu Kumar [*1], Farzana Mahdi [1], Ranjana Singh [2], Abbas Ali Mahdi [2], Kalbe Jawad [3], Raj Kumar Singh[4] and Manisha Singh [1]

Department of Biochemistry [1], Era's Lucknow Medical College & Hospital Lucknow-226 001, U.P., India
Department of Biochemistry [2], CSM Medical University Lucknow-226 003, U.P., India
Department of Biochemistry [3], UP Rural Institute of Medical Sciences & Research, Saifai, Etawah, UP-206 301, India
Shri Guru Ram Rai Institute of Medical & Health Sciences [4], Patel Nagar, Dehradun-248 001, U.K., India

Keywords:
Alloxan model of hyperglycemia – Cholic and Deoxycholic acid – Antioxidant enzymes - Lipases - Lecithin cholesterol acyltransferase – Plant antioxidants

Correspondence to Author:
Dr Vishnu Kumar

Associate Professor,
Department of Biochemistry, Era's Lucknow Medical College and Hospital, Sarfaraz Ganj, Hardoi Road, Lucknow- 226003, U.P., India.

E-mail: vkawasthi@hotmail.com

ABSTRACT: The hypolipidemic activity of *Cassia tora* (Chakvat, Chakunda) (Family: Caesalpiniaceae) seeds extract have been studied in alloxan-induced diabetic rats. In this model oral administration of seed extract (500 mg/kg bw.P.o.) for 15 days in diabetic-dyslipidemic rats exerted significant lipid lowering effect as assessed by the reversal of serum levels of total cholesterol, phospholipids, triglyceride, free fatty acids, protein and lipid peroxide. The decrease of lipids and apoprotein levels of Very Low Density Lipoprotein and Low Density Lipoprotein were followed by stimulation of plasma post-heparin lipolytic activity as well as lecithin cholesterol acyltransferase, hepatic superoxide dismutase, catalase, triglyceride lipase and lipoprotein lipase activities with increase in reduced glutathione. Lipid and apoprotein level of High Density Lipoprotein were also recovered partially on treatment with seeds extract. The results of the present study demonstrated antidyslipidemic and antioxidant activities in seed extract of *C. tora* which could be used in prevention of diabetic dyslipidemia and related complications. The hypolipidemic activity of *Cassia tora* seeds was compared with a standard drug glibenclamide (600 µg/ kg body wt/ day p.o.).

INTRODUCTION: *Cassia tora* Linn (Family: Caesalpiniaceae) commonly known Chakvat, Chakunda and Charota in Hindi, *Foetid Cassia* in English is an herbaceous foetid annual weed, almost on under shrub, up to 90 cm in height. It grows in tropical and Asian countries especially on way sides and waste places and on hills of low elevations up to 1,800 m as well as in plains. Different parts of the plant (Leaves, seed, and root) are claimed to be effective against a variety of ailments in indigenous medicine [1].

QUICK RESPONSE CODE

DOI: 10.13040/IJPSR.0975-8232.6(8).3484-89

Article can be accessed online on: www.ijpsr.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.6(8).3484-89

The leaves and seeds are acrid, thermogenic, laxative depurative, antiperiodic, liver tonic, antihelmintic, cardio tonic and are useful in ringworm, pruritis, leprosy, skin disease, jaundice, helminthiasis, flatulence, dyspepsia, intermittent fevers, constipation, ophthalmopathy, cough,

bronchitis, cardiac disorders and haemorrhoids [2, 3]. The leaves of *C. tora* are reported to have antirheumatic activity in folklore practice. Decoction of the leaves is used as laxative. The seeds of *C. tora* have been used in Chinese medicine as vision-improving, cardiotonic, hypolipidemic, aperients, antiasthnic and diuretic agent. Several polyharbal formulations are available in Chinese market for preventing the formation of atherosclerosis plaque [4].

