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Evaluation of antihepatotoxic potential of *Solanum xanthocarpum* fruit extract against antitubercular drugs induced hepatopathy in experimental rodents

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ABSTRACT

Objective: To assess the hepatoprotective effect of *Solanum xanthocarpum* (*S. xanthocarpum*) fruit extract against antitubercular drug-induced liver toxicity in experimental animals. **Methods:** Ethanolic (50%) fruit extract of *S. xanthocarpum* (100, 200 and 400 mg/kg bw) was administered daily for 35 days in experimental animals. Liver toxicity was induced by combination of three antitubercular drugs [isoniazid (I) 7.5 mg/kg, rifampicin (R) 10 mg/kg and pyrazinamide (P) 35 mg/kg] given orally as suspension for 35 days in rats. The hepatoprotective activity was assessed using various biochemical parameters like aspartate aminotransferase (AST), alanine aminotransferase (ALT), alkaline phosphatise (ALP), total bilirubin (TBL), albumin (ALB), total protein (TP), lactate dehydroginase (LDH), and serum cholesterol (CHL). Meanwhile, *in vivo* antioxidant activities as lipid peroxidation (LPO), reduced glutathione (GSH), superoxide dismutase (SOD) and catalase (CAT) were measured in rat liver homogenate. The biochemical observations were supplemented by histopathological examination. **Results:** The results demonstrated that treatment with *S. xanthocarpum* significantly ($P<0.05$-$P<0.001$) and dose-dependently prevented drug induced increase in serum levels of hepatic enzymes. Furthermore, *S. xanthocarpum* significantly (up to $P<0.001$) reduced the LPO in the liver tissue and restored activities of defence antioxidant enzymes GSH, SOD and CAT towards normal levels. Histopathology of the liver tissue showed that *S. xanthocarpum* attenuated the hepatocellular necrosis and led to reduction in inflammatory cells infiltration. **Conclusions:** The results of this study strongly indicate the protective effect of *S. xanthocarpum* against liver injury which may be attributed to its hepatoprotective activity, and thereby scientifically support its traditional use.

1. Introduction

Liver diseases are one of the most serious health problems in the world today but, despite tremendous advances in modern medicine, their prevention and treatment options still remain limited. However, the pathogenesis of hepatic diseases as well as the role of oxidative stress and inflammation therein is well established[1,2], and accordingly, blocking or retarding the chain reactions of oxidation and inflammation process could be a promising therapeutic strategy for prevention and treatment of liver injury. By virtue of its unique vascular and metabolic features, the liver is exposed to absorbed drugs and xenobiotics in concentrated form. Detoxification reactions (phase I and phase II) metabolize xenobiotics with the aim of increasing substrate hydrophilicity for excretion. Drug-metabolizing enzymes detoxify many xenobiotics but bioactivate or increase the toxicity of others. In the case of bioactivation, liver is the first organ to be exposed to the damaging effects of the newly formed toxic substance. Therefore, protective mechanisms relevant to the liver are of particular interest. Effectively, herbal products are widely

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used in the treatment of hepatic disorders all over the world[3,4].

Solanum xanthocarpum (*S. xanthocarpum*) Schrad. & Wendl. (family: Solanaceae) commonly known as yellow berried nightshade (synonym: Kantakari), is a prickly diffuse bright green perennial herb, woody at the base, 2-3 m height found throughout India, mostly in dry places as a weed on road sides and waste lands. The fruits are of 1.3 cm diameter berry, yellow or white with green veins, surrounded by enlarged calyx[5]. The fruits are known for several traditional medicine uses like anthelmintic, wound healing[6], antipyretic, laxative, antiinflammatory, urinary bladder, antiasthmatic, aphrodisiac activities and enlargement of the liver[7]. The stem, flowers and fruits are prescribed for relief in burning sensation in the feet accompanied by vesicular eruptions[8].

The fruits are reported to contain several steroidal alkaloids like solanacarpine, solanacarpidine, solancarpine, solasonine, solamargine and other constituents like caffeic acid, coumarins like aesculetin and aesculin, steroids carpesterol, diosgenin, campesterol, daucosterol and triterpenes like cycloartanol and cycloartenol[9].

