World Journal of
Advanced Science and Tehnology

Journal homepage: https://zealjournals.com/wjast/

(RESEARCH ARTICLE)

Nephroprotective potential of *Spondias mombin* against aluminum chloride induced-renal injury in female albino rats

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World Journal of Advanced Science and Technology, 2022, 02(01), 001–010

Publication history: Received on 07 June 2022; revised on 12 July 2022; accepted on 14 July 2022

Article DOI: https://doi.org/10.53346/wjast.2022.2.1.0033

Abstract

Aluminum chloride ($AlCl_3$) is a toxic to human and animals, and it's widely distributed in the environment. *Spondias mombin* is a herbal medicine used as a therapy for several ailment, renal diseases inclusive. This study evaluated the protective potential of *spondias monbin* against aluminum chloride induced-nephrotoxicity in female albino rat. Fifteen (15) adult female rats were divided into three (3) groups of five rats each. Group I served as negative control and received distilled water and feed. Group II served as positive control and received $AlCl_3$, and group III received aluminum chloride (100mg/kg body weight) and *Spondias mombin* (100mg/kg body weight) for 14 days. All treatment was given orally and lasted for a period of fourteen days. The result revealed that $AlCl_3$ significantly ($p<0.05$) increases urea, creatinine, and malondialdehyde (MDA) levels, and reduced renal superoxide dismutase and catalase activity as compared to the control group. The histopathological result showed marked detectable histopathological alternations in the renal tissues including degenerated glomeruli showing wide urinary space, vacuolar degeneration of tubules, and necrosis of cells. However, serum urea, creatinine and malondialdehyde levels were significantly ($p<0.05$) reduced in the *Spondias mombin* + $AlCl_3$ administered rats. While, superoxide dismutase and catalase activity were significantly ($p<0.05$) increased in *Spondias mombin* + $AlCl_3$ administered rats compared with the control. In addition, no abnormal histological changes were observed in the *Spondias mombin* + $AlCl_3$ administered rats compared with the $AlCl_3$. The results indicate that *Spondias mombin* possess nephroprotective potential against $AlCl_3$ induced renal injury via restoring oxidant/antioxidant balance.

Keywords: Nephroprotective; *Spondias mombin*; Aluminum Chloride; Renal parameters; Antioxidant enzymes

1 Introduction

Nephrotoxicity occurs when renal detoxification and excretion are not functioning maximally due to impairment or destruction of renal function by extrinsic or endogenous toxic chemicals [1]. Environmental substances, industrial chemicals, and food additives have been shown to have deleterious effects on several tissues in human and animals in humans and animals including the kidney [2]. Aluminum (Al) is one of these substances, broadly spread in the environment [3], which the Agency for Toxic Substances and Disease Registry listed as a priority hazardous substance in 2008 [4]. Humans and animals are easily exposed to Aluminum (Al) during daily life because of its present in manufactured food such as yellow cheese, corns, grain products, vegetables and tea leaves, and spices [5]. It is also extensively utilized in daily lifestyle as a component of kitchen utensils, medicines, cosmetics, food additives, and for water purification purposes [5].

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Aluminum elimination from the body is very limited and occurs primarily via urine; thus, the kidney is susceptible to damage after aluminum exposure [6,7]. The kidney contributes to the elimination of aluminum such as aluminum chloride ($AlCl_3$) through glomerular filtration, reabsorption of filtrated AlCl3 in tubules, secretion and excretion in distal tubules [8]. High exposure to aluminum as result of careless daily lifestyle of humans could result in renal accumulation of aluminum in the renal tubules, which resulted in renal dysfunction [9]. Aluminum (Al) primarily enters the human body through the digestive and respiratory system, where it accumulates in various tissues and organs such as the liver, kidneys, brain, and heart [8,10]. Several studies have demonstrated that high aluminum (Al) exposure and accumulation induced nephrotoxicity [11], hepatotoxicity [12], neurotoxicity [13] and haematotoxicity [14]. Gonzalez and coworkers [15] showed that aluminum can lead to renal tubular cell degeneration by producing reactive oxygen species (ROS), which lead to oxidative damage to cellular lipids, proteins, and DNAs. Similar studies by Newairy and colleagues [16] and Türkez and coworkers [17] reported that aluminum intoxication caused alternation in biochemical molecules, cell membrane lipid peroxidation activities, and decreases plasma and tissue antioxidant enzymes activities in laboratory animals.

