Original Article

# Centella Asiatica Improves Aluminum Chloride-Induced Toxicity in the Rat Liver and Kidney by Reducing Oxidative Stress and DNA Damage

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## ABSTRACT

**Introduction:** Aluminum (Al) is a harmful element to human beings and animals widely used worldwide. It has been associated with the incidence of several diseases. Centella Asiatica (CA) has been utilized as a natural antioxidant, hepatoprotective, and anti-inflammatory agent.

**Aim of the Work:** The current study aims to assess the safeguard function of CA extract against aluminum chloride (AlCl3) provoked hepatotoxicity and nephrotoxicity in rats.

**Material and Methods:** Forty-eight rats were distributed into 8 groups. Control group received dist. water and Al-group was given AlCl3 (100 mg/kg); groups (3, 4 &5) were given various dosages of CA treatment (200, 400, and 600 mg/kg); and groups (6, 7 &8) were treated with both CA (200, 400, and 600 mg/kg respectively) and AlCl3 (100 mg/kg) orally for five weeks. Oxidative stress biomarkers Malondialdehyde (MDA), Superoxide dismutase (SOD), and Glutathione (GSH) were assessed, the comet assay was used to assess the level of DNA damage in liver and kidney tissues, additionally, histopathological examinations were performed.

**Results:** CA treatment effectively eliminated free radicals and restored oxidant/antioxidant balance in the liver and kidneys. It decreased MDA levels and increased the activity of GSH and SOD. CA treatment also decreased DNA damage induced by Al. Histopathological studies indicated that CA extract improved the architecture of the liver and decreased the infiltration of inflammatory cells caused by Al.

**Conclusion:** Centella Asiatica can restore tissue homeostasis by increasing antioxidant enzymes, eliminating ROS, and serving as a protective agent for DNA, thus safeguarding liver and kidney tissues from aluminum-induced toxicity.

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**Key Words:** AlCl3, CA extract, hepatotoxicity, inflammation, nephrotoxicity.

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## INTRODUCTION

Aluminum (Al) is the third naturally occurring metal in the crust of the Earth. It is vastly utilized in modern lifestyles and industrial goods, exposing humans to potential threats[1,2]. This metal's principal path is through processed foods and chemically filtered water, with a smaller amount potentially entering through the skin[3]. There are several products containing aluminum, such as antacids, cosmetics, internal analgesics, anti-ulcer drugs, astringents, and antiperspirants[4]. Al accumulates in the liver, heart, brain, kidneys, and other mammalian organs. It is linked to hepatic dysfunction, nephrotoxicity, neurotoxicity, and cardiotoxicity[2,5-7]. Degeneration of renal tubular cells might result from Al deposition in the kidney as well and results in nephrotoxicity because most of the Al is excreted by the kidneys[8]. Whereas Al intoxication causes decline in antioxidant enzyme activities and a rise in the lipid peroxidation, which in turn causes oxidative stress by disrupting the oxidative/antioxidative equilibrium and damages lipids, proteins, and DNA[9-12].

Centella asiatica (CA) extract has been utilized for ages as herbal medicine in many countries[13]. In addition, CA is widely applied in the cosmetic, food, and pharmaceutical industries due to its various bioactive compounds, such as vitamins, minerals, triterpenoids, volatile oil, phenolic compounds, pectin, and free amino acids[14-16]. CA has numerous biological properties, including anti-inflammatory, antioxidant, antihyperlipidemic, antihypertensive, anti-atherosclerotic, neuroprotective, antibacterial, antidiabetic, diuretic, antiviral, cardioprotective, and anticancer activities[17].

Recent research has shown the CA extract's protective properties on the liver against acetaminophen[18]. Moreover, The extract can reduce renal oxidative stress by decreasing lipid peroxidation[19,20]. This may be due to CA containing abundant amounts of triterpene, asiatic acid, saponins, asiaticoside, madecassoside, and madecassic acid[21]. A triterpenoid component of CA extract is called Asiatic Acid (AA), exhibits anti-oxidative, hepatoprotective properties, and anti-inflammatory activities[22]. Limited studies

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illustrated the safeguarding role of CA extract against aluminum chloride-induced toxicity to rats.

In this work, the protecting role of three different doses of CA extract was investigated against AlCl3- stimulated toxicity in the tissues of the kidney and liver of rats. DNA damage was evaluated using comet assay and the lipid peroxidation biomarker Malondialdehyde (MDA), the activity of the antioxidant enzymes Glutathione (GSH) and Superoxide dismutase (SOD) was measured, and the histological changes was examined in the liver.

## MATERIAL AND METHODS

### *Chemicals*

Centella asiatica extract[23] was purchased from Amazon (Product code: SWV-14031), Aluminium chloride, formaldehyde, saline, agarose, low melting agarose, Triton X-100, Tris-(hydroxymethyl)-amino methane (Tris-base), absolute ethanol, ethylenediaminetetracetic acid disodium salt (Na2EDTA), and ethidium bromide (EtBr) was obtained from Sigma-Aldrich (St. Louis, Missouri, USA).

### *Experimental animals*

Institutional Animal Care and Use Committee (CU-IACUC) at Cairo University, Faculty of Science, approved the experimental animal protocol (approval number CU/I/F/78/19). The experimental animal investigations were conducted following ARRIVE principles. We obtained 48 adult male Wister rats, weighing between 100 and 150 grams, from the National Organization for Drug Control and Research in Cairo, Egypt. For seven days, the rats were housed in a climate-controlled environment with unlimited access to food and water.