The antispasmodic, cardiotonic, hypotensive, antianaphylactic, arbuda tumour[10], anti-urolithiatic and natriuretic activities were also reported[11]. Solasodine is present in a number of *Solanum* species (Solanaceae) such as *Solanum khasianum*, *Solanum xanthocarpum*, *Solanum nigrum*, *Solanum gracile*, *Solanum laciniatum*, *etc*[12]. Lupeol, apigenin and solamergine exhibited solasodine anticancer property[13], anti-nociceptive[14], antioxidant activities of the chloroform extract[15], and hypoglycaemic activity[16].

The flavanoids quercitrin and apigenin glycosides are the major chemical constituents which are present in the fruits of *S. xanthocarpum*[17]. To the best of our knowledge there was lack of scientific reports available in support of its traditional claim of hepatoprotective potential. So far, there has been only one research report on hepatoprotective effect against paracetamol[18]. Therefore, the present study was designed to demonstrate the hepatoprotective effect of *S. xanthocarpum* fruit extract against antitubercular drug induced hepatic damage in experimental animals.

2. Materials and methods

2.1. Chemicals

All the chemicals used were of analytical grade and procured from Sigma chemicals Co., USA and Qualigens fine chemicals, Mumbai, India.

2.2. Preparation of plant extract

Fresh and matured fruits were collected from campus garden of National Botanical Research Institute, Lucknow, India in November 2010. The plant material was identified and authenticated and the voucher specimen number NAB-79023 was deposited in the institutional herbarium. The freshly collected fruits (2 kg) of *S. xanthocarpum* were dried and powdered. The powdered plant material (900 g) was macerated with petroleum ether, the marc was exhaustively extracted with of 50% ethanol for three days. The extract was separated by filtraction and concentrated on rotavapour (Buchi,USA) and then dried in lyophilizer (Labconco,USA) under reduced pressure. The yield obtained was 198.40 g of solid residue (yield 22.04% w/w). The extract obtained was further subjected to preliminary phytochemical screening and pharmacological investigation.

2.3. Animals

Wistar rats weighing (150-170 g) and Swiss albino mice (25-30 g) of either sex were procured from CDRI, Lucknow. They were kept in departmental animal house in well cross ventilated room at (23±2 ℃) with light and dark cycles of 12 h for 1 week before and during the experiments. Animals were provided with standard rodent pellet diet (Amrut, India) and the food was withdrawn 18-24 h before the experiment though water was given *ad libitum*. All studies were performed in accordance with the guide for the care and use of laboratory animals, as adopted and promulgated by the Institutional Animal Care Committee, CPCSEA, India (Reg. No. 222/2000/CPCSEA).

2.4. Acute oral toxicity studies

Acute toxicity study was performed according to OECD guidelines No. 423[19]. Swiss albino mice of either sex were divided into six groups with six animals in each group. *S. xanthocarpum* was administered orally as a single dose to mice at different dose levels of 250, 500, 1 000, 1 500 and 2 000 mg/kg bw. Animals were observed periodically for the symptoms of toxicity and death within 24 h and then daily for 14 days.

2.5. Experimental protocol

The rats were divided into six groups with six in each group. Group I received saline and served as healthy control. Group II rats were administered in a combination of three anti-tubercular drugs [isoniazid-7.5 mg/kg, rifampicin-10 mg/kg and pyrazinamide-35 mg/kg] for 35 days by intra-gastric administration[20] in normal saline which severed as disease control while rats in group III, IV and V received orally 100, 200 and 400 mg/kg bw *S. xanthocarpum*o, respectively, 45 min prior to antitubercular drugs challenge for 35 days. Group VI rats received silymarin, the known hepatoprotective compound (Sigma Chemicals Company,USA), at a dose of 100 mg/kg, p.o., daily for 35 days, 45 min prior to antitubercular drugs challenge as a reference[21]. After the experimental period, all animals were sacrificed. The liver was dissected and blood was collected from the inner canthus of the eye.

2.6. Assessment of hepatoprotective activity

The collected blood was allowed to clot and serum was separated at 2 500 rpm for 15 min and the biochemical

parameters like serum enzymes: aspartate aminotransferase (AST, U/L), alanine aminotransferase (ALT, U/L)[22], alkaline phosphatase (ALP, U/L)[23], total bilirubin (TBL, mg/dL)[24], albumin (ALB, g/dL)[25], total protein (TP, g/dL)[25], lactate dehydroginase (LDH, U/L)[26] and total cholesterol (CHL, g/dL)[27] were assayed using assay kits.

