Research article

Anatomical and histological assessment of Arabic gum administration on visceral organs of diabetic rats

Shurooq H. Majeed Alnassiri[1], Muna S. Rashid[2], Huda A. Hameed[3]

[1]Department of Biology, College of Education for Women, Tikrit University, Tikrit, Iraq
[2]Department of Biology, College of Science, Tikrit University, Tikrit, Iraq
[3]Department of Physiology, Pharmacology and Biochemistry, College of Veterinary Medicine, Tikrit University, Tikrit, Iraq

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Corresponding author: **Muna S. Rashid.** Email: muna.salah@tu.edu.iq

ABSTRACT

Introduction and Aim: This century has seen a rise in the prevalence of diabetes mellitus, and since medications pose a number of risks and adverse effects, researchers have been experimenting with a variety of natural materials, including herbs. One among the herbs is Arabic gum which is considered beneficial in treating diabetes. In this study, we investigated the anatomical and histological effect of Arabic gum treatment in diabetes-induced rats when administered at different concentrations.

Materials and Methods In this study, albino rats were divided into four experimental groups: control, alloxan administered, alloxan and Arabic gum (5%) administered, and alloxan and Arabic gum (10%) administered. Following the experimental period, the four groups of animals were sacrificed and their anatomical and histopathological changes were studied.

Results: This study showed that alloxan induced diabetes caused liver, kidney and lung injuries. The groups that received alloxan with Arabic gum at concentrations 5 % and 10% exacerbated the organ damage. Several anatomical changes of the visceral organs were seen in relation to animals in the control group. Morphologically, groups that received Alloxan and Arabic gum had white spot lesions on the surfaces of the liver kidney and lungs. Histopathological changes were also observed in the liver, kidney and lungs of the animals when compared to controls.

Conclusion: Organs such as the liver, kidneys, and lungs were found to be damaged in alloxan-induced diabetic rats. The administration of Arabic gum at concentrations of 5% and 10% does not stop the damage to these organs.

Keywords: Arabic gum; alloxan; liver; kidneys; lung; lymphocytes.

INTRODUCTION

Diabetes is a chronic illness that can lead to a wide range of disorders as it prevents the body from absorbing nutrients from food (1,2). In 2014, diabetes affected 8.5% of adults over the age of 18 and was responsible for an estimated 4.2 million deaths among people aged between 20-79 years (3). Globally, the estimated deaths due to diabetes are around 11.3% (4,5).

Diabetes is considered more dangerous than other diseases, because of the risks associated with this disease. Although medications are a complete cure, they still have serious side effects. Studies with rats with diabetes showed sustained hyperglycemia with high hemoglobin glycosylated (6). The morphological alterations of the liver, including fibrosis, were observed in diabetic rats whose pancreatic beta cells were destroyed by alloxan (7).

Traditional treatments have been an important source of medicine for diabetes throughout the world. Over 400 of the thousands of medicinal plants on the WHO's list have been potentially used to treat diabetes. One among them is the herb Arabic gum, treatment by which has been shown to reduce hemostasis metabolic disturbance, oxidative stress, and other disorders such as hyperglycemia, weight increase and lung injury associated with diabetes (8-10). Intake of Arabic gum in parallel with insulin has been demonstrated to alter the negative effect of diabetes on blood parameters (11). In the present study we investigated the effect of arabic gum treatment in diabetes induced rats and showed the effect of Arabic gum on those rats when given at different concentrations.

MATERIALS AND METHODS

Study animals and experiment design

This study was conducted at the animal house facility of the Veterinary Medicine Department, University of Tikrit. Male albino rats of the strain Sprague Dawley aged 2-3 months and weighing 200-300g were used in the experimental studies. The animals were divided into four experimental groups with each group consisting of 10 animals each. The four experimental groups were as follows:

- Control group, where the animals were provided with regular diet food and water and was excluded from any dose or treatment
- Alloxan treated group: Animals were once injected subcutaneously with alloxan at a concentration of 150 mg/kg

- Alloxan and Arabic gum (5%) treated group: Animals subcutaneously with alloxan (150 mg/kg) along with normal feed were fed with Arabic gum at a concentration of 5% (5g of Arabic gum dissolved in 95 ml of water) for sixty days.
- Alloxan and Arabic gum (10%) treated group: Animals injected with alloxan (150 mg/kg) along with normal feed were fed with Arabic gum at a concentration of 5% (10g of Arabic gum dissolved in 95 ml of water) for sixty days.