Cardiovascular diseases are leading cause of death in both industrialized and developing nations. Disorders of lipid metabolism following oxidative stress are the prime risk factors for initiation and progression of heart diseases. The current therapies used for controlling hyperlipidemia; fibrates, stains and bile acid sequestraints are almost inefficient to regulate lipid metabolism. Furthermore, these drugs also cause a number of serious adverse effects in patients. Currently available treatment for hyperlipidemia in modern medicine, fibrats, statins or bile acids sequestraints and their combinations do not regulate lipid metabolism up to an appreciable mark, also have several adverse effects in patients. Therefore, there is a need to develop safe and effective treatment modalities for hyperlipidemia.

Furthermore medicinal plants play an important role in the treatment of lipid disorders, especially due to their lesser toxicity, side effects and cost effectiveness. Therefore, the research and development of hypoglycemic and lipid lowering drugs from natural products are the best option and also are in great demand. In view of the above considerations, the present study was designed to investigate antidyslipoproteinemic activity of *Cassia tora* seeds in hyperglycemic rats [5].

MATERIAL AND METHODS:

Preparation of seed extract:

Cassia tora seeds were collected from local area of Lucknow and identified taxonomically by Department of Pharmacology, Era's Lucknow Medical College Lucknow. A voucher specimen (CT-005/10) was also submitted. Seeds were crushed and dried under shade. The powder (500g) was extracted with 95 % ethanol in a soxhlet extractor for 72 h, the extract was concentrated to dryness under reduced pressure and controlled temperature (50-60 °C), yielding 23g of reddish brown solid (crude extract). This was stored in refrigerator and used to investigate hypolipidemic activity in rats[5].

Animals:

In vivo experiments were conducted as per guidelines provided by Animal Ethics Committee of Central Drug Research Institute, Lucknow, India. Male adult rats of Charles Foster strain (200-225g) bred in animal house of the Institute were used. The animals were housed in polypropylene cages and kept in uniform hygienic conditions, temperature 25-26 °C, relative humidity 50-60% and 12/12 h light/dark cycle (light from 8:00 am to 8:00 pm) and provided with standard rat pellet diet and *water ad libitum* [5].

Alloxan induced hyperglycemia:

The rats were divided into four groups having six animals in each as follows: control, hyperglycemic, hyperglycemic treated with *Cassia tora* seeds and hyperglycemic treated with glibenclamide. Diabetes was induced in rats by a single intraperitonial injection of alloxan monohydrate 150 mg/kg b.w. in 18 animals. After two weeks of diabetes induction, rats with serum glucose level 280-367 mg/dl were taken for the study.

C. tora seeds extract and glibenclamide were macerated with aqueous gum acacia (1% w/v) suspension and fed orally at the doses of 500 mg/kg b.w. and 600µg/kg, b.w., respectively. Control animals received same amount of vehicle.

After 15 days of feeding rats were fasted overnight and blood was withdrawn from the retro-orbital pluxes. A group of normal rats without treatment with alloxan was also included to serve as control. Animals were kept in controlled conditions. Temperature 25-26˚C, relative humidity 60-70% and 12/12 h light/dark cycle (light from 08:00 AM to 08:00PM), provided with standard pellet diet (Lipton India Ltd.), and water *ad libitum*[6].

Biochemical analysis of plasma:

Serum from above rats was fractionated into very low density lipoprotein (VLDL), low density lipoprotein (LDL) and high density lipoprotein

(HDL) by polyanionic precipitation method [7]. Serums as well as lipoproteins were analyzed for their total cholesterol: TC [8], triglyceride: TG [9], phospholipids: PL [10] and apoprotein [11] by standard procedures reported earlier, serum lipid peroxide (LPO) [12], free fatty acid (FFA) [13], plasma protein[14], Plasma lecithin cholesterol acyl transferase (LCAT) activity [15] and post heparin lipolytic activity (PHLA)[16] were also estimated.

Biochemical analysis of liver:

Liver homogenized (10% w/v) in cold 1 M phosphate buffer (pH7.2) was used for the assay of lipoprotein lipase (LPL) [16], and triglyceride lipase (TGL) [17] activities. Liver homogenate 10% w/v in 0.15 M KCl was also used for the estimation of superoxide dismutase (SOD) [18], Catalase (CAT) [19] and reduced glutathione (GSH) [20]. The lipid extract of each homogenate was used for the estimation of TC, PL and TG by above- mentioned methods.