Numerous phytochemicals found in medicinal plants have antioxidant properties, and they have become well-known and widely used as a medical therapy option for oxidative damage to tissues [18,19]. *Spondias mombin* is a member of the Anacardiaceae family. *S. mombin* is one of the extensively utilized medicinal plants in Southwest Nigeria and is also usually referred to as hog plum or yellow *mombin*. *Vitamins, minerals, and bioactive phytochemicals like flavonoids, phenolic acids, tannins, cardiac glycosides, and saponins have all been shown to be abundant in Spondias mombin* [20]. Several researchers have reported that *S. mombin* possesses antioxidant, anti-inflammatory, and anti-denaturation [21], antimicrobial [22], and hepato-protective properties [23].

Experimental trials on the use of *Spondias mombin* for the management of aluminum chloride induced renal complications are scarce. Furthermore, the possibility of treating distant organ oxidative damage with plant extracts has not been thoroughly studied. Given that *Spondias mombin* has strong antioxidant effects and can shield tissues from oxidative damage [23], it is reasonable to investigate its therapeutic effect against aluminum chloride oxidative stress in the kidney of laboratory animals. Therefore, this study investigated the protective effect of *Spondias mombin* against aluminum chloride induced-nephrotoxicity in female albino rat.

2 Material and methods

2.1 Chemicals/Reagents

Ethanol (Emerek Darstaatm.w 46.07), Aluminum chloride (BDH chemical ltd. England), 30MM hydrogen peroxide, 6M hydrogen tetraoxoulphate (H_2SO_4), Phosphate buffer, Carbonate buffer, $KMNO_4$, NaCl, NaOH, KH_2PO_4, Na_2HPO, HCL, Na_2CO_3, $NaHCO_3$, EDTA (Ethylene diaminetetra-acetic acid), Adrenaline solution, Chloroform and Formal Saline.

2.2 Preparation of *Spondias mombin* Leaf Extract

The preparation of *Spondias mombin* leaf extract was adopted from Aba et al. (2014). Leaves of *Spondias mombin* was gotten in Amassoma Community, Bayelsa State. The leaves were separated from the stalks of the stems, cleaned with clean water, and air dried at room temperature. The dried leaves were milled into fine powder with the aid of a grinding mill machine and stored in an air tight container to inhibit the growth of microorganism. About 450grams of the powdered leaf was extracted with 1350ml of 75% ethanol. The resulting decoction was filtered and the filtrate was subjected to a low but complete solvent evaporation using a water bath at a temperature of 60°C. Each of the rats was given a different concentration of the residue by mouth using appropriate weights of the residue produced in distilled water.

2.3 Experimental Animals

From the animal house of the Department of Pharmacy at Niger Delta University, Bayelsa State, fifteen (15) apparently healthy adult female Wister rats weighing between 117g and 250g were purchased. The rats were kept in cages and moved to the Department of Medical Biochemistry where they were given two (2) weeks to acclimate before being provided normal food (Pellet) and distile water. All procedures were carried out in compliance with the Institutional Animal Ethical Committee's (IAEC) directives for the control and supervision of animal experimentation (CPCSEA).

2.4 Experimental Design

A total of fifteen (15) adult Wistar rats separated into 3 groups of 5 rats each.

- Group I: (Control): Administered distilled water and pellet feed for fourteen (14) days.
- Group II: (Positive Control): Treated with 40 mg/kg per body weight of aluminum chloride ($AlCl_3$) daily by oral gavage for fourteen (14) days.
- Group III: Treated with 100mg/kg per body weight of aluminum chloride ($AlCl_3$) orally followed by the administration of 100mg/kg per body weight of ethanolic extract of *Spondias mombin* orally after one hour for fourteen (14) days.