The animals were housed in cages with five rats in each cage. The animals were fed with food and water and the temperature of the animal shelter fixed throughout the study period.

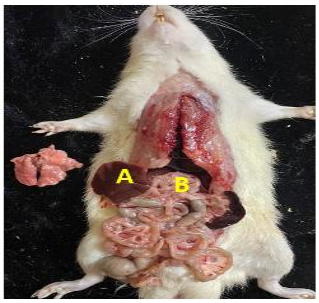
Anatomical and histological studies

At the end of the experimental period the animals were sacrificed by anesthetizing with chloroform in a sealed glass box. The abdominal cavity was cut open and the organs eviscerated, cleaned and rinsed with tap water. For histopathological studies tissues were collected. The organs first fixed with 10% formalin for 12 h were processed for histopathological studies by processing and staining of the tissues of organs based on the protocol of routine stain.

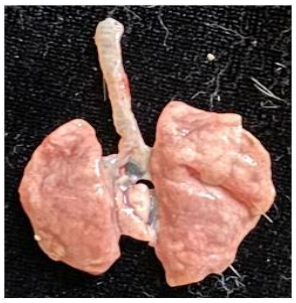
RESULTS

Results in the current study showed that the administration of Alloxan alone or in combination with Arabic gum caused morphological lesions on the surface of the liver, kidney, and lungs in rats (Fig.1). Alloxan induced diabetic rats were observed to exhibit liver congestion, white spots on liver and surface of pulmonary lobes, pedicle hemorrhage of the stomach and intestinal mesentery (Fig.1).

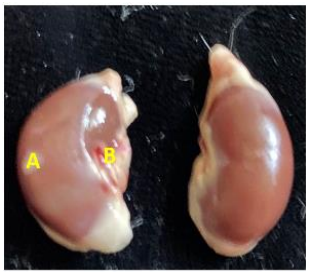
The study also revealed white spot lesions on the kidney's dorsal surfaces and the liver's surface lobes with the lesions on the liver lobes growing larger after Alloxan and Arabic gum (5 and 10%) were administered. Administration of Arabic gum at 5% and 10% concentrations together with alloxan caused the development of white spots on the surface of kidneys and kidney medial border as well as deposit of fat in kidney perianal tissue (Fig.1).



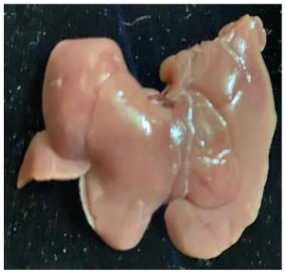
Alloxan induced diabetic rats showing A: white spot-on liver; B: Pedicle hemorrhage on stomach surface of and mesentery of intestine



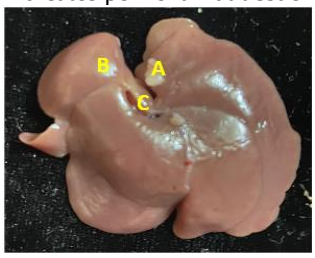
Alloxan induced diabetic rats showing white spot on surface of lung lobes



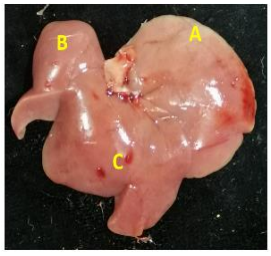
Alloxan and Arabic gum (5%) administered rats showing kidneys with white spots on A: the dorsal surface of the kidneys and B: on medial border C: indicates perirenal fat tissue



Alloxan and Arabic gum (5%) administered rats showing white spots and fissures on the surface of liver lobes



Alloxan and Arabic gum (10%) administered rats showing liver white spot lesions on right lobe (A) and left lobe (B) and Portal area with the depression of gallbladder (C)



Alloxan and Arabic gum (10%) administered rats showing hemorrhage on the stomach (A); pylorus (B) and pedicle (C) surface

Fig. 1: Anatomical changes observed in experimental rats treated with alloxan; Alloxan +Arabic gum (5%) and Alloxan +Arabic gum (10%).