### *Experimental design*

48 rats were separated into 8 groups, six in each group. They received three distinct oral doses of CA for five weeks as illustrated:

**Control group** was administered oral distilled water.

Al group was treated orally with (100 mg/kg/day) of AlCl3 was dissolved in distilled water.

The groups (3, 4&5) were treated with various doses of CA orally (200, 400, and 600 mg/kg/day) respectively dissolved in distilled water.

The groups (6, 7&8) were treated orally with CA and AlCl3. The CA was administered first (200, 400, and 600 mg/kg/day, respectively), followed by AlCl3 after 2 hours of CA administration (100 mg/kg/day). This was done for five weeks.

The doses of CA and AlCl3 were selected based on previous studies[24,25]. CA and AlCl3 were dissolved in distilled water and made freshly at the beginning of each experiment daily. For each group, half of the rats were subjected to the treatment for three weeks, while the other half have received the treatment for five weeks. The rats after 24 hours following the last treatment euthanized, and the liver tissues were stored for histological analysis, while the remaining kidney and liver tissues were kept for biochemical investigations and DNA damage assay.

### *Assessment of the oxidative stress biomarkers*

We followed the established protocols by Beutler *et al*., Ohkawa *et al*., and Nishikimi *et al*., The supernatants of the homogenized liver and kidney tissues were used to measure the levels of Malondialdehyde (MDA), Superoxide dismutase (SOD), and Glutathione (GSH)[26-28].

### *Assessment of the level of DNA damag using comet assay*

The degree of DNA degradation was determined using the alkaline comet test in both of the renal and hepatic tissues. Ehidium bromide-stained slides were examined using the fluorescent microscope (Leica, Germany). Fifty cells were scored using TriTek Comet ScoreTM Software Version 1.5. The following parameters were utilized to measure the DNA damage level in each cell: Tail length (TL), which quantifies DNA migration from the nucleus, DNA percentage (%DNA) in the tail, the tail moment (TM), and olive tail moment (OTM)[29,30].

### *Histopathological examination*

Fresh liver specimens from the treated groups were promptly fixed in ten percent buffered formalin. Then, the tissues were thoroughly washed with tap water, they were dehydrated using ascending grades of alcohol, then cleared using xylene. The samples were subsequently incorporated in the paraffin wax, heated for 24 hours at 56 °C in a hot air oven, and then sectioned into 5 micrometer-thick slices by a rotating LEITZ microtome. Tissue slices were gathered and placed on glass slides, deparaffinized using xylene, hydrated using a decreasing sequence of alcohol and stained using standard H&E stain, and investigated via a light microscope[31].

### *Statistical analysis*

Data gathered was confidently evaluated by applying IBM-SPSS software version 23 and conclusively found to be normally distributed based on the test of Kolmogorov-Smirnov. A robust two-way ANOVA was employed to fully investigate the effects of time and/or treatment on the examined variables. The test of Duncan was confidently employed to measure homogeneity among the groups, on the other hand, significant changes across time intervals were confidently detected using the least significant difference (LSD) method.

## RESULTS

### *CA extract ameliorates oxidative stress in the kidney*

The data of MDA level, GSH, and SOD activities revealed no significant differences ($P$>0.05) between the CA extract-treated groups and the control group, except for GSH activity in CA400 and CA600 groups were significantly ($P$<0.05) as compared to the control group.

Comparing the Al-treated group to the control group, there was a substantial ($P$<0.05) increase in MDA levels and a significant ($P$<0.05) drop in SOD and GSH activity. The groups given CA+Al showed an obvious decrease in the level of MDA with increasing CA dosage. After 3 weeks, there was a substantial increase in GSH activity, but after 5 weeks, this increase was insignificant for all CA+Al treated groups. SOD activity significantly differed in all CA+Al-treated groups when compared to the AlCl3-treated group after 3 weeks as demonstrated in (Figure 1).

### *CA extract ameliorates the oxidative stress in the liver*

The liver's GSH concentration, SOD activity, and MDA levels after three and five weeks are shown in (Figure 2). After three and five weeks, there were no statistically significant variations ($P$>0.05) in the MDA levels between the control and CA-treated groups. Regarding GSH levels, no statistically significant ($P$>0.05) variations was shown between the groups receiving varying dosages of CA treatment for the two durations. After three weeks, the SOD activity in the CA-treated groups differed significantly ($P$<0.05) from the control group, with the exception of CA200, which did not alter significantly ($P$>0.05). The group treated with aluminum (Al) exhibited a significant raise ($P$<0.05) in the MDA levels and a significant decreases ($P$<0.05) in GSH and SOD activities compared to the control group. Rats given CA+Al showed a significant ($P$<0.05) decrease in MDA levels when the dose of CA was increased at both 3 and 5 weeks. SOD and GSH activities demonstrated significant ($P$<0.05) elevation, except for CA200+Al, where (GSH&SOD) revealed no obvious change after three weeks when compared to the group received AlCl3 treatment. The GSH content was consistent among the CA200+Al, CA400+Al, and CA600+Al groups, showing a significant increase in comparison to the Al-treated group as shown in (Figure 2).