2.5 Sample Collection

At the completion of the treatment, the animals were anaesthetized using chloroform and sacrificed. Cardiac punctures were used to obtain blood samples, which were then dispensed in plain sample containers and allowed to clot properly at room temperature before being centrifuged for 10 minutes at 3000 rpm to separate the serum for urea and creatinine estimation. Thereafter, the rat was dissected and the kidney was excised and clean in normal saline, and part of it was placed in a sample bottle containing 10% formalin for histological examination. After being weighed, 10 grams of kidney tissue were homogenized in 0.1 M Tris buffer (pH 7.4) for 10 minutes at 3000 rpm. Malondialdehyde levels, catalase and superoxide dismutase activities were all measured using this homogenized kidney solution.

2.6 Estimation of Biochemical Parameters

The homogenized kidney and serum were used for biochemical estimations: superoxide dismutase (SOD) activity, Catalase (CAT), malondialdehyde (MDA), urea and creatinine, were measured by standard spectrophotometric methods. The Urease-Berthelot Method, as reported by Patton and Crouch [24], was used to measure serum urea. The method described by Bartels and Bohmer [25] was used to measure creatinine using Jaffe's method. Superoxide dismutase (SOD), catalase, urea, and creatinine levels in the blood were measured using test kits made by Randox Diagnostics in the UK. With the aid of analytical grade reagents, serum MDA was calculated.

2.7 Determination of serum Creatinine and Urea Concentration

The method for the estimation of serum creatinine was adopted from Bartels and Bohmer [25]. Principle: Creatinine and picric acid react in an alkaline solution to produce an orange-colored complex. The amount of the coloured complex produced is directly proportional to the amount of creatinine in the sample. At a wavelength of 510 nm, the colored complex's absorbance is measured spectrophotometrically. Serum urea level was measured by colorimetric method as described by Patton and Crouch, [24]. Principle: Urea is hydrolyzed by urease to ammonia and carbon IV oxide. The ammonia produced reacts with salicylate in the presence of nitroprusside and hypochlorite to give 2,2–dicarboxyl indophenol (blue) whose absorbance is measured at a wavelength of 600nm.

2.8 Estimation of Superoxide Dismutase (SOD)

Misra and Fridovich [26] method was adopted for the measurement of superoxide dismutase (SOD) activity. Principle: It is based on the ability of the superoxide dismutase to inhibit the autoxidation of epinephrine at pH 10.2. Procedure: The spectrophotometer was zeroed using a blank made of 3.0 ml of distilled water after being set at 420 nm. 0.2ml of distilled water was dispensed to the reference tube, and 0.2ml of the proper enzyme extracts were introduced to the proper labeled test tube. 2.5ml of the phosphate buffer was dispensed into each of these tubes, and after equilibrating at room temperature, 0.3ml of the 0.3mM adrenaline solution was dispensed to the reference and each of the test solutions. This was then allowed to mix, and the absorbance at 420 nm was measured.

2.9 Determination of Catalase

Catalase activity was estimated by the method of Aebi [27]. Catalase is preset in nearly all animal cells, plant and bacteria and acts to prevent accumulation of noxious H2O2 which is converted to O2 and H2O i.e. H2O2+ H202→2H2O + O2 peroxidase which were less widely distributed catalyze the above reaction. At high concentrations of low molecular weight alcohols or formaldehyde and low peroxide concentration, catalase exhibits peroxidative activity. Procedure: To a cuvette containing 1.9 mL of 50 mM phosphate buffer, 0.1 mL of hemolysate was added (pH 7.0). 1.0 mL of freshly made, 30 mM H2O2 was added to begin the enzymatic process. The rate of decomposition of H_2O_2 was measured by spectrophotometer from changes in absorbance at 240 nm. Catalase activity was measured in U/g Hb.

2.10 Determination of Malondialdehyde

Lipid peroxidation product was measured as an index of MDA formation by Shah and Walker‟s. [28] method. Principle: Malondialdehyde was determined as a conjugate with TBA. TCA was used to precipitate proteins, which were subsequently centrifuged to be eliminated. At 534 nm, the MDA-TBA complex was measured. Procedure: Two test tubes were labeled as test and blank, respectively. 1ml of the test solution was dispensed into the tube labeled test and 1ml of

distilled water into the tube labeled blank. Reagents 1, 2, and 3 were dispensed in 1 ml volume to the test and the blank, respectively, and mixed. The tubes were incubated for 15 minutes in a boiling bath, followed by 20 minutes of cooling at room temperature. Then, the test tubes were centrifuged at 2000 rpm for 15 minutes and the supernatant layer was read at 534 nm. The concentration of MDA (nmol/ml) was calculated by using the following formula: Concentration of the test= Abs (test) –Abs (blank) / 1.56 x 1000000.