Biochemical analysis of feces:

Feces spilling of Rat's from all groups over 15 days and processed for the cholic and deoxycholic acid [21].

Statistical analysis:

One-way-analysis of variance (ANOVA-Newman's student test) was performed by comparison of values for alloxan-treated group with control, alloxan and drug-treated with alloxan only. All hypothesis testing were two-tailed. $P<0.05$ was considered statistically significant and the results were expressed as mean ± SD. The Graph pad INSTAT 3.0 software was used to carried out the statistical analysis [22].

RESULTS:

Effect of *C. tora* seed extract on serum lipid, FFA, LPO and plasma protein in alloxan induced diabetic rats:

The data in **Table 1** show that, acute administration of alloxan markedly increased in the plasma; TC, TG and PL levels 97%, 130% and 45% , FFA 59%, LPO, 250% and decreased plasma protein 31%. However, treatment with *C. tora* seed extract caused reversal in the levels; TC 34%, TG 36%, PL 38%, FFA 15%, LPO 33% and protein by 29%. Glibenclamide reversed the levels; TC 20.0%, TG 25.0%, PL 7.0%, FFA 20%, LPO 39% and Protein 15.0%.

TABLE 1: EFFECT OF *C. TORA SEED* EXTRACT ON SERUM LIPID, PROTEIN, LIPID PEROXIDE AND FFA IN ALLOXAN-INDUCED DIABETIC RATS

Experimental schedule	Total cholesterol (mg/dl)	Triglycerides (mg/dl)	Phospholipids (mg/dl)	Protein (g/dl)	Serum lipid peroxide (n mol MDA/ml plasma	Serum free fatty acid (μ mol/L)
Control	74.23 ± 10.66	77.72 ± 7.54	86.76 ± 11.30	6.99 ± 0.45	2.53 ± 0.49	1.48 ± 0.17
Alloxan-treated	146.15 ± 26.80 ** (+ 97)	178.81 ± 13.60 ** (+130)	124.88 ± 14.68 ** (+45)	4.84 ± 0.36 ** (- 31)	8.88 ± 1.40** (+250)	2.36 ± 0.30** (+59)
Alloxan + *C. tora seed* extract (500 mg /kg b.w.)	96.19 ± 12.36 *** (-34)	115.17 ± 6.07*** (-36)	77.25 ± 7.22*** (-38)	6.23 ± 0.39** (+29)	6.18 ± 0.46*** (-33)	2.00 ± 0.24* (-15)
Alloxan + Glibenclamide (600 μg/kg b.w.)	117.18 ± 18.86** (-20)	133.78 ± 11.24** (-25)	116.45 ± 11.67 NS (-7)	5.57 ± 0.69 * (+15)	5.45 ± 0.99*** (-39)	1.88 ± 0.29** (-20)

Values are expressed as mean ± SD of 6 animals. Values in the paranthesis indicate percent change. Alloxan-treated group was compared with control, alloxan and drug-treated groups with alloxan. ***p<0.001, **p<0.01, *p<0.05, NS= Non significant.

Effect of *C. tora* seed extract on serum lipoprotein profile in alloxan-induced diabetic rats: Analysis of hyperglycemic serum (**Table 2**) showed marked increase in the levels of lipids and apoprotein constituting β-lipoproteins (VLDL and LDL) and these effects were pronounced for VLDL-TC, PL and TG 53%, 21% and 96% respectively and apoprotein 13%. There was increase in LDL-TC, PL, TG 325%, 43%, 134% respectively and apoprotein 24%. The decrease in HDL-TC, PL, TG and Apoprotein 27%, 23%, 5% and 28% respectively.

