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Research Article

Ameliorating Efficacy of Garlic and Tomato Extract against Cadmium Induced Renal Toxicity in Albino Mice

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ABSTRACT
Cadmium (Cd) is an environmental and industrial pollutant that may induce harmful effects on humans, such as lung fibrosis, kidney tubular dysfunction, hypertension, osteoporosis, and cancer. The kidney is the primary organ targeted by chronic cadmium exposure. This work aims to determine protective effects of garlic and tomato extract against Cd induced nephrotoxicity. In this study, mice were divided into four groups. Groups I as control mice. Group II animals were administered Cd (6 mg/kg bw) orally. Group III animals were given a single dose of Cd followed by a daily dose of garlic (100 mg/kg bw) and tomato extract (50 mg/kg bw) orally. Group IV mice were given Cd followed by GE + TE for next 15 days. Autopsies were done at the intervals of 15 and 30 days post treatment. Results showed that Cd caused a significant enhancement in serum Urea, blood urea nitrogen, creatinine and alkaline phosphatase causing severe damage in kidneys. Histopathological analyses showed marked degeneration and atrophy in glomerulus followed by hyperaemia, pyknotic cell formation in the tubules. Garlic and Tomato extract prevented the toxic alterations induced by Cd. These results suggest that both the antioxidants may have protective effects against Cd induced renal toxicity.

KEYWORDS: Cadmium (Cd); Garlic extract (GE); Tomato extract (TE); kidney and albino mice

INTRODUCTION

Heavy metals have become one of toxic substances found in our environment [1]. Cadmium is very toxic heavy metal and an important environment pollutant, present in soil, water, air, food and smoke [2]. Now days, Cd contamination of soil and water has been of great concern because this metal bioaccumulates in the upper levels of food chain including humans and its toxicity is dependent on the route, amount and the duration of exposure [3].

Cadmium induces toxicity in various target organs through several mechanisms. However most of its toxic effects are believed to result from a mechanism related to its ability to generate free radicals, at a rate enough to overwhelm the antioxidant defense system of the body [4]. Cd has an extremely long half-life (20-30 years) in the human body [5] and is highly cumulative, especially in the liver and kidney [6-12].

The kidneys are the main target organs of Cd exposure. After absorption in the body, Cd is distributed in various tissues. Long-term exposure to Cd leads to its accumulation, particularly in the liver and kidneys which leads to metabolic and histological changes, and finally damage to the cell membrane [13]. It is

excreted very slowly through the kidneys [14]. Long-term exposure to Cd can cause nephrotoxicity in humans; studies in rats have shown that Cd compounds can cause nephrotoxicity. Generally, toxic effects of Cd are due to production of oxidative stress and interfering with essential elements; especially zinc (Zn) [15].

Plant food sources contain bioactive compounds that may provide additional health benefits beyond the maintenance of adequate vitamins [16]. Recently, a great deal of attention has been focused on fruits and vegetables with potent antioxidant properties. In particular, tomato and garlic are recognized to possess a wide range of beneficial effects [17].

Garlic is versatile and widely accepted by almost all cultures. Garlic is rich in organosulphur compounds [18]. Garlic (*Allium sativum*) possesses many important nutritive and antioxidant substances as selenium, sulfur-containing compounds and vitamins (A, B, C and E). The organosulfur compounds are known to exhibit antioxidant and metal-chelating properties as well as modulating inflammatory and detoxification systems [19, 20].

Tomato products contains lycopene (a major constituent) which is believed to be associated with decreased risk of chronic diseases, and its effects are suggested to be due to antioxidant properties of lycopene [21]. Serum and tissue lycopene levels have been found to be inversely related to the incidence of several types of chronic diseases including cancer [22].

The antioxidant properties of lycopene have been demonstrated both *in vivo* and *in vitro* [23]. There is also recent evidence which suggests that lycopene acts as an antiinflammatory agent [24]. It has been demonstrated that lycopene can inhibit the expression of inflammatory cytokines and reverse the loss of antioxidant enzymes induced by inflammation caused by either injecting lipopoly-saccharide or exposure to iron [25].