2.11 Histopathological Analysis

The theory of dye, which states that basic dye stains the acidic components of the tissue while acidic dye stains the basic components, served as the basis for the histological reaction. While eosin is an acidic stain (counter stain), hematoxylin is a primary stain (basic dye) that stains the basic component (cytoplasm) of the cell, giving it a pink hue. The tissue was processed in accordance with the accepted histological processing procedures outlined by Aviwioro et al [32]. Erhlich's hematoxylin and eosin was used to stain the tissues after they were cut into 4 mm sections using a rotary microtome. Using an Olympus® digital microscope at x400 magnification, photomicrographs of the stained tissue slices were produced.

2.12 Statistical Analysis

All collected data were presented as mean and standard deviation. The gathered data were examined using the SPSS Software, version 23.0. One-way ANOVA was utilized to compare the results between the control group and the test group, and Bonferroni multiple comparison was used to compare the group means. A probability level of p 0.05 was used to assess the degree of significance. Level of significance was determined at a probability level of $p< 0.05$.

3 Results and discussion

Results from Table 1 revealed that there was significant ($P<0.05$) decrease in the body weight (165.80 ± 3.93) and kidney weight (2.02±0.06) in female albino rats treated with aluminium chloride ($AlCl_3$) in comparison with the control (191.22± 1.66 and 2.88±0.06) respectively. However, the body weight (193.38±3.30) and kidney weight (2.87±0.03) increased significantly ($P<0.05$) back to normal when treated with *Spondias mombin* + $AlCl_3$ as compared to the control group (191.22± 1.66 and 2.88±0.06). Results from Table 2 shows that there was significant ($P<0.05$) increase in the concentration of serum urea (13.75 ± 0.22) and creatinine (43.92±1.15) in female albino rat treated with $AlCl_3$ compared with the control group (5.63 ± 0.31and 22.48±1.06) respectively. However, there was statistically significant ($P<0.05$) decrease in the concentration of serum urea and creatinine in female albino rat treated with *Spondias mombin* + $AlCl_3$ back to normal (control group). Results from Table 3 shows that there was statistically significant ($P<0.05$) decrease in superoxide dismutase (SOD) and catalase (CAT) which MDA increased. On the other hand, there was significant ($P<0.05$) increase in SOD and CAT respectively which MDA decreased. Figure 1 shows the microscopic examination of the kidney sections from rats studied. Slide shows transverse section of kidney cortex with normal histology showing the normal glomerulus with a bowman's capsule. The proximal, distal tubules and collecting ducts are all consistent with normal histology. Figure 2 shows abnormal kidney showing a glomerulus with distorted membrane and loss of Bowman's capsule. Some pattern of tubular necrosis was detected in the rats intoxicated with 100 mg/kg of $AlCl_3$. Section inconsistent with normal morphology compare with normal. Fig 3.3 indicates kidney section of rats treated with *Spondias mombin* + $AlCl_3$ showing normal histology when compared to those treated with $AlCl_3$, showing the nephroprotective potential of *Spondias mombin.*

Table 1 Effect of Aluminum Chloride (**$AlCl_3$**) and the ethanol extract of *Spondias mombin* in the body weight and kidney weight of albino female rats

Treatment	Body Weight (g)	Kidney Weight (g)	Kidney Weight/Body Weight x 100%
Group I Normal Control (saline water)	191.22± 1.66a	2.88±0.06a	1.50±1.66a
Group II Positive control ($AlCl_3$)	165.80 ± 3.93b	2.02±0.06b	1.21±3.39b
Group III *Spondias mombin* (100mg/kg b.w) + $AlCl_3$ (100mg/kg b.w)	193.38±3.30a	2.87±0.03a	1.48±3.30a

Superscript letter(s) different from the control are statistically significant at ($P<0.05$).