The data in **Table 2** also show that treatment with *Cassia tora* seed extract for 15 days significantly reversed the level VLDL-TC 30% and PL, 13 %,TG 27% and Apoprotein 9% and decrease in LDL-TC 41%, PL, TG 24%, 39 % and apoprotein 13%. At the same time *Cassia tora* seed extract increased in the levels of HDL-TC, PL, TG 10%, 4%, 7% respectively, and apoprotein 15%. Glibenclamide decreased VLDL-TC, Apoprotein 26%, 9% respectively PL 8 % and TG 32 % and LDL-TC, TG 37%, 38% respectively, PL 7.0 % and apoprotein 13% respectively with simultaneously increase in HDL-TC, PL, TG, Apoprotein 4 %, 4 %, 5 %, 11% respectively.

TABLE 2- EFFECT OF *CASSIA TORA SEED* EXTRACT ON LIPOPROTEIN PROFILE IN ALLOXAN-INDUCED DIABETIC RATS

Experimental schedule	VLDL				LDL				HDL			
	TC (mg/dl)	PL (mg/dl)	TG (mg/dl)	Apo-protein (mg/dl)	TC (mg/dl)	PL (mg/dl)	TG (mg/dl)	Apo-protein (mg/dl)	TC (mg/dl)	PL (mg/dl)	TG (mg/dl)	Apo-protein (mg/dl)
Control	7.98	17.11	38.17	7.15	16.17	12.28	20.17	17.33	52.83	40.97	13.77	178.13
	±0.63	±1.98	±3.95	±1.04	±1.78	±1.11	±1.11	±1.61	±3.80	±3.35	±1.43	±11.34
Alloxan treated	12.19***	20.72***	74.76***	8.11*	68.68***	17.59***	47.21***	21.55*	38.71***	31.52***	13.00*	127.42***
	±1.20	±2.48	±5.70	±0.57	±8.65	±1.43	±6.29	±1.46	±3.75	±2.27	±1.28	±12.33
	(+53)	(+21)	(+96)	(+13)	(+32)	(+43)	(+134)	(+24)	(-27)	(-23)	(-5)	(-28)
Alloxan + *Cassia tora seed* extract	8.52***	17.98*	54.29***	7.36NS	40.51***	13.41*	28.66**	18.80NS	42.52NS	32.82NS	13.25NS	146.80*
	±0.99	±1.51	±4.85	±6.80	±3.46	±0.90	±4.28	±1.44	±4.41	±2.90	±1.25	±13.27
	(-30)	(-13)	(-27)	(-9)	(-41)	(-24)	(-39)	(-13)	(+10)	(+4)	(+7)	(+15)
Alloxan+ glibenclamide	9.04	19.30NS	51.02***	7.30NS	43.33***	17.44NS	29.24**	18.70NS	40.12NS	32.12NS	13.59NS	140.96NS
	±0.96*	±2.39	±5.62	±0.86	±3.80	±1.40	±4.36	±1.52	±4.22	±1.55	±1.28	±12.41
	(-26)	(-8)	(-32)	(-9)	(-37)	(-7)	(-38)	(-13)	(+ 4)	(+4)	(+5)	(+11)

Values are expressed as mean ± SD of 6 animals. Values in the parenthesis indicate percent change. Alloxan-treated group was compared with control, alloxan and drug-treated groups with alloxan. ***p<0.001, **p<0.01, *p<0.05, NS= Non significant

Effect of *C. tora* seed extract on hepatic SOD, CAT, TGL, LPL and reduced GSH in alloxan-induced diabetic rats:

The data in **Table 3** shows that administration of alloxan in rats decreases the levels of SOD 33%, CAT 25%, TGL 21% and LPL 31% and depletion of GSH 45% respectively. Treatment with *C. tora* seed extract for 15 days reactivates SOD 40% , CAT 24 %, TGL 17% LPL 29% and recovered GSH 35%. Glibenclamide increases the levels of SOD 26% , CAT 16%, TGL 17 %, LPL 23% and recovered GSH 41 % respectively) (**Table 3**).