### *CA extract protects the kidney tissue against DNA damage*

In (Figure 3), The control group and those received the CA doses for both durations did not differ significantly in terms of TL, %DNA damage, or TM values. However, there was a notable ($P$<0.05) difference in the OTM values in all CA treated groups in comparison with the control group. At both durations, there was a notable alteration in the DNA damage parameters between the AlCl3-treated group and the control group. Additionally, in comparison to the Al group at both durations, the experimental animals treated with varying doses of CA+Al showed a significant ($P$<0.05) reduction in the DNA damage parameters (TL, %DNA, TM, and OTM) in a dose-dependent manner. Subsequent to the clarification of the statistical results, the findings were further confirmed by fluorescence microscopy images, as depicted in (Figure 4)

### *CA extract protects the liver tissue against DNA damage*

The changes in TL, %DNA, TM, and OTM in the liver after 3 and 5 weeks are displayed in (Figure 5). No significant differences in TL and %DNA damage and TM values among the control group and those treated with different doses of CA at the examined durations, except CA600 (TL) and CA400 (TM) for 3 weeks were statistically significant ($P$<0.05) in comparison to the control group. However, the OTM values in the majority of the CA groups differed significantly ($P$<0.05) from those of the control group.

For both durations, there was a statistically significant increase in all DNA damage measures in the Al-treated group when compared to the control group. Furthermore, all DNA damage indicators showed a significant ($P$<0.05) decrease in experimental animals treated with CA+Al. The findings were additionally supported by fluorescence microscopy images, as illustrated in (Figure 6), which visually validated the statistical data.

### *Protective effect of CA extract on hepatic tissue architecture*

By using the light microscope the liver sections were examined. Both the control and treated groups (CA200, CA400, and CA600) exhibited normal liver architecture and hepatocytes with a typical histological structure of the central vein after 3 weeks of treatment. However, degenerated hepatocytes, portal vein congestion, and a few inflammatory cells entering the portal area were observed in the AlCl3 group. The CA200+Al group also included deteriorated hepatocytes with a little infiltration of inflammatory cells and severe dilatation of the portal vein. The CA400+Al group exhibited congestion in the portal vein with edema and few inflammatory cell infiltrations, while the CA600+Al group showed nearly normal hepatocytes in the portal area, few inflammatory cell infiltrations, and congestion in the portal vein with edema as shown in (Figure 7).

After 5 weeks of treatment, hepatic sections revealed normal hepatic architecture and normal hepatocytes with regular structure of the central vein in both the control and treated CA200, CA400, and CA600 groups, respectively. In contrast, the AlCl3 group exhibited islands of hepatocytes in the portal area surrounded by edema and a few inflammatory cells, along with fibrosis. Additionally, the CA200+Al group showed fatty changes in the hepatocytes at the periphery of the lobes, while the CA400+Al group had a few inflammatory cell infiltrations in the portal area. The CA600+Al group displayed normal hepatocytes, as depicted in (Figure 8).

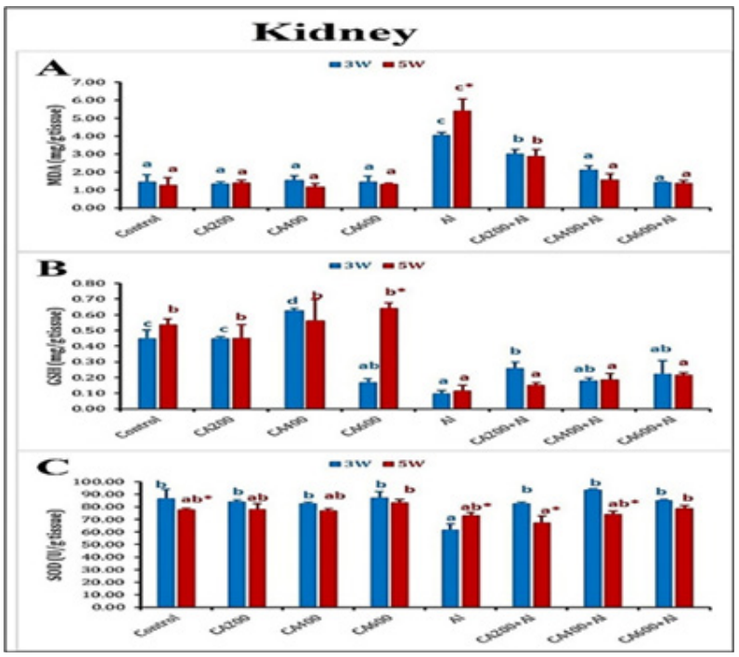


**Fig. 1:** Bar graph represents the change in the level of malondialdehyde (MDA), glutathione (GSH), and superoxide dismutase (SOD) for each of the experimental groups were measured in the renal tissue. The data are presented as mean ± standard error of the mean. Within the same time interval, values with the same superscript letters are not significantly different ($P>0.05$), while those with different letters are significantly different ($P<0.05$). *: represents the significant difference ($P<0.05$), as compared to the values after 3 weeks. CA refers to Centella asiatica and Al refers to AlCl3.