Table 2 Effect of Aluminum Chloride (**$AlCl_3$**) and the ethanol extract of *Spondias mombin* in the serum urea and creatinine of albino female rats

Treatment	Urea (mmol/L)	Creatinine (mmol/L)
Group I Normal control (saline water)	5.63 ± 0.31[a]	22.48±1.06[a]
Group II Positive control ($AlCl_3$)	13.75 ± 0.22[b]	43.92±1.15[b]
Group III (*Spondias mombin* (100mg/kg b.w) + $AlCl_3$ (100mg/kg b.w)	5.68 ±0.30[a]	22.76±0.81[a]

Superscript letter(s) different from the control are statistically significant at (P<0.05).

Table 3 Effect of Aluminum Chloride (**$AlCl_3$**) and the Ethanol Extract of *Spondias mombin* on Antioxidant Enzymes in the Kidney of albino female rats

Enzyme	SOD (unit/mg protein)	CAT (unit/mg protein)	MDA (unit/mg protein)
Group I (Control distilled water)	7.77±0.27[a]	75.11±1.29[a]	385.52±0.69[a]
Group II Positive control ($AlCl_3$)	5.86±0.13[b]	65.05±1.32[b]	399.52±1.47[b]
Group III *Spondias mombin* (100mg/kg bw) + $AlCl_3$ (100mg/kg b.w)	7.78±0.28[a]	75.11±1.30[a]	385.53±0.70[a]

Superscript letter(s) different from the control are statistically significant at (P<0.05).

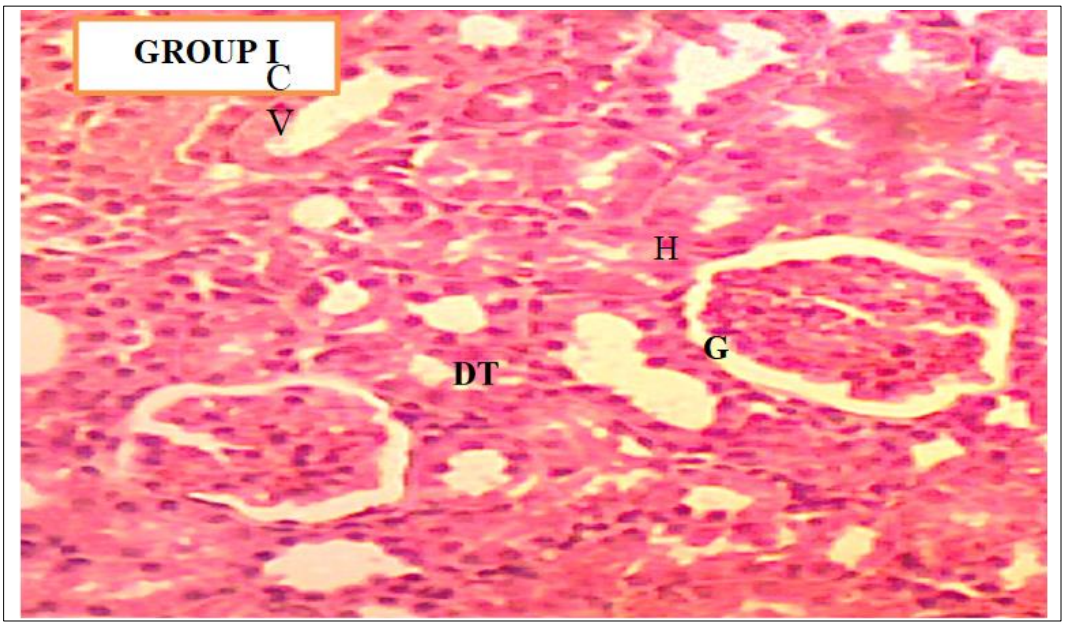

Figure 1 CONTROL (Saline water). Microphotograph of kidney section showing normal histomorphology of the kidney (normal glomeruli (G), distal tubules (DT), proximal tubules and collecting ducts (C))