2.7. Assessment of antioxidant parameters

2.7.1. Assessment of lipid peroxidation (LPO)

The dissected out liver samples were washed immediately with ice cold saline to remove as much blood as possible. Liver was homogenized (5%) in ice cold 0.9% NaCl with a Potter-Elvenhjem glass homogenizer. The homogenate was centrifuged at 800 for 10 min and the supernatant was again centrifuged at 12 000 for 15 min and the obtained mitochondrial fraction was used for the estimation of LPO[28]. A volume of the homogenate (0.2 mL) was transferred to a vial and was mixed with 0.2 mL of 8.1% (w/v) sodium dodecyl sulphate solution, 1.5 mL of 20% acetic acid solution (adjusted to pH 3.5 with NaOH) and 1.5 mL of 0.8% (w/v) solution of thiobarbituric acid (TBA) and the final volume was adjusted to 4.0 mL with distilled water.

Each vial was tightly capped and heated in a boiling water bath for 60 min. The vials were then cooled under running water. Equal volumes of tissue blank or test samples and 10% TBA were transferred into a centrifuge tube and centrifuged at 1 000 g for 10 min. The absorbance of the supernatant fraction was measured at 532 nm (Beckman DU 650 spectrometer). Control experiment was processed using the same experimental procedure except the TBA solution was replaced with distilled water[29]. Malonyldialdehyde (MDA) is an end product of LPO, which reacts with TBA to form pink chromogen TBA reactive substance. 1,1,3,3-tetra ethoxypropan was used as standard for calibration of the curve and was expressed as nmole/mg protein.

2.7.2. Assessment of catalase (CAT) and superoxide

The liver tissue was homogenized (5%) and mitochondrial fraction was prepared as described above. Decomposition of H_2O_2 in presence of CAT was followed at 240 nm[30]. One unit (U) of CAT was defined as the amount of enzyme required to decompose 1 μmol of H_2O_2 per min, at 25 ℃ and pH 7.0. Results were expressed as units (U) of CAT activity/mg protein. Superoxide dismutase (SOD) activity was estimated by the inhibition of nicotinamide adenine dinucleotide reduced)-phenazine methosulphate-nitrobluetetrazolium reaction system as described by Nishikimi *et al*[31] and as adapted by Kakkar *et al*[32]. One unit of the enzyme is equivalent to 50% inhibition in the formazan formation in 1 min at room temperature (25±2 ℃) and the results were expressed as units (U) of SOD activity/mg protein.

2.7.3. Assessment of reduced glutathione (GSH) activity

The concentration of GSH was determined by the method of Anderson[33] based on the development of a yellow color when 5,5-dithiobis (2-nitrobenzoic acid) was added to compounds containing sulfhydryl groups. The reaction mixture contained equal volumes of 4% sulfosalicylic acid and tissue samples were homogenized in 4 volume of ice cold 0.1 mL phosphate buffer (pH 7.4). The method used for estimating GSH in this study also measured non-protein sulfhydryl concentration inclusive of GSH. However, 80%-90% of the non-protein sulfhydryl content of the cell represents free endogenous GSH. Enzyme activity was expressed as mg/100 g[34].

2.8. Histopathological studies

For histological studies, the liver tissues were fixed with 10% phosphate buffered neutral formalin, dehydrated in graded (50-100%) alcohol and embedded in paraffin. Thin sections (5 μm) were cut and stained with routine hematoxylin and eosin (H & E) stain for photo microscopic assessment. The initial examination was qualitative, with the purpose of determining histopathological lesions in liver tissue.

2.9. Statistical analysis

The values were represented as mean±SEM for six rats. Analysis of variance (ANOVA) test was followed by individual comparison by Newman-Keuls test using Prism Pad software (Version 3.0) for the determination of level of significance. The values of $P<0.05$ were considered statistically significant.

3. Results

3.1. Acute toxicity studies

S. xanthocarpum produced no mortality at 2 000 mg/kg. Therefore, one-tenth of the maximum, no mortality dose of extract as therapeutic middle dose (200 mg/kg) and just double as well as half dose of it as the highest (400 mg/kg) and the lowest dose (100 mg/kg), respectively, were selected in this study.