According to histopathological studies, alloxan-induced diabetes resulted in liver, kidney, and lung damage. The organ damage was amplified in the groups treated with alloxan and Arabic gum at concentrations of 5% and 10%. The alloxan group showed pyknosis in the nuclei of hepatocytes and necrosis and atrophy of hepatocytes, dilation of the sinusoids and increased Kupffer cells (Fig. 2).

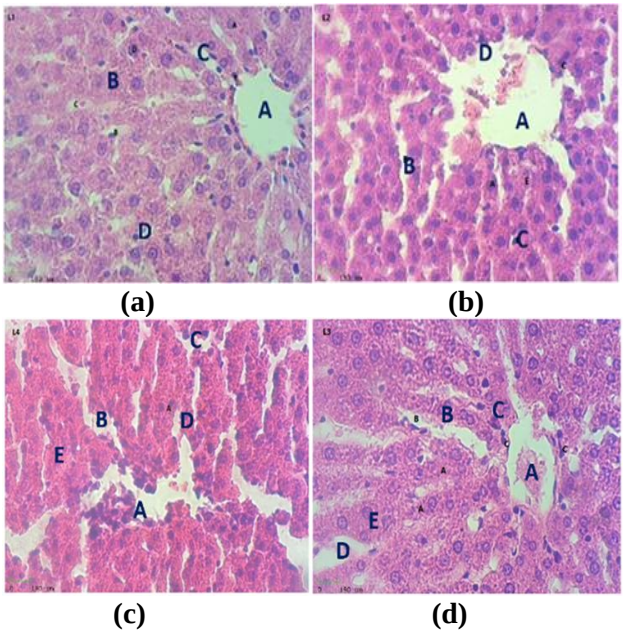
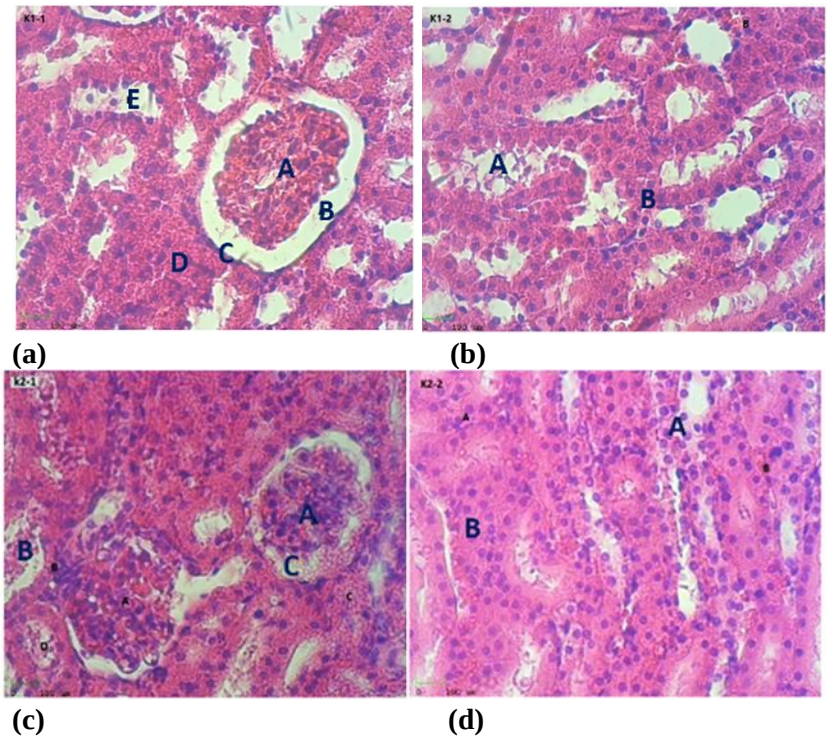