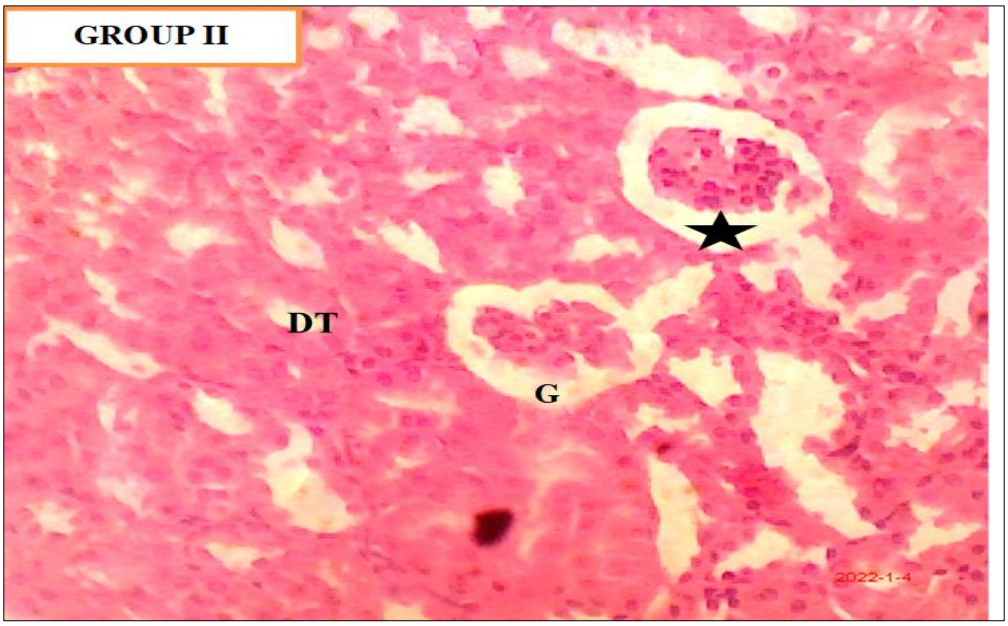

Figure 2 Microphotograph of kidney from rats intoxicated with 100mg/kg $AlCl_3$. Slide shows morphology of the kidney with degenerated glomeruli (G) showing wide urinary space (star) and vacuolar degeneration of tubules. Section inconsistent with normal morphology compared to the negative control (DT). (Haematoxylin and Eosin X40 Magnification)