3.2. Effect of S. xanthocarpum on serum AST, ALT, ALP, TBL, ALB, TP, LDH and CHL levels

The effects of various doses of *S. xanthocarpum* were studied on serum marker enzymes and total bilirubin in antitubercular drugs intoxicated animals. Hepatic injury induced by antitubercular drugs caused significant change in marker enzyme as AST by 280.27%, ALT by 384.34%, ALP by 141.95%, TBL by 367.12%, ALB by 38.70%, TP by 38.24%, LDH by 69.51% and CHL by 113.32% compared to control group. The percentages protection in marker enzyme of treated groups at 100, 200 mg/kg were as follows: AST 5.21 ($P<0.05$), 33.98 ($P<0.001$), ALT 8.22 ($P<0.05$), 55.28 ($P<0.001$), ALP 15.44 ($P<0.01$), 47.84 ($P<0.001$), TBL 26.98 ($P<0.01$), 65.98 ($P<0.001$), ALB 5.32 ($P<0.01$), 28.24 ($P<0.001$), TP 2.14 (ns), 32.38 ($P<0.001$), LDH 1.83 ($P<0.01$), 13.99 ($P<0.001$), and CHL 4.22 (ns), 20.87 ($P<0.001$) when compared to toxic group while maximum percentage protection in marker enzyme

Table 1

Effect of *S. xanthocarpum* on serum AST (U/L), ALT (U/L), ALP (U/L), TBL (mg/dL), ALB (g/dL), TP (g/dL), LDH (U/L) and CHL (g/dL) against R+I+P induced hepatopathy in rats (mean±SEM) (n=6).

Groups	AST	ALT	ALP	TBL	ALB	TP	LDH	CHL
Control	102.26±5.13	49.81±4.22	69.23±4.88	0.73±0.16	4.91±0.04	6.80±0.07	421.35±2.01	33.34±2.40
R+I+P	388.86±6.20***	241.25±8.80***	167.57±6.50***	3.41±0.39***	3.01±0.04***	4.20±0.03***	714.21±3.10***	71.12±3.20***
SXE 100	368.61±5.62[a]	221.41±7.24[a]	141.69±6.21[b]	2.49±0.14[b]	3.17±0.02[b]	4.29±0.01[n]	701.12±3.00[b]	68.12±2.80[n]
SXE 200	256.73±6.87[c]	107.89±6.46[c]	87.41±4.61[c]	1.16±0.11[c]	3.86±0.02[c]	5.56±0.03[c]	614.33±3.10[c]	56.28±2.70[c]
SXE 400	122.37±5.54[c]	57.27±5.33[c]	72.65±6.64[c]	0.85±0.14[c]	3.97±0.01[c]	5.89±0.02[c]	516.21±3.00[c]	45.12±2.00[c]
Silymarin	109.89±4.43[c]	52.84±4.72[c]	68.34±6.21[c]	0.83±0.13[c]	4.68±0.05[c]	6.22±0.12[c]	504.23±3.94[c]	36.12±1.90[c]

[n]: non significant; ***: P<0.001 compared with respective control group I; [a]: P<0.05, [b]: P<0.01, [c]: P<0.001 compared with group II (R+I+P); SXE: *S. xanthocarpum*; R: rifampicin; I: isoniazid; P: pyrazinamide.

at the dose of 400 mg/kg and silymarin (100 mg/kg) as AST 68.53 (P<0.001), 71.74 (P<0.001), ALT 76.26 (P<0.001), 78.10 (P<0.001), ALP 56.65 (P<0.001), 59.22 (P<0.001), TBL 75.07 (P<0.001), 75.66 (P<0.001), ALB 31.89 (P<0.001), 55.48 (P<0.001), TP 40.24 (P<0.001), 48.10 (P<0.001), LDH 27.72 (P<0.001), 29.40 (P<0.001), and CHL 36.56 (P<0.001), 49.21 (P<0.001) which is almost comparable to the group treated with silymarin, a potent hepatoprotective drug used as reference standard (Table 1).

3.3. Estimation of LPO, GSH, SOD and CAT

The results in Figure 1 showed clear significant percentage change in the antioxidant levels of LPO in antitubercular drugs intoxicated rats as 322.58 (P<0.001) compared to control group. Treatment with *S. xanthocarpum* at the doses of 100, 200 and 400 mg/kg significantly prevented this heave in levels and the percentages protection in LPO were 38.16 (P<0.05), 53.43 (P<0.01) and 74.80 (P<0.001), respectively. The GSH, SOD and CAT content had significantly increased in *S. xanthocarpum* treated groups whereas antitubercular drugs intoxicated group had shown significant decrease in these parameters compared to control group.