Fig. 2: Liver Histopathology (H & E X 40) **(a)** Normal liver cells showing, A: Central vein; B: liver cells columns; C: Blood sinusoids and D: Kupffer cells. **(b)** Liver cells treated with Alloxan showing, A: Blood clot in central vein; B: Atrophy of liver cells; C: Pyknosis of nuclei of liver cells; D: Absence of membrane in central vein. **(c)** Liver cells treated with Alloxan+Arabic gum (5%), A: Blood clot in central vein; B: Dilation of blood sinusoids C: Kupffer cells D: Atrophy of hepatocytes E: Liver cells disorganization. **(d)** Liver cells treated with Alloxan+Arabic gum (5%), A: Blood clot in central vein; B: Atrophy of hepatocytes C: Hypertrophy of Kupffer cells D: Dilation of blood sinusoids E: Hypertrophy of liver cells

In the kidneys with alloxan, the cortex showed atrophied glomeruli and diffusion of inflammatory cells, hemorrhage and necrotic cells, as well as degeneration and sloughing in the epithelium lining the convoluted tubules (Fig.3). In the kidney medulla, an increase in the interstitial connective tissues, hemorrhage from the blood vessels and narrowing in the tubules was observed (Fig.3). The lungs of alloxan administered rats showed an increase in thickness of the alveoli with high infiltration of WBCs, blood vessels with congested hemolysis blood, and degeneration of the connective tissues around the vessels in addition to necrosis of alveolar cells (Fig.4).

In the alloxan and Arabic gum (5 and 10%) administered groups, an increase in the liver necrosis along with increase in hepatocytes and dilation in blood sinusoids, damage in central vein wall and desquamation of endothelial was indicated (Fig.2)

In the kidney cortex the complete segmentation of glomeruli and sloughing of epithelial cells lining the convoluted tubules and the presence of some degenerative cells were seen. The kidney medulla increase with interstitial connective tissues and eosinophilic casts are present in the lumen of tubules (Fig.3). The kidney medulla also showed sloughing of epithelial cells and narrowing the lumen of renal tubules with hypertrophy in cells lining the tubules (Fig.3). Similarly in the lungs, the alveolar walls were found thickened than in normal tissue with aggregation in lymphatic cells, degeneration of the tissue around the vessels (Fig.4). The damage to liver, kidneys and lungs was observed to increase with increasing Arabic gum concentrations.