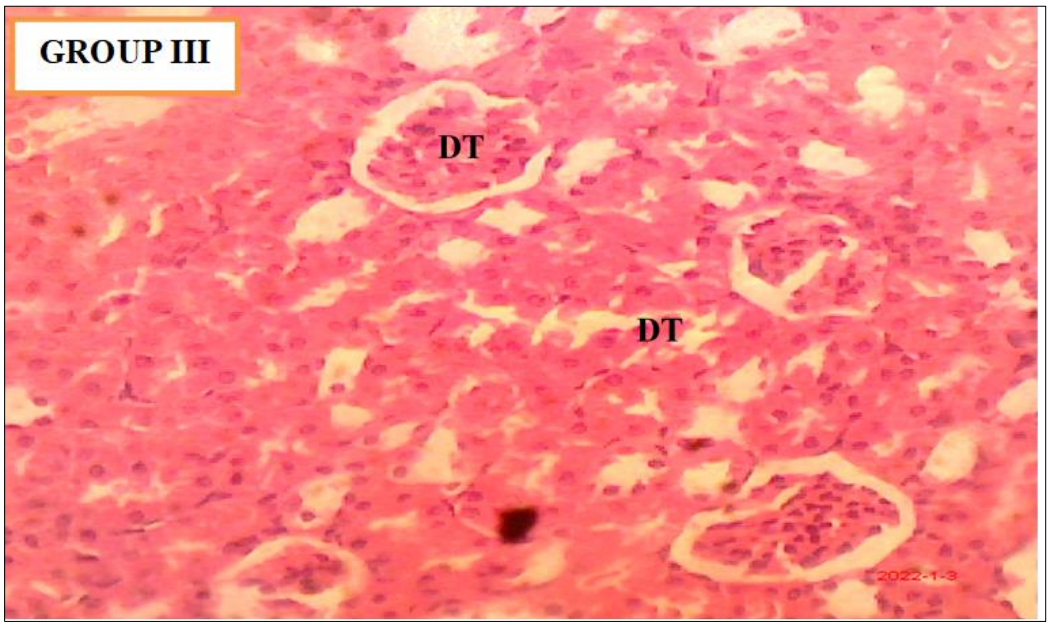

Figure 3 Microphotograph of kidney after the administration of *Spondias mombin* (100mg/kg b.w) and **$AlCl_3$** (100mg/kg b.w). Slide shows normal histology of the kidney when compared to that treated with **$AlCl_3$** alone, glomeruli (G), distal tubules (DT). (Haematoxyllin and Eosin stained X40 Magnification)

4 Discussion

This study was performed to investigate the protective potential of *Spondia mombin* against aluminium chloride induced biochemical and histological changes in the kidney of female rats. However, it is an established fact that plasma urea and creatinine as well as oxidative stress markers such as malondialdehyde, superoxide dismutase and catalase are renal health indicators, and the alteration in their levels and activities is an indicator of the renal dysfunction and

disturbances in the histological architecture of kidney. Renal toxicity is caused by aluminum accumulation in the kidneys [30]. According to reports, the normal process of renal excretion may expose the kidney to high quantities of aluminum, making the kidney prone to aluminum-mediated toxicity, which depends on the exposure route [2].

The current investigation demonstrated that the body weight of Aluminum Chloride administered rats was significantly ($P<0.05$) decreased compared to group I (control). Also, the visceral organ (kidney) weight was significantly reduced ($p<0.05$) as compared with the control group (Table 1). This is consistent with previous works by Ogueche et al., [31] and Bekhedda et al., [32], which stated that body weights of animals, decreases with respect to the concentration of toxicant ($AlCl_3$) and duration. This reduction in body weight and organ (kidney) weight may be attributed to the anorectic potential of aluminum, by decreasing the biosynthesis of serotonin and dopamine, that are primarily regulate digestive and dietary behaviour and the control of satiety [32]. However, the rats treated with Aluminum chloride and *Spondias mombin* demonstrated significant ($p<0.05$) increase in the body weight and kidney weight in comparison with $AlCl_3$ alone treated rats.

Prolong exposure to aluminum chloride induced renal toxicity due to elevated concentrations of serum creatinine and urea that are dependable biomarkers of renal dysfunction [30]. Creatinine and urea are metabolic wastes that are normally excreted and only small amount remain in the blood. aluminum chloride disrupts renal physiology resulting in elevated creatinine and urea in circulation. The findings in the current study revealed that $AlCl_3$-intoxicated rats showed significantly ($p<0.05$) elevated serum urea and creatinine concentration with marked detectable histopathological alternations in the renal tissues including with degenerated glomeruli showing wide urinary space, vacuolar degeneration of tubules, and necrosis of cells (table 2 & figure 2). This is consistent with the works of Imam et al. [33], Yakubu and Musa [34] and Vijayaprakash *et al.* [35], which reported an elevated serum urea and creatinine levels in $AlCl_3$-intoxicated rats. The alterations observed could be mediated by several mechanisms such as the production of pro-oxidant by $AlCl_3$ that initiate cellular damage [36], or could be related to metabolic disturbances [37]. In contrary, the rats administered with $AlCl_3$ and *Spondia mombin* did not show any significant difference in serum urea and creatinine levels with normal kidney histological architecture when compare with the control. However, it causes an improvement of the histological changes or damage induced by aluminum chloride intoxication. This finding indicates that *Spondias mombin* possess a nephroprotective potential against $AlCl_3$-induced nephrotoxicity.