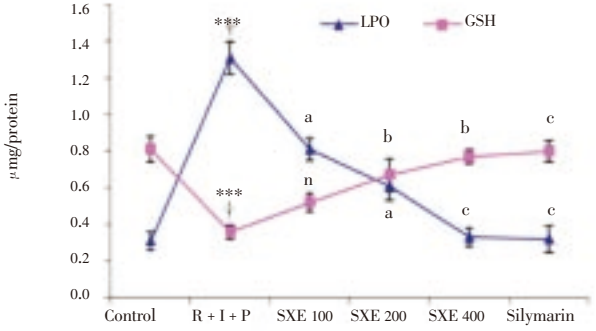

Figure 1. Effect of *S. xanthocarpum* on liver LPO (MDA nmole/min/mg of protein) and GSH (nmole/mg of protein) against R+I+P induced liver toxicity in rats.

Values are mean±SEM of 6 rats in each group. n: non significant; ***: P<0.001 compared with respective control group I; a: P<0.05, b: P<0.01, c: P<0.001 compared with group II (R+I+P); SXE: *S. xanthocarpum*; R: rifampicin; I: isoniazid; P: pyrazinamide.

The percentages changed of GSH, SOD and CAT in antitubercular drugs intoxicated group were as 55.55 (P<0.001), 66.14 (P<0.001) and 40.27 (P<0.001), respectively. Figure 2 explained the percentages protection in GSH as 44.44 (ns), 86.11 (P<0.05), 113.88 (P<0.01) and SOD 33.43 (ns), 84.69 (P<0.05), 159.91 (P<0.001) while in CAT 13.10 (ns), 35.10 (P<0.05), 43.01 (P<0.01) at the doses levels 100, 200 and 400 mg/kg, respectively. In different doses level of *S. xanthocarpum*, 400 mg/kg showed maximum protection which was almost comparable to those of the normal control and silymarin.

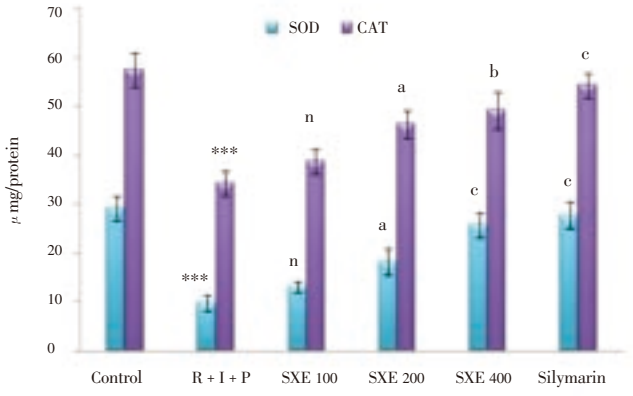

Figure 2. Effect of *S. xanthocarpum* on liver SOD (unit/mg of protein) and CAT (units/mg of protein) against R+I+P induced liver toxicity in rats.

Values are mean±SEM of 6 rats in each group. n: non significant; ***: P<0.001 compared with respective control group I; a: P<0.05, b: P<0.01, c: P<0.001 compared with group II (R+I+P); SXE: *S. xanthocarpum*; R: rifampicin; I: isoniazid; P: pyrazinamide.

3.4. Histopathological observations

The histological observations basically supported the results obtained from serum enzyme assays. Liver section in normal control rats showed central vein surrounded by hepatic cord of cells while antitubercular drugs treated rats liver section showed liver cell necrosis with inflammatory collections and loss of cellular boundaries. Whereas the *S. xanthocarpum* treated groups showed absence of cell necrosis, but with minimal inflammatory conditions. The *S. xanthocarpum* 400 mg/kg, p.o. treated group showed regeneration of hepatocytes around central vein with near normal liver architecture possessing higher hepatoprotective action (Figure 3).

