ORIGINAL ARTICLE

PROTECTING THE LIVER: TAMARIX DIOICA MITIGATES ARSENIC-INDUCED HEPATOTOXICITY IN ALBINO RATS

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Background: The rise of arsenic contamination in both water and food supplies has emerged as a notable worldwide health issue, posing serious risks to human well-being, notably through liver damage. The objective was to observe the protective effects of Tamarix dioica in arsenic-induced liver toxicity in albino rats. **Methods:** This experimental study was conducted at the Department of Anatomy, LUMHS Jamshoro, from August 2022 to February 2023. The study utilized 30 adult male Albino rats as utilized in similar published studies, equally divided in three groups. Group A (control), Group B (rats administered arsenic orally), and Group C (rats administered arsenic orally along with Tamarix dioica. After the experimental period, the animals were weighed and liver function tests, i.e., ALT, AST, and total bilirubin, reduced liver weight &length, and the manifestation of steatosis to evaluate the hepatotoxicity of arsenic and its potential prevention by Tamarix dioica. **Results:** The findings demonstrated that arsenic exposure significantly impacted both liver function and morphology. However, concurrent administration of Tamarix dioica with arsenic appeared to alleviate these effects. The treated group exhibited lower liver function markers, higher liver weight, and less severe steatosis and hepatic ballooning; the reduction in lobular inflammation did not reach statistical significance. These results suggest a potential protective role of Tamarix dioica against arsenic-induced hepatotoxicity. **Conclusion:** This study demonstrated that Tamarix dioica reduced the biochemical and histological markers of arsenic-induced liver injury in albino rats.

Keywords: Albino rats; Antioxidant; Arsenic-induced hepatotoxicity; Liver; Tamarix dioica

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INTRODUCTION

Arsenic contamination in water and food sources remain a substantial global concern due to its detrimental effects on human health, particularly concerning hepatotoxicity. Arsenic is a metalloid, which is present abundantly in the atmosphere. It enters in the human body through consumption of contaminated water and food products.[1] Prolonged exposure to arsenic causes multiple deleterious effects to vital organs such as liver and heart. It may cause skin lesions, and various types of cancers.[2]

The liver is a vital organ responsible for detoxification and metabolism. Consequently, it is vulnerable to the toxic effects of arsenic. Arsenic-induced hepatotoxicity is characterized by oxidative stress, inflammation, impaired liver function, and histopathological alterations. These effects can ultimately result in severe liver diseases, such as fibrosis, cirrhosis, and hepatocellular carcinoma.[3]

Currently researchers are exploring natural compounds with hepatoprotective properties as potential remedies for arsenic-induced liver damage. Among these, Tamarix dioica (TD), a plant species in the family Tamaricaceae, has garnered attention for its antioxidant and hepatoprotective properties. [4] Tamarix dioica, commonly known as Athel pine or salt cedar, is native to dry regions. Since long time it is in traditional medicine for several illnesses. Previous researches also reported the potential of TD extract in protecting against liver damage induced by toxins and oxidative stress.[5]

Hence this study is designed to investigate the role of TD in preventing arsenic-induced hepatotoxicity. By assessing the effects of TD extract on liver function and histopathological changes in an animal model of arsenic toxicity, we aim to elucidate its potential as a natural remedy for mitigating arsenic-induced liver damage.

MATERIAL AND METHODS

This experimental study was conducted out at the Department of Anatomy at Liaquat University of Medical and Health Sciences (LUMHS) Jamshoro in alliance with Sindh Agriculture University

(SAU) Tandojam and Department of Pathology LUMHS. Approval of this study proposal was granted by Research Ethical Committee (REC) vide letter no. LUMHS/REC/58 dated 08/03/2022). This study was carried on 30 adult male albino rats, a group size consistent with comparable published hepatotoxicity studies.[6] Albino rats having weights between 150–250 grams obtained from Animal house of SAU, Tandojam. All animals were handled according to the guiding principles by US National Institutes of Health (NIH) and housed in stainless steel cages (with sawdust bedding). The animals were kept under hygienic conditions at 23–25 °C with free access of food and water and 12-hrs light/dark cycle.[7]