The present work was aimed to evaluate the protective and therapeutic role of garlic and tomato extract on cadmium induced biochemical and histopathological alterations in kidney of albino mice.

MATERIALS AND METHODS

Animals

Swiss albino mice weighing 20-25g were procured from CRI, Kasauli. They were kept and acclimatized to the laboratory conditions for 15 days under optimal conditions of light and temperature. They had *ad libitum* access to tap water. The animals were handled with humane care in accordance with the guidelines of the 'Committee for the Purpose of Control and Supervision of Experiments on Animals (CPCSEA)', India and all experimentation procedures were approved by Institutional Animal Ethical Committee (Reg No. 107/99/CPCSEA/2014-33).

Chemicals

Cadmium chloride ($CdCl_2$) was bought from S.D FINE CHEM LIMITED, Mumbai. It was dissolved in double glass distilled water and administered orally to mice. Garlic and tomatoes were obtained from the local market. Fresh garlic extract (GE) was prepared by the method of Iwalokun *et al.* [26] and tomato extract (TE) was prepared by the method of Salawu *et al.* [27] and was administered orally to mice.

Experimental Design

The mice were divided into four groups of five mice each. **Group I** – Control animals were given distilled water. **Group II** – Animals were administered a single dose of 6 mg/kg bw of cadmium orally. **Group III** – Animals were given an acute dose of 6 mg/kg bw of cadmium followed by a daily dose of 100 mg/kg bw of GE and 50 mg/kg bw of TE orally for 15 days. **Group IV**- mice were given a single dose of Cd and were kept for 15 days followed by GE + TE for next 15 days. Autopsies were done on 15 and 30 days post treatment.

Biochemical Analysis

On the day of autopsy, 1ml of blood was collected from each mouse under ether anesthesia. Blood was pooled in separate eppendrof tubes, centrifuged (3000 rpm for 15 minutes) and serum was collected in separate clean tubes. It was then used for various biochemical analyses. Serum urea, Blood urea nitrogen (BUN), creatinine and Alkaline Phosphate (ALP) were determined by using appropriate kits provided by Reckon Diagnostics P. Ltd., Vadodara, India.

Histopathological Analysis

Immediately after the autopsies, excised kidneys were removed, weighed and then fixed in alcoholic Bouin's fixative. The tissues were then washed, dehydrated, cleared in xylene and embedded in paraffin wax followed by their microtome sectioning at 5 – 7 µ. H & E staining technique was employed for histopathological studies.

Statistical Analysis

The data was analyzed by using Student's *t*-test and Anova.

RESULTS AND DISSCUSSION

Cd is ubiquitous and due to the increasing industrial use of Cd, evaluation of toxic potentials of this metal is important for the risk assessment of those ordinarily exposed to it. Cd accumulates mainly in the kidney and liver; these two organs are critical targets for acute Cd toxicity [13, 14]. The kidneys are the major sites of antagonistic interactions of essential element including Zn with Cd; therefore, it is a target organ for Cd toxicity [2].

Organ weight is an essential benchmark for toxicological studies [28]. The weight of kidney was non significantly decreased in Cd treated group as compared to control (Fig. 1). This reduction may be attributed to the damaging effects of cadmium on kidney tissue. Anderson *et al.* [29] suggested that organ toxicity can be evaluated by considering the weight of the organs after exposure to toxicant in animal toxicity studies. In Cd +GE +TE treated groups III and IV, a significant increase was observed in kidney weight of mice.