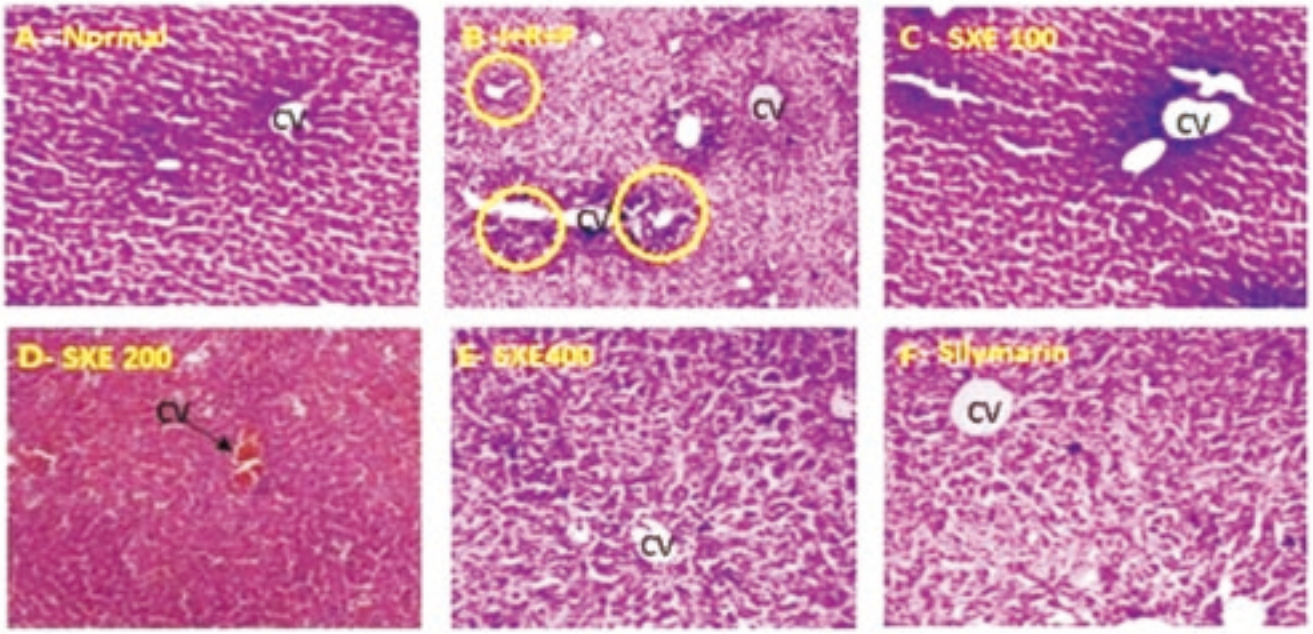

Figure 3. Histopathology of liver tissues.
A: Liver section of normal control rat showing central vein surrounded by hepatic cord of cells (normal architecture); B: Liver section of antitubercular drugs treated rats showing massive fatty changes, focal necrosis with portal inflammation and loss of cellular boundaries (indicated by circle); C: Liver section of rats treated antitubercular drugs and 100 mg/kg of SXE showing mild focal necrosis with sinusoidal dilatation; D: Liver section of rats treated antitubercular drugs and 200 mg/kg of SXE showing less inflammatory cells, absence of necrosis and slight congestion in central vein; E: Liver section of rats treated antitubercular drugs and 400 mg/kg of SXE showing regeneration of hepatocytes around central vein toward near normal liver architecture; F: Liver section of rats treated antitubercular drugs and 100 mg/kg of silymarin showing normal liver architecture; SXE: *S. xanthocarpum*; R: rifampicin; I: isoniazid; P: pyrazinamide.

4. Discussion

In the present investigation, *S. xanthocarpum* was evaluated for the hepatoprotective activity using antitubercular drugs induced liver toxicity in rat. Drug-induced liver toxicity is a potentially serious adverse effect of the currently used antitubercular chemotherapeutic regimens containing isoniazid, rifampicin and pyrazinamide. All these drugs are potentially hepatotoxic independently, when given in combination their toxic effects are enhanced in a synergistic manner. The conversion of monoacetyl hydrazine, a metabolite of isoniazid, to a toxic metabolite *via* cytochrome P450 leads to hepatotoxicity. Rifampicin induces cytochrome P450 enzyme causing an increased production of toxic metabolites from acetyl hydrazine (AcHz). Rifampicin can also increase the metabolism of isoniazid to isonicotinic acid and hydrazine, both of which are hepatotoxic. The plasma half life of AcHz (metabolite of isoniazid) is shortened by rifampicin and AcHz is quickly converted to its active metabolites by increasing the oxidative elimination rate of AcHz, which is related to the higher incidence of liver necrosis caused by isoniazid and rifampicin in combination[35,36]. Pyrazinamide, in combination with isoniazid and rifampicin is also, associated with an increased incidence of hepatotoxicity[37].