Leaves of T. dioica were obtained from Botanical garden and verified from Department of Botany, SAU, Tandojam. Dried T. dioica aqueous extract was prepared by grinding followed by soaking in distilled water (20g/200ml) overnight and then boiled at 100 ºC. The extract was cooled at room temperature and the supernatant was then filtered.[8] Arsenic trioxide was purchased from local chemist store Hyderabad Sindh. For preparation of dosage a stock solution of arsenic was prepared by dissolving the appropriate amount in distilled water. The dosage concentration was calculated to achieve 10 mg of arsenic per kg of rat weight.[9]

The animals after following one week of acclimatization were weighed and divided into three groups each comprises of 10 animals kept in separate cages with labels of each group.

Group A: Control group, was given drinking water and normal rodent chow ad libitum.

Group B: Experimental group was administered Arsenic 10mg/kg orally for 15 days.

Group C: Experimental group was administered Arsenic 10mg/kg orally and T. dioica extract daily in a dose of 100mg/kg/day for 15 days. [10]

After completion of experiment animals were weighed. Blood samples were collected by cardiac puncture after anesthetizing the animals with ether inhalation from all the animals for the assessment of liver function test (LFT). Blood samples were collected in plain tubes; serum after separation by centrifugation was biochemically assessed for LFT; the parameter used were alanine transaminases (ALT), and aspartate transaminases (AST) bilirubin.[11]

Animals were dissected after cervical dislocation and liver was removed, washed with normal saline, and its gross morphological parameters; weight, size and presence of any obvious anomalies were noted. The weight of the liver was measured by electronic balance. The size of the liver was measured by measuring scale.[12] Liver tissue after morphological examination was fixed in 10% formalin for 24 hours and processed for microscopy on automatic tissue processor (Leica TP 1020, USA). The prepared tissue blocks; embedded in paraffin, were section on rotatory microtome into 4‑µm thick sections, followed by Haematoxylin and Eosin (H&E) staining for histopathological examination. Sections were observed with the help of a microscope (Nikon Eclipse 50i Japan) and images were acquired (200x and 400x magnifications). [12]

SPSS-21 was used for data analysis. Quantitative variables were normally distributed and are presented as mean and standard deviation; qualitative variables are presented as frequency and percentage. One-way analysis of variance was used to compare body weight, liver function tests and liver morphometry across the three groups. Histological grades are ordinal and the control group had no variance, so these were compared using the Kruskal-Wallis test across all three groups, with the Mann-Whitney U test for the pre-specified comparison between the arsenic-only group (B) and the arsenic plus Tamarix dioica group (C), which is the comparison on which the protective claim rests. A p-value of <0.05 was considered statistically significant.

RESULTS

All the 30 rats survived during study period of 15 days showed significant difference in final weight versus initial weight in all three groups. (Table 1).

Liver function tests differed significantly across the three groups (Table-2). In Group A the mean ALT was 15.16 U/L, AST 85.3 U/L and total bilirubin 0.6 mg/dL. In Group B these rose to 48.81 U/L, 205.4 U/L and 1.38 mg/dL respectively, and in Group C they were intermediate at 42.62 U/L, 161.02 U/L and 0.9 mg/dL. All three comparisons were significant on one-way analysis of variance ($p<0.001$).

Morphological assessment of the liver involved measuring the liver weight in three groups. The mean liver weight was 4.5±0.1 grams for group A, 1.23±0.3 grams for group B, and 3.9±0.5 grams for group C. A comparison of liver weights among the groups yielded a significant difference (0.014) in liver weight.