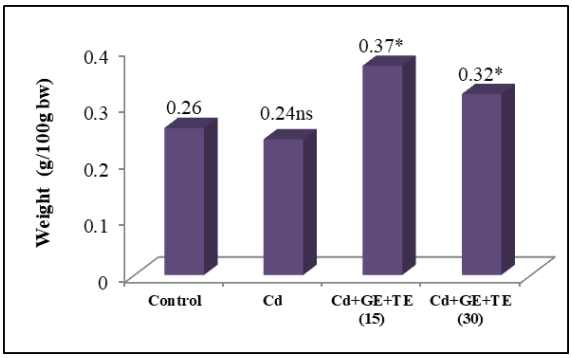

Fig.1 Kidney weight in all the treated groups. Control Vs Cd, Cd Vs Cd+GE+TE. * p<0.01, ns Non Significant

There was dose-dependent and significant ($p<0.01$) elevation in urea and creatinine in Cd treated mice (Fig. 2 and 3). It was in accordance with the results of other workers [30-33]. Further, heavy metals have been found to cause alterations in the blood biochemical attributes [34-36].

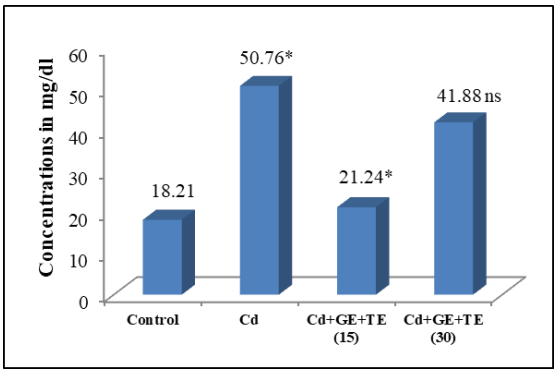

Fig. 2: Urea concentration in all the treated groups. Control Vs Cd, Cd Vs Cd+GE+TE * p<0.01, ns Non Significant

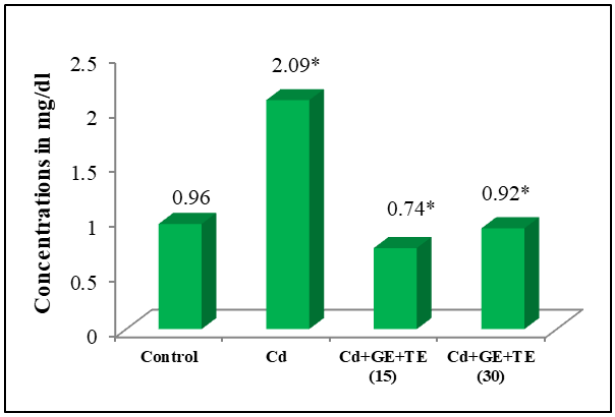

Fig. 3: Creatinine concentration in all the treated groups. Control Vs Cd, Cd Vs Cd+GE+TE
*** p<0.01, ns Non Significant**

Harper *et al.* [37] correlated the elevated urea with increased protein catabolism in mammals and for the conversion of ammonia to urea as a result of increased synthesis of arginase enzyme involved in urea production. Gaurav *et al.* [38] also stressed that urea and creatinine levels are used to monitor renal function and their levels will not rise until at least half of the kidney nephrons are destroyed.

It has been proposed that Cd exerts a direct effect on glomerulus and this leads to decrease in urea and creatinine clearance [39]. It has been postulated that increased levels of serum urea and creatinine are linked to kidney disease [40].

Cd treatment leads to the significant ($p<0.01$) elevation in the level of BUN (Fig. 4) which is an also an indicator of kidney damage as blood urea nitrogen is derived from normal metabolism of protein and is excreted in the urine. Jadhav *et al.* [41] suggested that a non-renal effect such as dehydration caused by decreased water intake due to poor palatability of dosed water could result in increase of BUN concentrations and this further indicates glomerular damage.

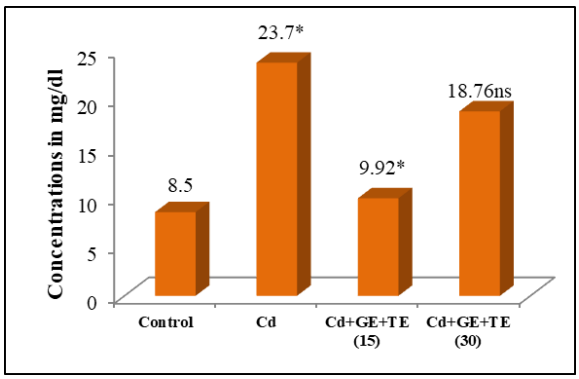

Fig. 4 BUN concentration in all the treated groups. Control Vs Cd, Cd Vs Cd+GE+TE
*** p<0.01, ns Non Significant**