TABLE 3: EFFECT OF *CASSIA TORA SEED* EXTRACT ON HEPATIC SOD, CAT, TGL, LPL AND GSH IN ALLOXAN-INDUCED DIABETIC RATS

Experimental schedule	SOD (Unit /min /mg protein)	CAT (Unit /min /mg protein)	TGL (n mol FFA released/hr/mg protein)	LPL (n mol FFA released/hr/mg protein)	Reduced glutathione µmoleGSH/g
Control	3.21±0.20	3855±248.17	75.11±5.78	95.69±7.71	5.23±0.58
Alloxan treated	2.14±0.16***	2873±402.08***	59.63±4.62**	66.36±5.46**	2.75±0.32***
	(-33)	(-25)	(-21)	(-31)	(-47)
Alloxan + *C. tora seed* extract	3.00±0.13***	3550±504.59***	69.71±4.88*	85.34±9.79***	3.71±0.48***
	(+40)	(24+)	(+17)	(+29)	(+35)
Alloxan + *Glibenclamide*	2.70±0.13***	3342±482.02*	69.85±7.08*	81.89±8.68**	3.87±0.50***
	(+26)	(+16)	(+17)	(+23)	(+41)

Values are expressed as mean ± SD of 6 animals. Values in the parenthesis indicate percent change. Alloxan-treated group was compared with control, alloxan and drug-treated groups with alloxan. ***p<0.001, **p<0.01, *p<0.05, NS= Non significant.

Effect of *C. tora* seed extract on faecal bile acids, plasma LCAT, PHLA in alloxan induced diabetic rats: Administration of alloxan in rats markedly decreased in the levels of cholic acid 28% and deoxycholic acid 35% in feces, as well as LCAT 33% and PHLA 28%, in plasma. The treatment with *C. tora* seed extract for 15 days increased the levels of cholic acid 25% and deoxycholic acid 62% in feces and LCAT 51.0 % and PHLA 39 % in plasma of alloxan induced

diabetic rats. Glibenclamide decreased the levels of cholic acid 28% and deoxycholic acid 26% in feces and also LCAT 28% and PHLA 18% in plasma (**Table 4**).

TABLE 4: EFFECT OF *C. TORA SEED* EXTRACT ON FAECAL BILE ACIDS, PLASMA LECITHIN CHOLESTEROL ACYLTRANSFERASE AND PLASMA POST-HEPARIN LIPOLYTIC ACTIVITIES IN ALLOXAN-INDUCED DIABETIC RATS

Experimental schedule	Faecal bile acids		Plasma lecithin cholesterol acyl transferase activity (n mol Cholesterol released/hr/l)	Plasma post -heparin lipolytic activity (n mol FFA formed/h/l)
	Cholic acid (µg/g feces)	Deoxycholic acid (µg/g feces)		
Control	74.31±6.80	54.76±11.30	61.58±4.90	15.29±1.78
Alloxan-treated	53.68 ± 6.49*** (-28)	35.34±7.83*** (-35)	41.04±3.76*** (-33)	10.96 ± 0.98** (-28)
Alloxan + *C. tora seed* extract (500 mg/kg b.w.)	67.08 ± 1.76** (+25)	57.36 ± 11.36*** (+62)	62.17 ± 4.92** (+51)	15.19 ± 1.19* (+39)
Alloxan + Glibenclamide (600 µg/kg b.w.)	68.67 ± 3.81** (+28)	44.61 ± 2.08** (+26)	53.32 ± 1.23** (+28)	12.95 ± 1.16** (+18)

Values are expressed as mean ± SD of 6 animals. Values in the paranthesis indicate percent change. Alloxan-treated group was compared with control, alloxan and drug-treated groups with alloxan. ***p<0.001, **p<0.01, *p<0.05.

DISCUSSION: In the present study, seed of *C. tora* were tested for their anti-dyslipidemic and antioxidant activities in alloxan induded diabetic rats. Alloxan causes reversible damage to insulin producing β-cells found in the pancreas, and that is why this animal model have been used for primary screening of test drug for anti dyslipoproteineic activities. In the present study we found that, intoxication with alloxan caused increased levels of TC, PL, TG, FFA, LPO as well as decrease in protein. The analysis of the lipid and apoprotein components of β lipoproteins showed that alloxan intoxication in rats also caused significant increase in TC, PL, TG and Apoproteins components of VLDL and LDL. On the other hand levels of TC, PL, TG and Apoproteins components were decreased in HDL. Due to alloxan intoxication levels of SOD, CAT, TGL, LPL and GSH were also decreased.