Length of liver was another parameter assessed on Morphometry which reveals in Group A was 10.5±0.3 cm, while it was 8.4±0.2 cm in Group B and 9.2±0.3 cm in Group C with a significant difference observed among groups ($p<0.001$) (Table-3)

Histopathological assessment of rat liver was evaluated by using the scoring system validated Nonalcoholic Steatohepatitis (NASH) Clinical Research Network.[13] (table 4 and figure 1).

All ten rats in the control group (Group A) showed no steatosis (Grade 0). In Group B, two rats (20%) exhibited Grade 1, five (50%) Grade 2 and three (30%) Grade 3 steatosis. In Group C, four rats (40%) had no steatosis, three (30%) Grade 1, two (20%) Grade 2 and one (10%) Grade 3. The difference across the three groups was significant on the Kruskal-Wallis test ($p<0.001$), and the comparison between Group B and Group C was also significant on the Mann-Whitney U test ($p=0.023$), indicating that co-administration of Tamarix dioica reduced the severity of steatosis.

In Group A, all ten rats exhibited no inflammation (Grade 0). In Group B, four rats (40%) had Grade 1, three (30%) Grade 2 and three (30%) Grade 3 inflammation. In Group C, one rat (10%) had no inflammation, six (60%) Grade 1 and three (30%) Grade 2, with none reaching Grade 3. The difference across the three groups was significant on the Kruskal-Wallis test ($p<0.001$), which reflects the contrast between the control group and both arsenic-exposed groups. The comparison between Group B and Group C did not reach statistical significance (Mann-Whitney U, $p=0.085$), so a protective effect of Tamarix dioica on lobular inflammation is suggested by the shift away from Grade 3 but is not demonstrated in this sample.

In Group A, all ten rats exhibited Grade 0 hepatic ballooning. In Group B, four rats (40%) showed Grade 1 and six (60%) Grade 2, indicating an arsenic-induced increase in ballooning. In Group C, five rats (50%) showed no ballooning, three (30%) Grade 1 and two (20%) Grade 2. The difference across the three groups was significant on the Kruskal-Wallis test ($p<0.001$), and the comparison between Group B and Group C was also significant on the Mann-Whitney U test ($p=0.017$), indicating a protective effect of Tamarix dioica against hepatic ballooning. No fibrosis was seen in any group.

Table-1: Weight of animal groups n=30

Weight of Animal (gm)	Group A	Group B	Group C	*p*-value
Initial weight	225±20.3	220±25.2	215±15.2	0.563
Final weight	210±20.3	110±25.2	201±15.2	<0.001

Table-2: Liver function test in animal groups n=30 (ANOVA)

Liver Function Test	Group A	Group B	Group C	
	Mean±SD	Mean±SD	Mean±SD	*p*-value
ALT U/L	15.16±6.59	48.81±9.62	42.62±4.90	<0.001 *
AST U/L	85.3±6.35	205.4±7.10	161.02±10.21	<0.001 *
Total bilirubin (mg/dl)	0.6±0.13	1.38±0.11	0.9±0.10	<0.001 *