Alkaline phosphatase is a zinc containing enzyme present in many tissues. It hydrolyses phosphorylcholine, so that choline can be transported across the bile canalicular membrane. There was increased level of ALP in cadmium treated group (Fig. 5). The significant ($p<0.01$) increase value of ALP activity is in agreement with the observations of Kodama *et al.* [42] and they attributed it to the increased phosphorylation or tissue damage caused by cadmium.

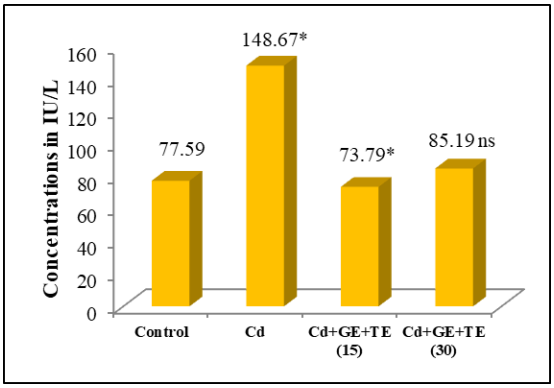

Fig. 5: ALP activity in all the treated groups. Control Vs Cd, Cd Vs Cd+GE+TE
*** p<0.01, ns Non Significant**

The increase in ALP may be attributed to the production of free radicals after intoxication which could have affected the cellular permeability leading to elevation in circulating level of this enzyme [43].

Also in the present study, the mice administered with garlic and tomato extract showed significant improvement in serum enzymes indicative of kidney function as compared with Cd treated group. In co-administered protective group III, there was significant ($p<0.01$) decline in all the biomarkers of kidney in comparison to Cd treated group. These two ingredients proved to be effective due to the strong antioxidant potential of their constituents which reduced the toxic effects induced by Cd. This study also confirmed that simultaneous administration of preventive substances along with Cd showed more protection in comparison to their therapeutic approach.

Histopathology analysis of control mice showed normal histological structure of renal corpuscles and renal tubules. The renal corpuscle consisted of tuft of blood capillaries surrounded by Bowman's capsule. The renal tubules included proximal convoluted tubules (PCT) lined by large pyramidal cells with a brush border and distal convoluted tubules (DCT) lined by cuboidal cells (Fig. 6).The renal medulla consists of collecting ducts (Fig. 7).

The mice treated with Cd (group II) exhibited histopathological changes as shrinkage or degeneration of the glomerular tuft, cytoplasmic degeneration of cells of the renal tubules, pyknotic nuclei, some tubules are necrotic, multiple foci of haemorrhage, dilation and congestion of blood cells (Fig. 8). Similarly, renal medulla also showed hyperaemia and degeneration in the walls of the collecting ducts (Fig. 9). These observations are in accordance with results of other workers [44-46].

Cd induced nephrotoxicity is thought to be mediated by cadmium-metallothionein (Cd-Mt) complex, which is synthesized in the liver and is taken up by the renal proximal tubule cells [47]. When Mt becomes insufficient for binding to all the Cd ions in liver, it is released in to blood, then it is filtered and taken up by the kidney [48]. On its way to kidney, it causes damage to the cortical region causing a gradual loss of organ function [49, 50]. These changes may also be due to production and accumulation of free radicals as a result of increased MDA in the renal tissue of Cd treated mice [51].

These pathological lesions induced by Cd were remarkably reduced by the pre and post administration of Cd + GA + TE (group III and IV) respectively. It was observed that the recovery was more in pre treated protective group III and showed the glomeruli and renal tubules appeared to be similar as that of control (Fig. 10). Renal medulla showed partial amelioration with some shrinkage in the lumen and pyknotic nuclei formation (Fig. 11).