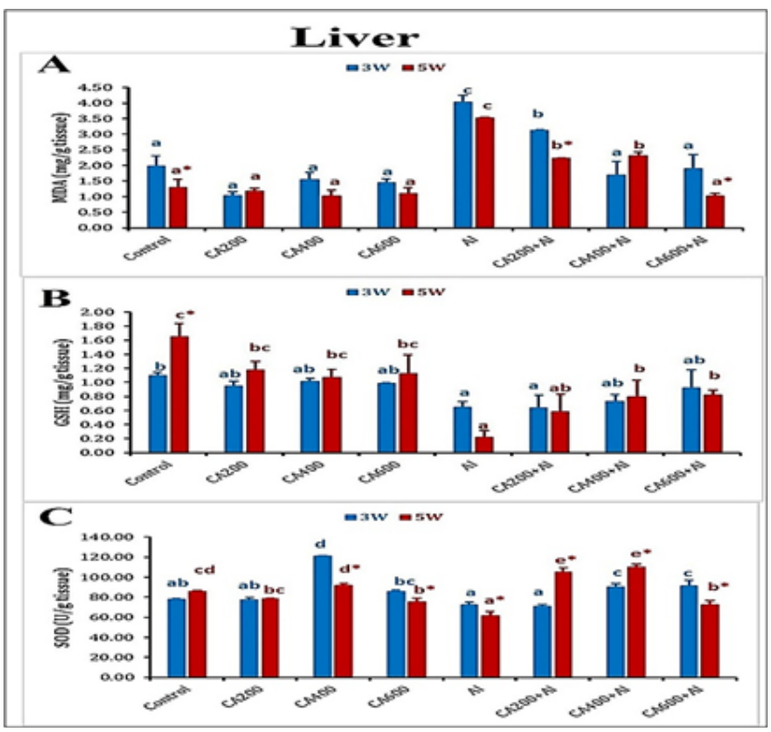


**Fig. 2:** The levels of malondialdehyde (MDA), superoxide dismutase (SOD), and glutathione (GSH) in the hepatic tissue of all the experimental groups are presented as mean ± standard error of the mean. At the same time interval, values marked with the same superscript letters are not significantly different ($P>0.05$), while those marked with different letters are significantly different ($P<0.05$). * indicates a significant difference ($P<0.05$) compared to the values after 3 weeks. CA refers to Centella asiatica and Al refers to AlCl3.

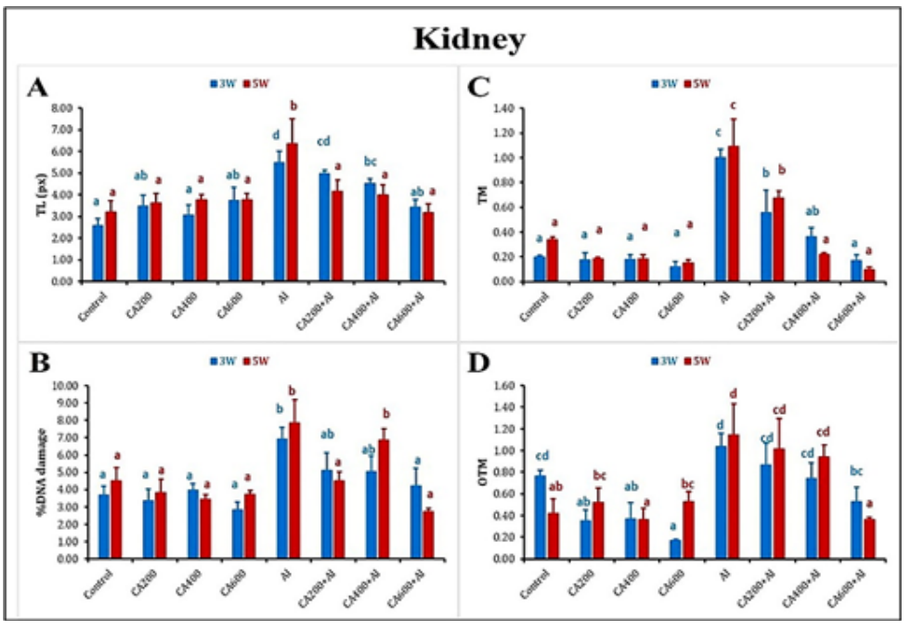


**Fig. 3:** Bar graph represents the changes in tail length (TL, px), the percent DNA damage in the tail (%DNA), the tail moment (TM), and the olive tail moment (OTM) in the renal tissue of all the experimental groups. Data are displayed as mean ± standard error of the mean. At the same time interval, the values marked with the same superscript letters are insignificantly ($P$>0.05) different, whereas those marked with different letters are significantly ($P$<0.05) different. *: represents a significant difference ($P$<0.05), as compared to the values after 3 weeks. CA: centella asiatica and Al: AlCl3.