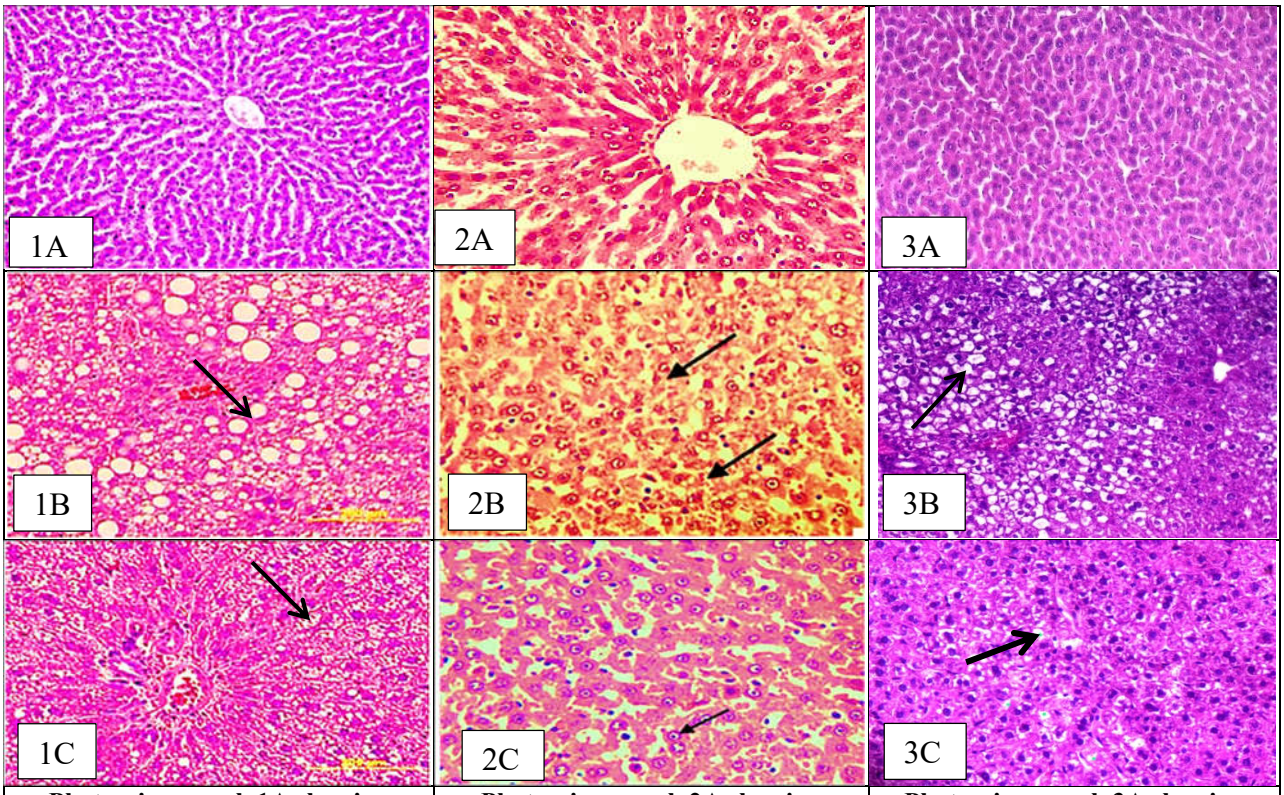
Table-3: Morphometric assessment in animal groups n=30

Morphological assessment of Liver	Group A	Group B	Group C	*p*-value
Weight (gms)	4.5±0.1	1.23±0.3	3.9±0.5	<0.001
Length (cms)	10.5±0.3	8.4±0.2	9.2±0.3	<0.001

Table 4: Histological findings in animal groups n=30

Group	Steatosis				*P* -value
	Grade 0	Grade 1	Grade 2	Grade 3	
A	10 (100%)	0	0	0	<0.001
B	0	02 (20%)	05 (50%)	03 (30%)	
C	04 (40%)	03 (30%)	02 (20%)	01 (10%)	
	Lobular inflammation				
	Grade 0	Grade 1	Grade 2	Grade 3	<0.001
A	10 (100%)	0 (00%)	0 (00%)	0 (00%)	
B	0 (00%)	04 (40%)	03 (30%)	03 (30%)	
C	01(10%)	06 (60%)	03(30%)	00 (00%)	
	Hepatic ballooning				
	Grade 0	Grade 1	Grade 2		<0.001
A	10 (100%)	0	0		
B	0 (00%)	04 (40%)	06 (60%)		
C	05 (50%)	03 (30%)	02 (20%)		

Steatosis	Hepatic ballooning	Lobular Inflammation



Photomicrograph 1A showing normal/no, 1B significant &1C mild Steatosis	Photomicrograph 2A showing normal/no, 2B significant &2C mild Hepatic ballooning	Photomicrograph 3A showing normal/no, 3B significant &3C mild Lobular inflammation