In addition to these mechanisms, oxidative stress induced hepatic injury is one of the important mechanisms in hepatotoxicity produced by antitubercular drugs[38]. The results of the present study suggested that *S. xanthocarpum* possesses hepatoprotective activity against the hepatotoxicity induced by the combination of three antitubercular drugs. The present study revealed a significant increase in the level of AST, ALT, ALP, TBL, LDH, CHL while decrease in ALB and TP levels of group II on exposure to antitubercular drugs, indicating considerable hepatocellular injury. Elevated levels of these enzymes in serum are presumptive markers of drug induced necrotic lesions in the hepatocytes[39]. Enhanced susceptibility of hepatocytes cell membrane to antitubercular drugs induced peroxidative damage might have resulted in increased release of these diagnostic marker enzymes into the systemic circulation[40]. The activities of ALT and AST are sensitive indicators of acute hepatic necrosis, and the ALP level is known to be indicative of hepatobiliary disease[41].

Administration of *S. xanthocarpum* at different doses (100, 200 and 400 mg/kg) attenuated the increased levels of the serum enzymes, produced by antitubercular drugs and caused a subsequent recovery towards normalization comparable to the control group I animals. The hepatoprotective effect of the *S. xanthocarpum* was further accomplished by the histopathological examinations. *S. xanthocarpum* at different dose levels offers hepatoprotection, but 400 mg/kg is more effective than all other lower doses. As an alternative to induce cellular damage by covalent binding, there is evidence that these antitubercular drugs cause cellular damage through the induction of oxidative stress, a consequence of dysfunction of hepatic antioxidant defence system. The role of oxidative stress in the mechanism of antitubercular drugs induced hepatitis has been reported by Attri *et al*[42]. The body has

an effective defence mechanism to prevent and neutralize the free radical induced damage. This is proficient by a set of endogenous antioxidant enzymes such as SOD, and CAT. These enzymes constitute a mutually supportive team of defence against reactive oxygen species (ROS)[43]. The significantly reduced activities of SOD and CAT observed point out the hepatic damage in the rats administered with antitubercular drugs but treatment with 100, 200 and 400 mg/kg of *S. xanthocarpum* groups showed significant increase in the level of these enzymes which indicates the antioxidant activity of the *S. xanthocarpum*. Many antibiotics therapy can favour free radical production and cause cellular damage[44]. The combination of antitubercular treatment (isoniazid+rifampicin+pyrazinamide) in experimental animals enhanced lipid peroxidation, indicating increased oxidative stress in liver[45]. Increase in the level of lipid peroxides in liver reflected the hepatocellular damage. The depletion of antioxidant defences and/or raise in free radical production deteriorates the prooxidant-antioxidant balance, leading to oxidative stress-induced cell death[46-53]. Depletion of GSH is known to result in enhanced lipid peroxidation and excessive lipid peroxidation can cause increased glutathione consumption[54], as observed in the present study.

Furthermore, treatment with different doses of *S. xanthocarpum* (100, 200 and 400 mg/kg) significantly reduced the level of lipid peroxidation, an important cause of destruction and damage to hepatocellular membranes, and elevated the level of GSH in liver. The increase in hepatic GSH level in the rats treated with *S. xanthocarpum* may be due to *de novo* GSH synthesis or GSH regeneration.

On phytochemical screening, *S. xanthocarpum* revealed the presence of flavonoids, steroidal alkaloids, triterpenes, flavanoids, quercitrin and apigenin glycosides. Hence, it is possible that the mechanism of hepatoprotection of *S. xanthocarpum* may be due to its antioxidant property present in these phytochemicals by reducing the oxidative stress imposed by antitubercular drugs and other like anti-inflammatory property[55] which may prevent inflammatory hepatic damage.

From the results, it is clear that the *S. xanthocarpum* has exhibited dose dependent activity, however the dose level of 400 mg/kg, p.o. showed greater activity as compared to control and standard groups. Liver histopathology images evidenced that *S. xanthocarpum* attenuated the hepatocellular necrosis and led to reduction in inflammatory cells infiltration, which may be attributed to its hepatoprotective effects. Further investigations are required for the identification of active constituents responsible for the hepatoprotection.

Conflict of interest statement

We declare that we have no conflict of interest.

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