The post treated therapeutic group IV, exhibited very limited recovery as Bowman's capsule with glomerulus appeared to be normal but there was immense degeneration in the lining of the tubules (PCT and DCT) along with their deranged structure (Fig. 12). The renal medulla also showed vacuolation and cytoplasmic congestion in the lumen of the collecting ducts (Fig. 13).

Treatment with garlic and tomato showed significant decline in the kidney biomarkers (Urea, creatinine, BUN and ALP) in group III

($p<0.01$) and a non significant reduction in group IV as compared to Cd treated group. These results are in agreement with the results of [52], who revealed that treatment with aged garlic extract appeared to enhance the recovery from carbon tetrachloride (CCl4). Yang *et al*. [53] also reported that diallyl sulfide (DAS) and related compound from garlic reduced CCl_4, N-nitrosodimethylamine- and acetaminophen-induced toxicity in rodents. It was somewhat surprising that garlic ameliorated the toxic reactions of a wide variety of toxic agents. It seems unlikely that garlic is only an antioxidant in these situations. Garlic extracts elicit antioxidant action by scavenging reactive oxygen species (ROS), enhancing the cellular antioxidant enzyme superoxide dismutase, catalase and glutathione peroxidase, and increasing glutathione in the cells [52, 54] due to the presence of high content of sulfur compounds [55].

Similarly, Rao and Agarwal [56] observed that, dietary supplementation of lycopene from traditional tomato products increased lycopene concentration in plasma and reduced oxidative damage to lipids and proteins. Tomato extract contains lycopene, having antioxidant and anti-inflammatory properties [57] and other antioxidants which exerts as inhibitory effect against certain diseases that have an oxidative stress component [58].

Garlic and Tomato extract proved to be useful in ameliorating Cd induced renal injury in mice from biochemical and histopathological aspects.

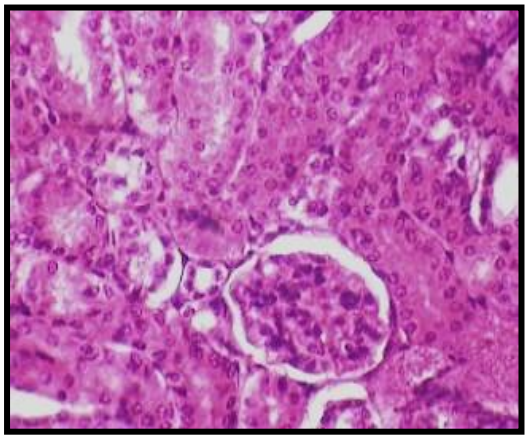

Fig. 6 Showing renal cortex of normal mice with Bowman's Capsule and convoluted tubules. X400

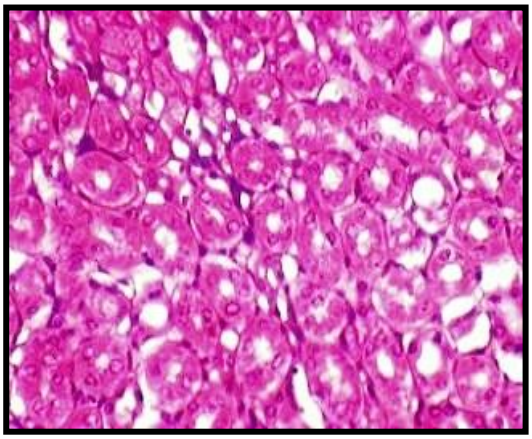

Fig. 7 Showing renal medulla of normal mice with collecting ducts. X400

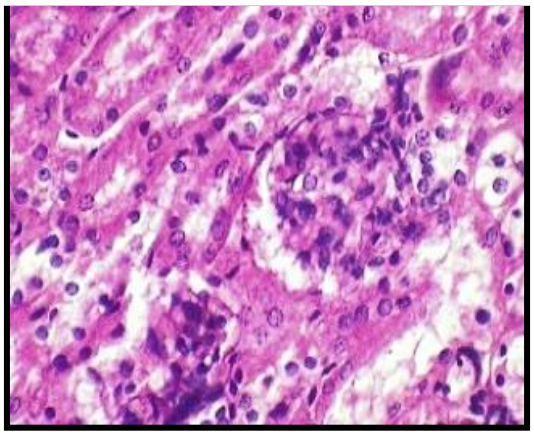

Fig. 8 Showing renal cortex of group II mice with atrophied Bowman's Capsule and hyperaemia in convoluted tubules. X400