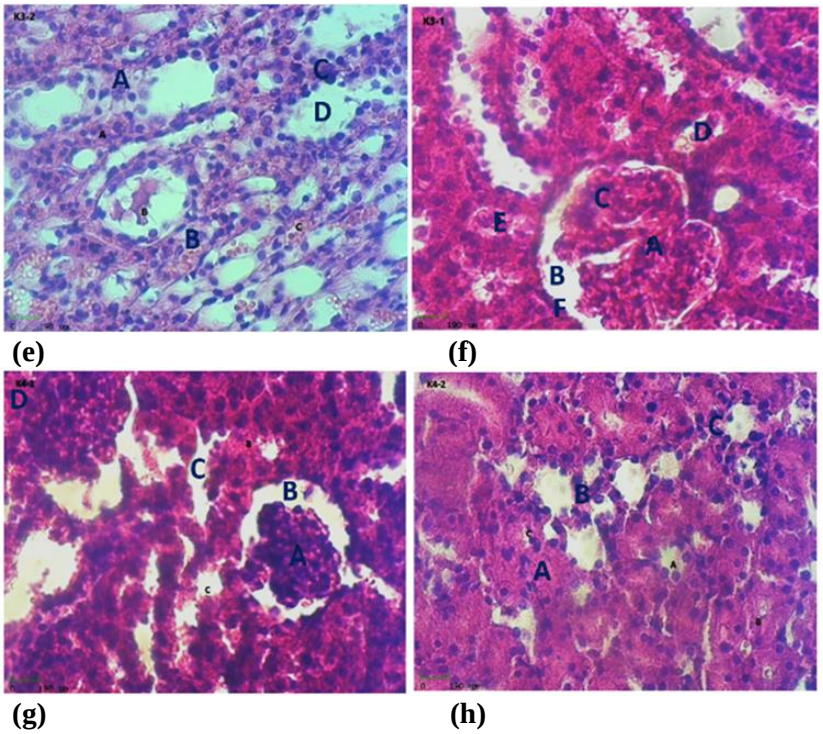
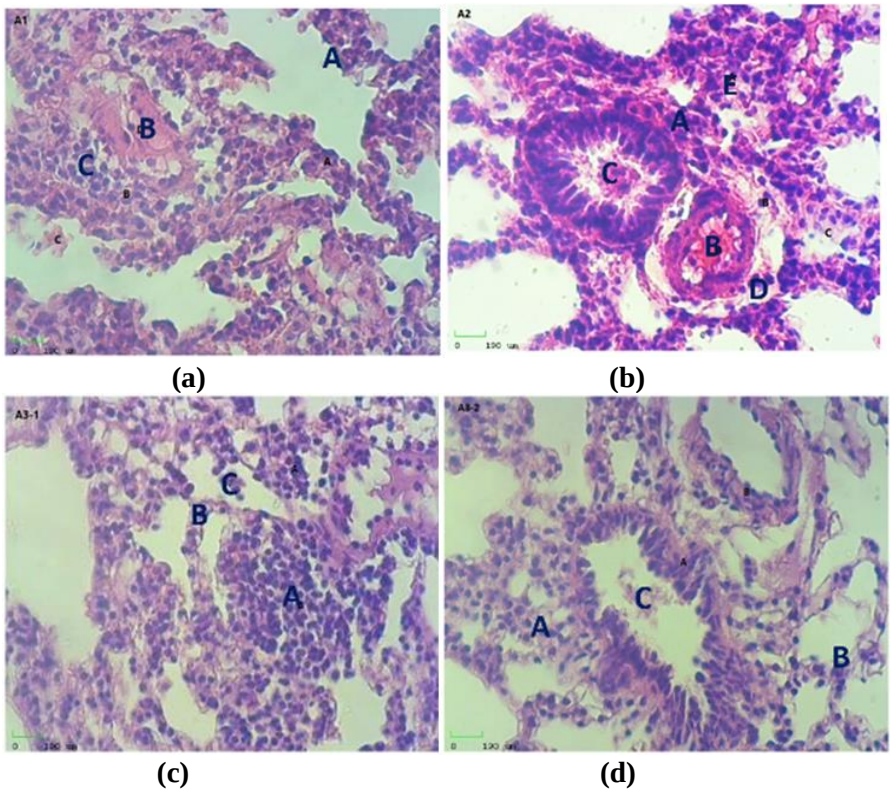
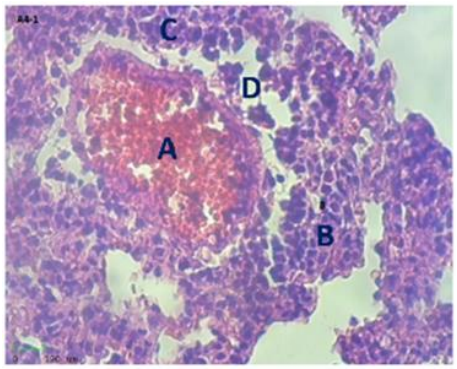


Fig. 3: Histopathology of kidney tissue (H & E X 40). **(a)** Normal renal cortex, showing A: Glomerulus; B: Capsular space; C: Bowman capsule; D: Proximal convoluted tubules; E: Distal C.Ts **(b)** Normal renal cortex, showing A: Renal tubules; B: Interstitial C.t **(c)** Kidney cells treated with Alloxan showing, A: Atrophy of glomeruli with WBCs infiltration; B: Epithelial cells desquamation; C: Capsular space widening. **(d)** Kidney cells treated with Alloxan showing, A: Desquamation of Renal medulla cells; B: Renal tubular cell hypertrophy. **(e)** Kidney treated with Alloxan+Arabic gum (5%), A: Epithelial desquamation; B: WBCs infiltration in the interstitial connective tissue; C: Macrophages; D: Dilation of renal tubules. **(f)** Renal cortex after treatment with Alloxan+Arabic gum (5%), A: Partial atrophy of glomerulus; B: Widening of capsular space; C: Cellular desquamation; D: Hyaline casts in the lumen of tubules; E: Bowman capsule thickening. **(g)** Kidney treated with Alloxan+Arabic gum (10%), A: Atrophy of glomeruli with WBCs diffusion; B: Capsular space dilatation; C: Necrosis of epithelial cells of tubules; D: Interstitial hemorrhage. **(h)** Renal medulla after treatment with Alloxan+Arabic gum (10%), A: Hypertrophy of renal tubular cells; B: Degeneration of epithelial cells of Henle loops; C: WBCs infiltration in the interstitial CT.