The kidney is involved in the elimination of several toxins, xenobiotics, and pollutants which are known to produce high amounts of free radicals, causing oxidative stress that is primarily involved in the pathogenesis of renal injury/damage [38]. Oxidative stress has been implicated in aluminum chloride-induced organs/tissues dysfunction toxicity including nephrotoxicity (Oda, 2016). A study by Yuosef, [39] demonstrated that aluminum chloride induced oxidative stress in rabbit organs (kidney). The current study showed statistically significant ($p<0.05$) increase in activities of lipid peroxidation, and significant ($p<0.05$) reduction in the superoxide dismutase (SOD) and catalase (CAT) activities in the $AlCl_3$ induced rats compared with the control group (table 3). The primary toxic influence of $AlCl_3$ on cells/tissues is attributed to its cellular damage that targets the cell membrane, thus influences its fluidity and permeability causing lipid peroxidation to the plasma membrane, leading to the elevated malondialdehyde (MDA) levels [40]. The increase in lipid peroxidation is in accordance with Mohammed, [41], who reported an increased lipid peroxidation products (MDA) level in $AlCl_3$ intoxicated rats. Furthermore, the study revealed that $AlCl_3$ significantly ($p<0.05$) decreases the renal SOD and CAT activities in the study animals. This reduction in the activities of SOD and CAT signifies the reduction a biosynthesis of these defense enzymes due to higher accumulation of $AlCl_3$ and/or higher accumulation of superoxide anion ($O2.-$) and H_2O_2 in renal tissue [40]. The superoxide anion ($O2.-$) and H_2O_2 interaction seen in $AlCl_3$ accumulation resulted in the formation of peroxynitrite ($ONOO-$) which amplify renal injury [42].

Furthermore, the study also revealed that treatment of $AlCl_3$ intoxicated rats with *Spondias mombin* after one hour for 14 days significantly ameliorate or protects renal toxicity by decreasing the level of serum creatinine and urea, reduced renal lipid peroxidation activities and elevation in SOD and Catalase activities as shown in (table 3). *S mombin* alleviates $AlCl_3$ induced renal injury by repairing the antioxidant balance favoring the endogenous antioxidant molecules replacement, through the stimulation process to increase antioxidant enzymes in renal tissues. The protective potential of *S. mombin* could be attributed to the polyphenolic groups present in *S. mombin* that reduce LPO production and scavenge $O2.-$ and H_2O_2. The antioxidant activity of *S. mombin* may mitigate nephrotic oxidative susceptibility through neutralization of RONS subsequently diminish nephrotoxicity mediated by $AlCl_3$ [41].

The histological studies revealed that the kidney section treated with $AlCl_3$ showed an abnormal kidney architecture having a glomerulus with distorted membrane and loss of bowman's capsule, and tubular necrosis when compared to the control as shown in (figure 2). However, the kidney section treated with *Spondias mombin* (100mg/kg body weight) and $AlCl_3$ (100mg/kg body weight) revealed a normal kidney morphology having a glomerulus with a bowman's capsule as compared to those treated with $AlCl_3$ (figure 3). This indicates that *Spondias mombin* possess a nephroprotective

potential against $AlCl_3$-induced renal injury. This confirmed the result of the renal biochemical parameters (urea and creatinine). This protective property could be attributed to phytochemicals such as alkaloids, flavonoids and tannins present in *S. mombin* extracts which is responsible for the observed histological changes. These compounds have been shown to exhibit differential biochemical and pharmacological actions that can cause cell toxicity [43].

5 Conclusion

The result revealed that exposure aluminum induced marked detectable alterations in histological and biochemical parameters such as urea, creatinine, malondialdehyde, superoxide dismustase (SOD) and catalase (CAT). The study also demonstrated that *Spondias mombin* suppresses the toxic effect of $AlCl_3$ nephrotoxicity by alleviation of biochemical parameters and reducing the degenerative changes in renal tissues. This could be attributed to its ability to scavenge ROS and enhancing the endogenous antioxidant molecules causing modulation of renal blood flow and glomerular filtration rate, thus regulate the renal function. In view of the result of this study and previous report, it is highly recommended that people should avoid or minimize exposure to aluminum content in foods, water and environment.

Compliance with ethical standards

Acknowledgments

The authors appreciate Technical Laboratory Instructors and students in the Department of Medical Biochemistry and Medical Laboratory Science for their support in making the work a huge success.

Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

Statement of ethical approval

The study protocol was approved by the Ethical and Research Committee of Niger Delta University, Bayelsa State, Nigeria. The ethical principles for medical research involving animal subjects as outlined in the Helsinki declaration in 1975 and subsequent revisions were strictly followed in the course of this study.

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