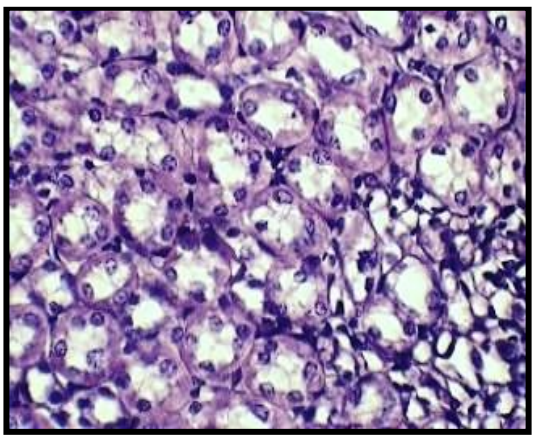

Fig. 9 Showing renal medulla of group II mice with hyperaemia and in convoluted tubules. X400

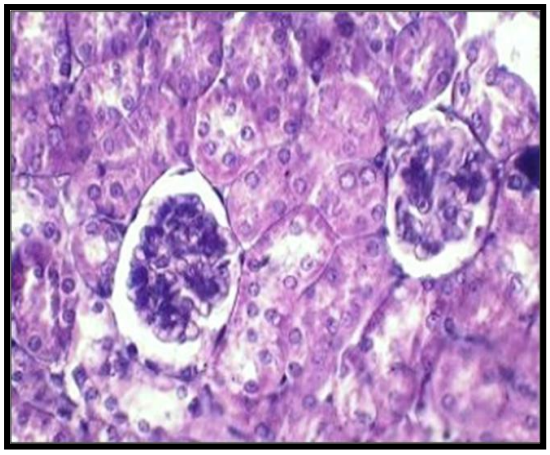

Fig. 10 Showing renal cortex of group III mice with almost normal Bowman's Capsule and convoluted tubules. X400

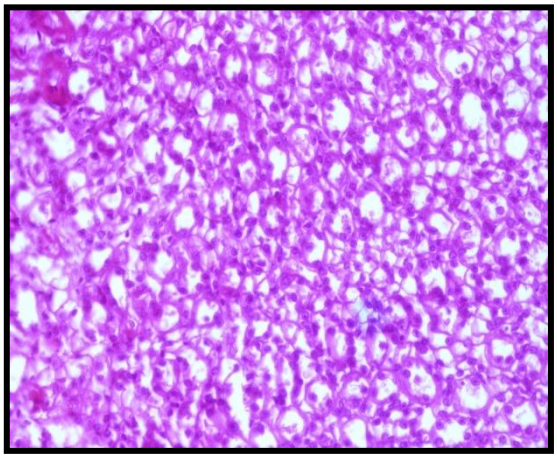

Fig. 11 Showing renal medulla of group III mice with normalized collecting ducts little shrinkage in the lumen. X400

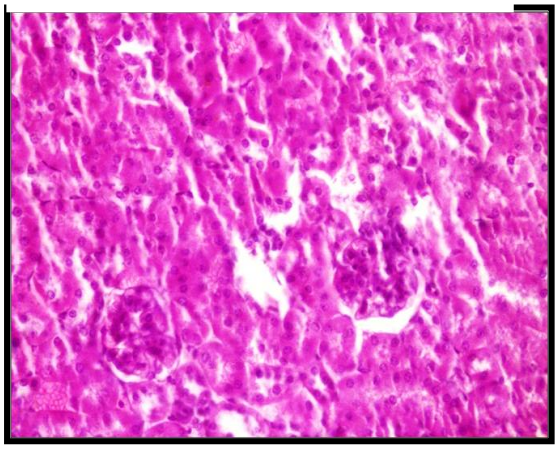

Fig. 12 Showing renal cortex of group IV mice with stable glomerular tuft but degeneration in the convoluted tubules. X400