(e)

Fig. 4: Histopathology of lung (H & E X 40). **(a)** Normal lung tissue, showing A: Alveolar walls with lining epithelium; B: Blood congestion; C: Lymphocytic aggregation in the interstitial connective tissue. **(b)** Lungs treated with Alloxan showing, A: Lymphocytic infiltration; B: Epithelial desquamation of bronchioles lumen; D: macrophages; E: Necrotic cells of alveolar walls. **(c)** Lung tissue after treatment with Alloxan+Arabic gum (5%), A: condensation of lymphocytic infiltration; B: Degeneration of interstitial CT; C: Desquamation of alveolar epithelial cells. **(d)** Lung tissue after treatment with Alloxan+Arabic gum (5%), A: Lymphocytic aggregation around the wall of bronchiole; B: Degeneration of alveolar wall; C: inflammatory edema in the lumen of bronchiole. **(e)** Lung tissue after treatment with Alloxan+Arabic gum (10%) showing A: Blood congestion; B: Condensation of lymphocytic aggregation in the interstitial CT; C: aggregation in the blood vessel; D & E: Necrotic cells around the blood vessel

DISCUSSION

In this study, we investigated the effect of 5 and 10% concentrations of arabic gum on anatomical and histological features of organs such as liver, kidney, and lungs of alloxan-induced diabetic rats. The morphological and histological appearance of these organs in normal non-diabetic rats was in line as previously described (12). The mechanical route of injury, in which oxidative stress plays a role in the control of cellular migration, proliferation, and signaling, was described by Kannan and his coauthors (13). This leads to altered structural changes to organelles such as mitochondria and endoplasmic reticulum in organs which in turn causes alterations in permeability of cell membrane and ions change (14). The protective effect of Arabic gum on organ injury in experimentally induced diabetic animals has been documented by several studies (14, 15). However, results with Arabic gum when administered at concentrations of 5 and 10% showed no improvement in anatomical and tissue damage caused due to diabetes. This probably could be due to the low concentration of Arabic gum used in this study as opposed to higher levels in previous similar studies. However, our result is in agreement with (15) that using the Arabic gum with gentamicin and Arabic gum alone showed congestion of blood sinusoids and central vein with infiltration of inflammatory cells and apoptosis of hepatic cells associated with degeneration of cytoplasm. This result was also in agreement with (16) who described the histological architecture of renal tissue with presence of histopathological changes in the cortex and medulla of kidney induced by diabetes. This result is identical to the results of (17) that explained the cause of renal changes by alloxan. Our result with alloxan and Arabic gum administered at concentrations of 5% and 10% showed to increase the damage within kidneys which contrasts with a similar study by Fayez *et al.*, (18) and Evan *et al.*, (19). Barreling *et al.*, (20) also reported the serum creatinine, endothelin and angiotensin II to be significantly reduced in diabetes rats when treated with Arabic gum. Arabic gum used as an antioxidant was reported to improve the renal function (21) and suggested as a treatment option in diabetics with chronic renal failure (22).

Our results also contrast earlier animal studies (23, 24) wherein, Arabic gum was shown to ameliorate the systemic injury caused due to diabetes. Similarly, administration of Arabic gum in diabetic mice was shown to reduce lung oxidative stress (25) which in contrast to findings for lungs in this study. Animals administered with Arabic gum in this study were observed to have sustained hyperglycemia, reduced insulin plasma levels and elevated levels of glycosylated hemoglobin which contrasts with previous studies which indicated that significant hypolipidemia, hypoglycemia, and antioxidant activity and altered the negative impacts in tissue histology of organs such as liver kidneys and lungs (19, 26-28).

CONCLUSION

Alloxan causes tissue damage to organs, particularly the liver, kidneys, and lung. Administration of arabic gum, at concentrations of 5% and 10%, does not prevent the damage caused to these organs.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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