Figure-1: Histological sections of liver stained with haematoxylin and eosin staining

DISCUSSION

Body weight measures animal health, therefore reduction in body weight is indicating ill health due to arsenic toxicity. The results of the present study indicated that arsenic intoxication markedly decreased the body weight and liver weights of experimental rats. The study by Gora *et al*. examined the effects of Arsenic on the growth of rats by administering Arsenic at a similar dose of 10mg/kg orally and measured initial weight of the animals similar to present study.[14] A comparable preservation of body weight has been reported for other hepatoprotective plant extracts; Haldar et al. found that Swietenia mahagoni bark extract limited weight loss in rats with paracetamol-induced hepatic damage.15

Liver enzymes such as ALT and AST, which are integral to liver parenchymal cells, escape into the bloodstream after liver damage. The level of these enzymes in blood are indicators of liver dysfunction. Strong correlation between hepatocellular damage and enzyme leakage in bloodstream is evident by several studies.[16] This study reveals significant rise in AST, ALT, and bilirubin level due to arsenic intoxication which are in line with study by Habib *et al*., reveal similar elevated ALT levels on their study on animal model.[17]

Urfi et al. examined the hepatoprotective effect of the closely related Tamarix gallica against rifampicin and isoniazid induced liver injury in rats and demonstrated positive outcomes.18 Their findings are consistent with the present results and suggest that hepatoprotective activity may be shared across the genus, although species-specific comparisons have not been made.

Steatosis is a core component of the NASH CRN scoring system used here, and its mechanisms and models have been reviewed by Peng et al.19 Komal et al. demonstrated that Tamarix dioica exerted hepatoprotective effects in rats with carbon tetrachloride induced liver injury, although steatosis was not graded separately in that study.8 Alnuqaydan et al. reported that the related species Tamarix articulata reduced carbon tetrachloride

induced hepatic injury and fibrosis in rats, modulating both inflammatory and antioxidant markers.20 The present finding of reduced steatosis in the Tamarix dioica treated group is consistent with this body of work, although the models and dosing regimens differ.

Lobular inflammation is a further measure of liver injury. Inflammation was clearly increased in both arsenic-exposed groups relative to controls, and the distribution shifted away from Grade 3 in the group receiving Tamarix dioica, but the difference between the two arsenic-exposed groups did not reach statistical significance (p=0.085). This finding should therefore be regarded as hypothesis-generating rather than as evidence of a protective effect, and a larger sample would be required to determine whether the apparent shift is real. Li et al. similarly reported that arsenic exposure increased inflammatory markers and produced histopathological changes consistent with liver inflammation.22

No directly comparable study of Tamarix dioica against arsenic was identified. Saha and Mukherjee reported hepatoprotective effects of green tea extract against arsenic-induced liver damage, including hepatic ballooning. Both studies highlight the potential of herbal interventions in attenuating the adverse effects of arsenic exposure on liver health, providing further support for the protective role of plant extracts against arsenic-induced hepatotoxicity.[23]

CONCLUSION

This research underscores the promising role of Tamarix dioica in mitigating arsenic-induced hepatotoxicity. With arsenic contamination posing a critical environmental health risk and liver damage being a major consequence of prolonged exposure, the findings shed light on the potential benefits of this medicinal plant. This research offers valuable insights. Tamarix dioica reduced the biochemical and histological markers of arsenic-induced liver injury in this model, and emerges as a candidate for further investigation. Antioxidant activity was not measured in this study, and the mechanism of the observed protection therefore remains to be established.

Conflict of Interest:
None.
Research Grant:
None

AUTHORS' CONTRIBUTION

NA: Data collection and analysis, write-up. BG: Literature search. DK: Literature search, data collection. SM: Data interpretation and proof reading. PG: Conceptualization of study design and proof reading.

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