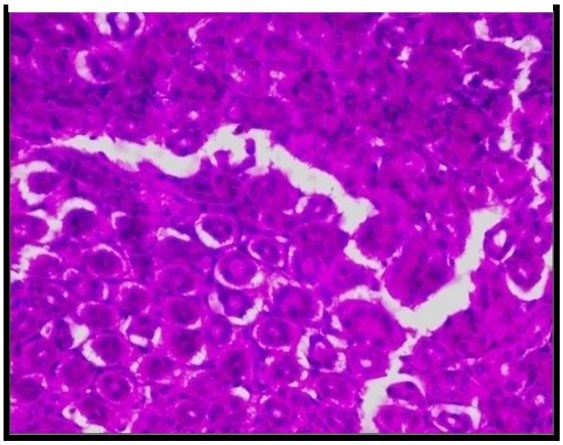

Fig. 13 Showing renal medulla of group IV mice with cytoplasmic congestion in the lumen of collecting ducts. X400

CONCLUSION

Our results suggest that GE +TE supplementation has the ability to ameliorate kidney damage, thus attenuating Cd in mice. The protective effect of GE might be due to S-allyl cysteine, which is a major constituent of GE which has been proved to inhibit the expression of CD36 along with its antioxidant and anti-glycation properties. The protective action of tomato may be due to the presence of lycopene, a strong antioxidant which normalized all the biochemical parameters. Both the extracts showed alarming protection, when administered concomitantly with Cd as compared to, when they were given as a therapeutic dose after Cd caused severe injury to the tissue.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this research article.