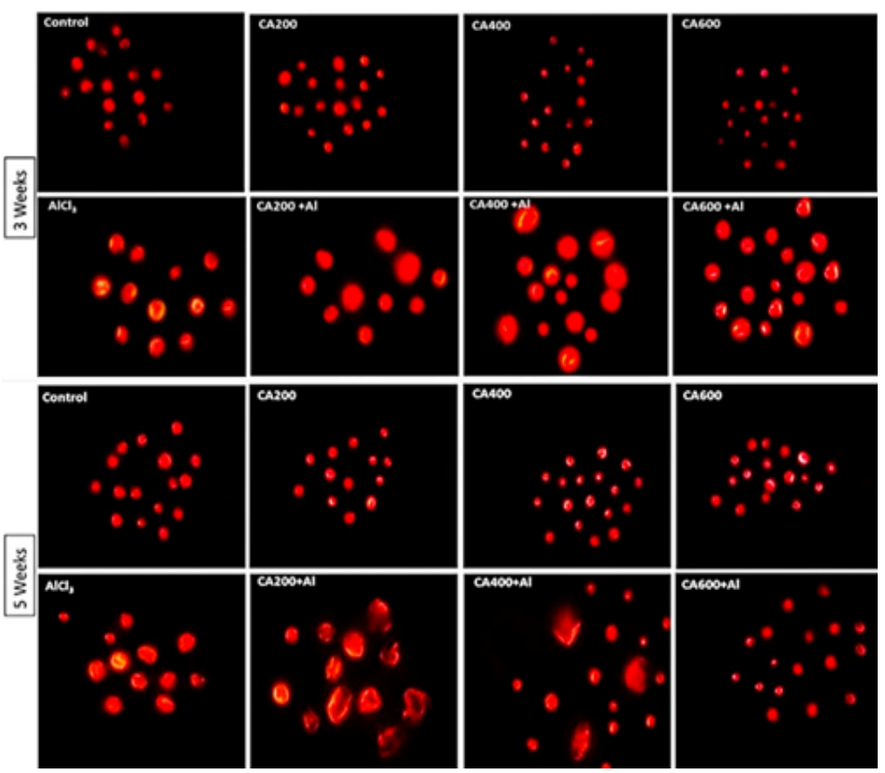


**Fig. 4:** Representative fluorescent microscope images show the extent of DNA damage using the alkaline comet assay in the renal tissue of rats administered different doses of Centella asiatica (CA) (200, 400, and 600 mg/kg/day) with and without aluminum chloride (AlCl3) (100 mg/kg/day) for 3 and 5 weeks.

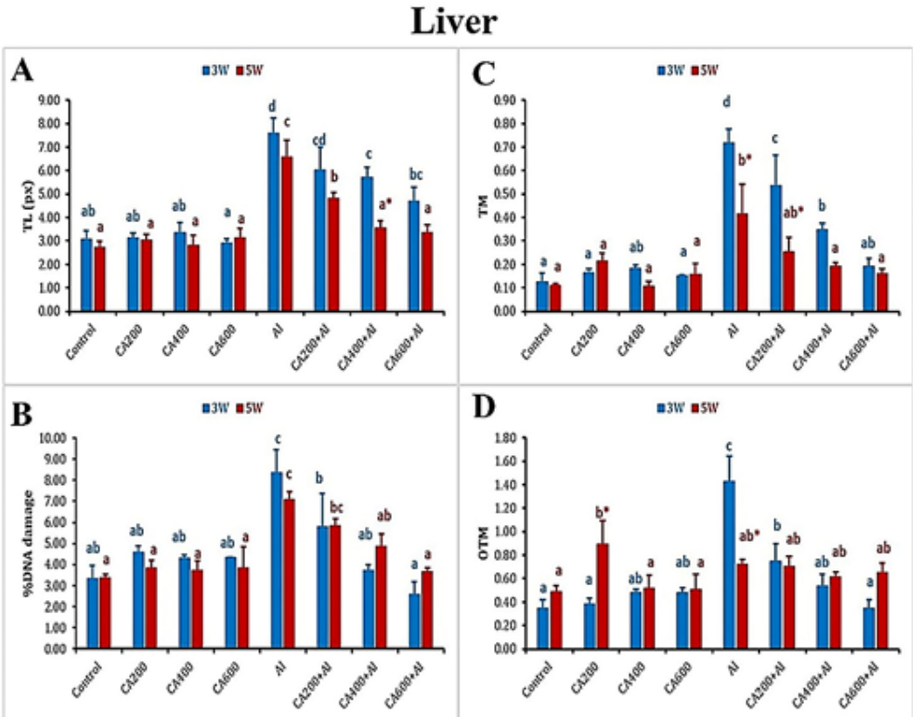


**Fig. 5:** The Bar graph represents the DNA damage parameters tail length (TL, px), the percent DNA damage in the tail (%DNA), the tail moment (TM), and the olive tail moment (OTM) in the hepatic tissue of all the experimental groups. Data are displayed as mean ± standard error of the mean. At the same time interval, the values marked with the same superscript letters are insignificantly ($P$>0.05) different, whereas those marked with different letters are significantly ($P$<0.05) different. *: represents a significant difference ($P$<0.05), as compared to the values after 3 weeks. CA: centella asiatica and Al: AlCl3.