Fecal bile acids, LCAT, PHLA were also decreases by alloxan. Similar observations were reported by others. Lipases play a significant role in lipoprotein metabolism and decreased lipoprotein lipases activities in diabetes are main cause of atherosclerosis [23]. However, treatment with *C. tora* seed extract for 15 days reversed these effects.

beneficial effects may be due to bioactive compounds like typical alkaloids, anthraquinones, chrysophanol, emodin, rhein, euphol, bas-seol

The abnormal high concentration of serum lipid in diabetes is mainly due to the increase in the mobilization of free fatty acid from the peripheral depots, since insulin inhibits the hormone sensitive lipase [24]. On the other hand, glucagons, catecholamine and other hormones enhance lipolysis. The marked hyperlipidemia that characterizes the diabetic state may, therefore, be regarded because of the unregulated actions of lipolytic hormones on the fat depots [25]. *C. tora* and glibenclamide both caused a significant decrease in the plasma levels of TC, TG, PL and FFA in alloxan-induced hyperglycemia. In alloxan induced diabetic rats, *C. tora* seed extract could increased the level of HDL by increasing the activity of LCAT, which might contribute to the regulation of blood lipids.

LCAT play a key role in lipoprotein metabolism and most of the lipoprotein changes are the outcome of primary abnormality owing to the diseases related with lipid metabolism [6]. *C. tora* seed extract enhanced the excretion of bile acids through feces and this contributed to regress the cholestesteosis in liver damage. In conclusion, the lipid lowering activity of *C. tora* might be due to inhibition of hepatic cholesterol biosynthesis, activation of tissue lipases, SOD, CAT and these phenolic glycosides namely: ru- brofusarine triglucoside, nor-rubrofusarin gentiobioside, demethyl flavasperone gentiobioside, torochrysone

gentio- bioside, torachrysone tetra- glucoside and torachrysone apioglucoside [23]

ACKNOWLEDGEMENT: One of us (Vishnu Kumar) is grateful to the director, CDRI, Lucknow for experimental support, Director Academics, Era's Lucknow Medical College and Hospital, Lucknow for financial support and late Dr Ramesh Chander, Retired Scientist, Central Drug Research Institute, Lucknow for their expert guidance and scientific support.

REFERENCES:

1. Awasthi VK , Mahdi F, Chander R, Khanna AK, Saxena JK, Singh R, Mahdi AA, Singh RK: Hypolipidemic activity of *Cassia tora* seed in hyperlipidemic rats. Indian Journal of Clinical Biochemistry 2015; 30(1): 78-83.
2. Pawar HA, D'mello PM: *Cassia tora* Linn: An Overview. International Journal of Pharmaceutical Science & Research 2011; 2(9): 2286-2291.
3. Chaurasia B, Dhakad RS, Dhakar VK, Jain PK: Preliminary Phytochemical and pharmacological (Antidiabetic) screening of Cassia tora Linn International Journal of Pharmacy & Life Sciences 2011; 2(5):759-766.
4. Shakywar Y, Jain A , Verma M , Panwar AS, Agarwal A: Pharmacognostical Properties and their Traditional Uses of *Cassia tora* Linn. International Journal of Pharmaceutical & Biological Archives 2011; 2(5):1311-1318.
5. Kumar V, Singh P, Chander R, Mahdi F, Singh S, Singh R, Khanna AK, Saxena JK, Mehdi AA, Singh VK and Singh RK. Hypolipidemic activity of *Hibiscus rosa sinensis* roots in alloxan induced diabetic rats. Indian Journal of Biochemistry & Biophysics 2009; 46: 507-510.
6. Kumar V , Mahdi F , Chander R , Singh R , Mahdi AA, Khanna AK, Bhatt S, Kushwaha RS, Jawad K, Saxena JK , Singh RK: Hypolipidemic and antioxidant activity of *Anthocephalus indicus* (KADAM) root extract. Indian J Biochem & Biophysics 2010; 47: 104-109.
7. Burstein M & Legmann P: Lipoprotein precipitation in monographs as atherosclerosis, *Ed., Clarkson* TB London, Paris, New York. S. Karger. 1982; II Ed, 78 -93.
8. Zlatkis A, Zak B & Boyle AJ: A new method for the direct determination of serum cholesterol Journal of Laboratory & Clinical Medicine 1953; 41, 486-492.
9. Van Handel SE & Zilversmit DB: Micro method for direct determination of serum triglycerides. Journal of Laboratory & Clinical Medicine 1957; 50, 152-157.
10. Zilversmith DB, Davis DK: Micro determination of plasma phospholipids by trichloroacetic acid precipitation. Journal of Laboratory & Clinical Medicine: 1950; 35: 155-160.
11. Radding CM and Steinberg D: Studies on the synthesis and secretion of serum lipoproteins by rat liver slices. Journal Clinical Investigation 1960; 39: 1560-1569.
12. Ohkawa H, Ohisha N and Yagi K: Assay for lipid peroxides in animal tissue by thiobarbituric reactions. Annals of Biochemistry 1979; 95: 351-360.
13. Mosinger F: Photometric adaptation of Dole's microdetermination of free fatty acids. Journal of lipid Research 1965; 6:157-9.
14. Lowry OH, Rosebrough NJ, Farr AL, Randall RJ. Protein measurement with folin phenol reagent. Journal of Biological Chemistry1951; 183: 265-272.
15. Nagasaki T & Akanuma Y: A new colorimetric method for the determination of plasma lecithin: cholesterol acyltransferase activity. Clinical Chemiei Acta 1977; 75: 371-375.
16. Wing DR, Robinson DC: Clearing factor lipase in adipose tissue. A possible role of adenosine 3', 5'-(cyctic) – monophosphate in the regulation of its activity. Biochemistry Journal 1968; 109: 841-849.
17. Mayes PA & Felts J M: The functional status of lipoprotein lipase in rat liver Biochemistry Journal 1968*;* 108: 483-487.
18. Mc Cord JM, Fridovich I: Superoxide dismutase, an enzyme function for erythrocuprin (hemocuprin). Journal of Biological Chemistry 1969; 244: 6049-55.
19. Aebi H, Heiniger JP, Lanber E: Catalase in vitro. Helv. Chim. Acta. 1964; 47: 1428.
20. Ellman GL: Tissue sulfhydryl groups. Arch Biochemistry 1959; 82:70-77.
21. Mosbach EH, Klenisky HJ, Hal P, Kendall FE: Determination of deoxycholic acid and Cholic acid in bile. Archive of Biochemistry and Biophysics 1954; 5: 402-409.
22. Woodson RF: Statistical Methods for the analysis of Biochemical Data. Chichester: Wiley 1957; pp. 315.
23. Kumar V, Mahdi F, Chander R, Husain I, Khanna AK, Singh R, Saxena JK, Mahdi AA and Singh RK: *Tinospora cordifolia* regulates lipid metabolism in allaxon induced diabetes in rats. International Journal of Pharmacy & Life Sciences 2013; 4(10): 3010-3017.
24. Seidel D & Wall A In: Landman L & Staddler GA: Liver in metabolic disease MIP Press, Lancaster, England 1983; 81-95.
25. Gulia Y, Choudhary M: Antiulcer activity of hydro alcoholic extract of *Cassia tora* linn using ethenol induced ulcer. International Journal of Pharmacy and Pharmaceutical Sciences 2012; 4(2): 160-163.

How to cite this article:
Kumar V, Mahdi F, Singh R, Mahdi AA, Jawad K, Singh RK and Singh M: *Cassia Tora* Seeds Extract Regulates Lipid Metabolism in Alloxan Induced Diabetic Rats. Int J Pharm Sci Res 2015; 6(8): 3484-89.doi: 10.13040/IJPSR.0975-8232.6(8).3484-89.