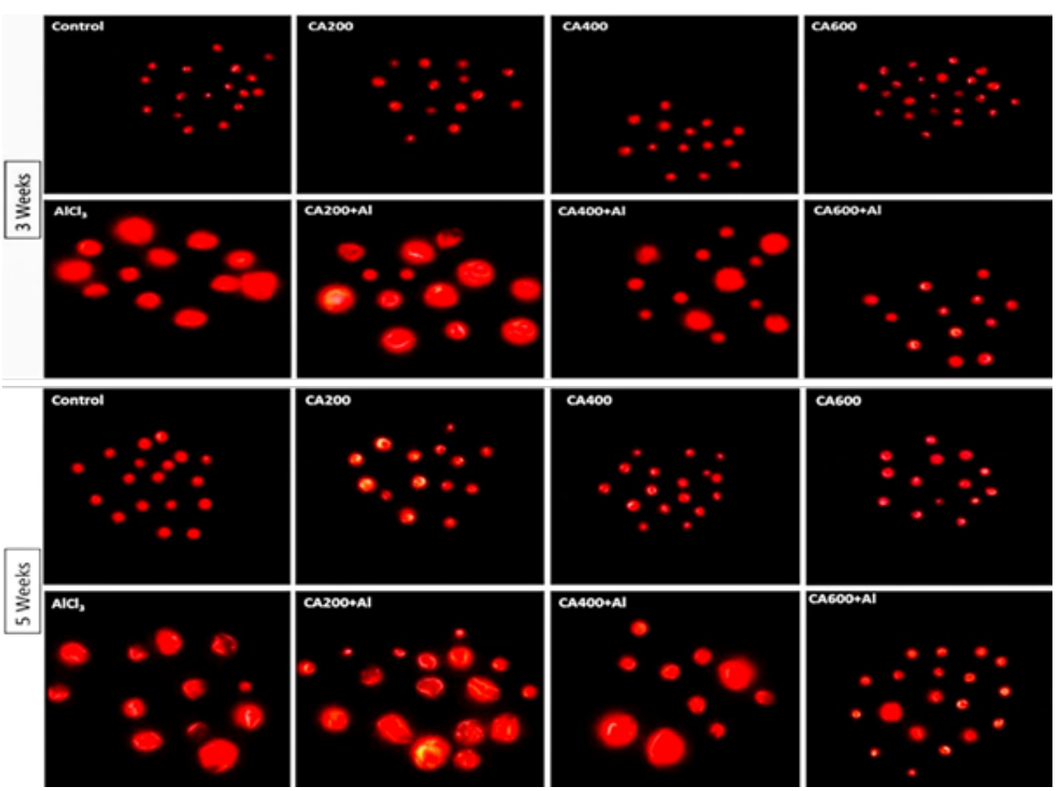


**Fig. 6:** Representative fluorescent microscope images show the extent of DNA damage using the alkaline comet assay in the hepatic tissue of rats administered various dosages of Centella asiatica (CA) (200, 400, and 600 mg/kg/day) with and without aluminum chloride (AlCl3) (100 mg/kg/day) for 3 and 5 weeks.

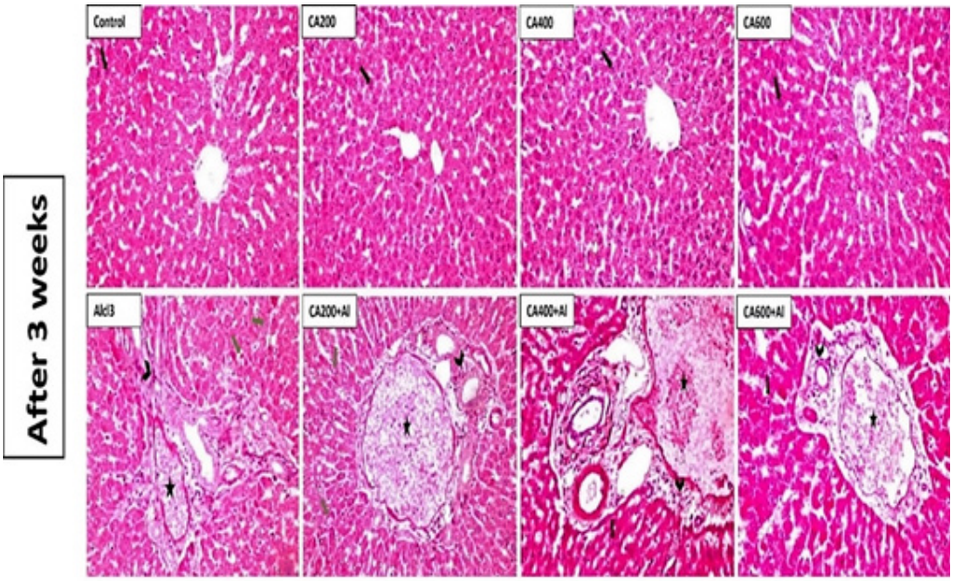


**Fig. 7:** Photomicrographs of liver sections of rats administered varying oral doses of CA (200, 400, and 600 mg/kg/day) with and without AlCl3 (100 mg/kg/day) for 3 weeks. The liver section from the control group exhibited normal histology (black arrow). The CA200, CA400, and CA600 groups respectively displayed normal hepatic architecture and healthy hepatocytes (black arrow). In the AlCl3 group, hepatocytes appeared degenerated (green arrow), with few infiltrations of inflammatory cells in the portal area (arrowhead) and obstruction of the portal vein (star). The CA200+Al group exhibited degenerated hepatocytes (green arrow) with a few inflammatory cell infiltrations (arrowhead) and severe dilatation of the portal vein. The CA400+Al group revealed an obstructed portal vein (star) with edema and a few infiltrations of inflammatory cells (arrowhead). Finally, the CA600+Al group displayed nearly normal hepatocytes (black arrow) in the portal area, with a few inflammatory cell infiltrations (arrowhead), congestion in the portal vein, and edema (H&E, 400x).

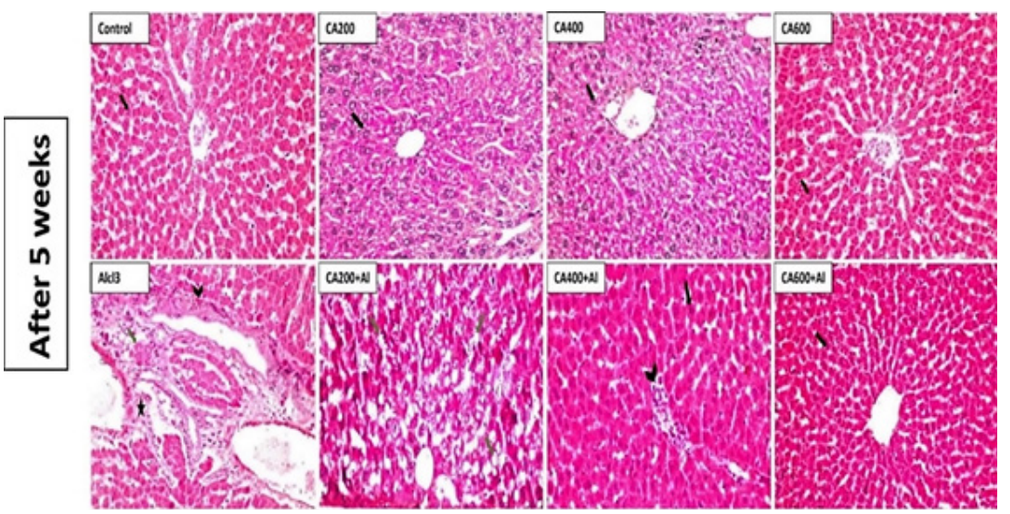


**Fig. 8:** Photomicrographs of liver sections of rats treated with different doses of CA (200, 400, and 600 mg/kg/day) orally with and without AlCl3 (100 mg/kg/day) for 5 weeks. The hepatocytes and central vein of the control group showed normal histological structure (black arrow). Animal groups treated with different CA doses displayed normal hepatic architecture and normal hepatocytes (black arrow). The AlCl3 group showed degenerated hepatocytes (green arrow), obstruction of the portal vein (star), and a few infiltrations of inflammatory cells in the portal region (arrowhead). The groups treated with CA in addition to AlCl3 also exhibited varying degrees of hepatocyte degeneration (green arrow), inflammatory cell infiltration (arrowhead), and portal vein abnormalities (star). Finally, the CA600+Al group showed hepatocytes nearly normal (black arrow) in the portal area, and normal histological structure (H&E, 400x).

## DISCUSSION

The current study demonstrated the protective effects of different CA extract dosages (200, 400, and 600 mg/kg) against the induced-AlCl3 toxicity in the rats' liver and kidney tissues. The CA extract was effective in restoring the biochemical balance following exposure to Al in the liver and kidney tissues. The CA extract decreased the amount of MDA, and increased the activity of the antioxidant enzymes (GSH and SOD) in a dose-dependent manner. Furthermore, CA safeguards the DNA from Al-toxicity, it reduced all DNA damage parameters in CA+Al treated groups as compared to Al group, in the examined durations, in a dose-dependent manner. The hepatic tissue's histological study suggested that CA extract could potentially be able to heal the tissue damage induced with AlCl3.

The liver is a critical organ plays important role in the metabolism, the detoxification, and maintaining the body's balance. Its intricate system of enzymes, transporters, and metabolic functions is crucial for converting harmful toxins into less harmful substances. When the liver is damaged or its function is impaired due to an overdose of drugs or xenobiotics, it is known as hepatotoxicity or liver toxicity[32]. The kidney is essential for regulating fluid and electrolyte balance, removing waste and toxins, controlling blood pressure, and producing hormones. Exposure to harmful chemicals can cause acute kidney injury (AKI) by impacting the glomeruli and renal tubules in humans[33].

Aluminum chloride is one of the widely used element. Al can disturb the balance between prooxidants and antioxidants in tissues, resulting in excessive reactive oxygen species (ROS) generation and causing biochemical and physiological dysfunctions[34,35].

Al can get into a person's body through air pollution, insecticides, food, and cosmetics[36]. The two main ways that aluminum enters the body are orally and through the lungs. Even though the gastrointestinal tract absorbs very little aluminum, oral consumption is linked to the highest toxicological consequences[37]. The principal locations of aluminum distribution are the bone, liver, testes, brain, and kidneys, according to the Agency for Toxic Substances and Disease Registry (ATSDR). Aluminum is linked to neurotoxicity, cardiotoxicity, hepatic dysfunctions, and nephrotoxicity[38,39].

The current study illustrated that the treatment with 100 mg/kg of AlCl3 caused an imbalance between oxidants and antioxidants, which was shown by the rise in the MDA level with a notable decrease in (GSH and SOD) activity in both of the kidney and liver tissues during the two examined durations. This was consistent with earlier studies that established a connection between Al consumption, changes in tissue antioxidant enzyme activity, and ROS production. Several studies illustrated elevation in the MDA levels and reduction in the enzyme activities after AlCl3 treatment in both of liver and kidney[40-43].

Animal groups treated with CA extract alone showed normal levels of MDA, GSH, and SOD. Additionally, co-administration of CA with Al illustrated improvement in the equilibrium between oxidants and antioxidants, as evidenced via reduction in MDA levels and rising in the antioxidant enzymes SOD and GSH concentration in the liver and kidney. So CA extract has the ability to diminish AlCl3-induced hepatic and renal toxicity. This was consistence with a previous study that illustrated, CA extract lowers the MDA levels in the animals while raising SOD and catalase levels in liver homogenates[32]. Because CA extract contains a variety of polyphenol components, it is one of the best sources of antioxidants[44].

Free radicals attack nucleic acids, lipids, and proteins resulting in oxidative DNA damage[45]. MDA is a highly reactive aldehyde that can damage DNA by creating adducts with DNA bases[46]. The AlCl3-treated group displayed a notable increase across all measures of DNA damage including Tail length (TL), %DNA, olive tail moment (OTM), and tail moment (TM) in the tissues of the kidneys and liver. These outcomes were consistent with an earlier research on Al-induced nephrotoxicity in rats, which revealed a notable rise in all DNA damage parameters[47]. This is because Al produces ROS, which are the primary cause of nephrotoxicity, and induces oxidative stress to carry out its harmful effects[47].

However, Co-administration of CA+Al had a significant impact in reducing all DNA damage parameters in the liver and kidney at both durations. This result agreed with an earlier study of Ferah Okkay *et al*. (2022), that suggested CA can control DNA damage by decreasing 8-Hydroxydeoxyguanosine (8-OHdG) expression. Excessive ROS production causes DNA oxidative damage and the synthesis of 8-OHdG[48,49]. CA has strong antioxidant properties and contains phenolic compounds such as tannins, coumarins, and flavonoids, which are crucial in scavenging radicals and protecting DNA[50]. CA has a safegurade role against DNA damage in various organs, including the kidney, liver, testes, and brain. Additionally, our findings are corroborated by earlier research that showed CA's protective effects against hepatic injury by increasing the levels of antioxidant enzymes in rats[51,52].

The histopathological findings revealed that AlCl3 produced hepatocyte degeneration, portal vein congestion and infiltration of inflammatory cells in the portal region. These outcomes, agreed with earlier study had shown the hepatotoxicity of AlCl3[43]. Exposure to Aluminum chloride causes the blood sinusoids to dilate and get congested, the hepatocytes to deteriorate and become necrotic, and the central vein to become congested. CA+Al treated groups showed enhancement in liver architecture and reduced inflammatory cells infiltration for both durations (3 & 5 weeks). This aligned with research conducted by Choi *et al*. (2016). Furthermore, Ferah Okkay *et al*. (2022), illustrated that CA alleviates hepatotoxicity through lowering apoptosis induced by oxidative stress. Additionally, previous study revealed the ability of CA to reduce liver

fibrosis and suppress histological alterations in the liver induced with AlCl3+D-gal[32].

## CONCLUSION

The study revealed that the CA extract possesses protective properties for the kidney and liver tissues. The CA extract has the ability to restore the liver and kidney tissues' biochemical equilibrium through raising antioxidant enzyme (SOD and GSH) and lowering MDA levels. Moreover, CA extract acted as a safeguard agent against DNA damage, reducing all DNA damage parameters and preserving the liver's structural integrity.

## CONFLICT OF INTERESTS

There are no conflicts of interest.

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**الملخص العربى**

# عشبة سرة الأرض تحسن السمية الناجمة عن كلوريد الألومنيوم في كبد وكلى الجرذان عن طريق تقليل الإجهاد التأكسدي وتلف الحمض النووي

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**المقدمة:** يعتبرالألومنيوم من العناصر الضارة للبشر والحيوانات حيث يستخدم على نطاق واسع في جميع أنحاء العالم وقد ارتبط بحدوث العديد من الأمراض.
عشبة سرة الأرض تم استخدامها كعامل طبيعي مضاد للأكسدة، وقائي للكبد، ومضاد للالتهابات.
**الهدف:** تهدف الدراسة الحالية إلى تقييم الدور الوقائي لمستخلص عشبة سرة الأرض ضد السمية الكبدية والكلوية التي يسببها كلوريد الألومنيوم في الجرذان.
**المواد و الطرق:** تم تقسيم ٤٨ فأر الي ٨ مجموعات: مجموعة الكنترول تلقت الماء المقطر، ومجموعة الألومنيوم تلقت (١٠٠ ملجم/كجم/يوم) من كلوريد الألومنيوم ، والمجموعات (٣ و ٤ و ٥) تلقت جرعات مختلفة من عشبة سرة الأرض (٢٠٠ و ٤٠٠ و ٦٠٠ ملجم/كجم/يوم)، والمجموعات (٦ و٧ و٨) تلقت كلا من عشبة سرة الأرض (٢٠٠ و٤٠٠ و٦٠٠ ملجم/كجم/يوم) و كلوريد الألومنيوم (١٠٠ ملجم/كجم/يوم) عن طريق الفم لمدة خمسة اسابيع. تم تقييم المؤشرات الحيوية للإجهاد التأكسدي (مالونديهايد و جلوتاثيون و سوبر أكسيد ديسميوتاز)، وتم استخدام فحص المذنب لتقييم مستوى تلف الحمض النووي في أنسجة الكبد والكلى، بالإضافة إلى إجراء فحوصات تغيرات الأنسجة.
**النتائج:** قضى علاج عشبة سرة الأرض بشكل فعال على الجذور الحرة واستعاد توازن الأكسدة/مضادات الأكسدة في الكبد والكلى. حيث قام بخفض مستويات مالونديهايد وزاد من نشاط جلوتاثيون و سوبر أكسيد ديسميوتاز. كما أدى علاج عشبة سرة الأرض إلى تقليل تلف الحمض النووي الناجم عن الألومنيوم. كما أشارت الدراسات النسيجية إلى أن مستخلص عشبة سرة الأرض ادي الي تحسين بنية الكبد وتقليل تسلل الخلايا الالتهابية التي سببها الألومنيوم.
**الخلاصة:** يمكن لعشبة سرة الأرض استعادة توازن الأنسجة عن طريق زيادة الإنزيمات المضادة للأكسدة، ،والعمل كعامل وقائي للحمض النووي، وبالتالي حماية أنسجة الكبد والكلى من السمية الناجمة عن الألومنيوم.