REFERENCES

1. Orisakwe OE, Afonne OJ, Nwobodo E, Asomungha L, Dioka CE. Low-dose mercury induces testicular damage protected by zinc in mice. Eur J Obstet Gynecol Reprod Biol 2001; 95: 92- 96.
2. Jarup L, Berglund M, Elinder CG. Health effects of cadmium exposure: A review of its literature and a risk estimation. Scand Work Environ Health 1998; 24:1.
3. Satarug S, Baker JR. Urbenjapol S, Haswell-Elkins M, Reilly PE, Williams DJ, Moore MR. Aglobal perspectrive on cadmium pollution and toxicity in non-occupatioanally exposed population. Toxicol Lett 2003; 137:65.
4. Bagachi D, Bagchi M, Hassoun EA, Stohs SJ. Cadmium induced excretion of urinary lipid metabolites, DNA damage, glutathione depletion and hepatic lipid peroxidation in Sprage-Dawley rats. Biol trace Elem Res 1996; 52(2): 143.
5. Flora SJ, Mittal M, Mehra A. Heavy metal induced oxidative stress and its possible reversel by chelation therapy. Indian J Med Res 2008; 128: 501-523.
6. Nordberg GF, Bigawam K, Nordberg M, Friedmann JM. Cadmium. Hand Book on the Toxicology of Metals. Amsterdam: Elsevier Publications; 2007, p 445.
7. Nawrot TS, Van Hecke E, Thijs L, Richert T, Kuznestsova T, Jin Y et al. Cadmium-related mortality and long term secular trends in the cadmium body burden of an environmentally exposed population. Environ Health Perspect 2008; 116: 1620-1628.
8. Munga A, Xhaxhiu D, Laci D, Dova I. Cadmium accumulation in the main organs during a chronic exposure. Nat Monte Pod 2010; 9: 719-730.
9. Johri N, Jacquillet G, Unwin R. Heavy metal poisoning: The effects of cadmium on kidney. Biometals 2010; 23:783-792.
10. Wlostowski T, Dmowski K, Bonda-Ostaszewka E. Cadmium accumulation, metallothionein and glutathione levels, and histopathological changes in the kidneys and liver of magpie (*Pica pica*) from a zinc smelter area. Exotoxicol 2010; 19: 1066-1073.
11. Nakamura Y, Ohba K, Suzuk K, Ohta H. Health effects of low-level cadmium intakeand the role of metallothionein on cadmium transport from motherrats to fetus. J Toxicol Sci 2012; 37:149-156.
12. Guirlet E, Das K. Cadmium toxicokinetics and bioaccumulation in turtles: Trophic exposure of Trachemys scripta elegans. Exotoxicol 2012; 21:18-26.
13. Casalino E, Calzaretti G, Sblano C, Landriscina C. Molecular inhibitory mechanisms of antioxidant enzymes in rat liver and kidney by cadmium. Toxicology 2002; 179 (1-2): 37-50.
14. Jarup L. Cadmium overload and toxicity. Nephrol Dial Transplant 2002; 17 Suppl 2:35-39.
15. Swiergosz-Kowalewska R. Cadmium distribution and toxicity in tissues of small rodents. Microsc Res Tech 2001; 55(3):208–222.
16. Howe JA, Tanumihardjo SA. Carotenoid-biofortified maize maintains adequate vitamin A status in Mongolian gerbils. J Nutr 2006; 136: 2562-7256.
17. Bhuvaneswari V, Velmurugan B, Abraham SK, Nagini S. Tomato and garlic by gavage module 7, 12-dimethylbenz[a]anthracene-induced genotoxicity and oxidative stress in mice. Brazil J Med Biol Res 2004; 37(7): 1029-1034.
18. Lachiman J, Pronek D. Total polyphenol and main flavanoid antioxidants in different onion (*Allium cepa* L.) varieties. Hort Sci (Pragne) 2003; 30(4):142-147.
19. Ferrari M. Protection against oxidative damage of erythrocyte membrane by the flavonoid quercetin and its relation to iron chelating activity. Free Rad Biol Med 2000; 29: 3-4.
20. Morales AL, Vincete-Sanchez C, Mirjana J. Effect of guercetin on metallothionein, nitric oxide stnthesis and cyclooxygenase-2 expression on experimental chronic cadmium nephrotoxicity in rats. Toxicol Applied Pharmacol 2006; 210: 128-135.
21. Jamshidzadeh A, Baghban M, Azarpira N, Bardbori A M, Niknahad H. Effects of tomato extract on oxidative stress induced toxicity in different organs of rats. Food Chem Toxicol 2008; 46 (12): 3612-3615.
22. Agarwal S, Rao AV. Tomato lycopene and its role in human health and chronic diseases. CMAJ 2000; 163(6): 139-144.

23. Wertz K, Siler U. Goralczyk R. Lycopene: modes of action to promote prostate health. Arch Biochem Biophysi 2004; 430: 127-134.
24. Kim GY, Kim JH, Ahn SC, Lee HJ, Moon DO, Lee CM, Park YM. Lycopene suppresses the lipopolysaccharide-induced phenotypic and functional maturation of murine dendritic cells through inhibition of mitogen-activated protein kinases and nuclear factor-kappa B. Immunology 2004; 113: 203-211.
25. Riso P, Visioli F, Grande S, Guarnieri S, Gardana C, Simonetti P, Porrini M. Effect of a tomato-based drink on markers of inflammation, immunomodulation, and oxidative stress. J Agric Food Chem 2006; 54:2563-2566.
26. Iwalokun BA, Ogunledun A, Ogbolu DO, Bamiro SB, Jimi-Omojola J. *In-vitro* antimicrobial properties of aqueous garlic extract against multidrug-resistant bacteria and *Candida* species from Nigeria. J Med Food 2004; 7(3): 327-333.
27. Salawu EO, Adeleke AA, Oyewo OO, Ashamu EA, Ishola OO, Afoladi AO, Adesanya TO. Prevention of renal toxicity from lead exposure by oral administration of *Lycopersicon esculentum*. J Toxicol Environ Health 2009; 1(2): 22-27.
28. Desai KR, Moid N, Patel PB, Highland HN. Protective efficacy of *Allium sativum* on deltamethrin induced toxicity in reproductive tissues in male mice. Int J Pharmaceut Sci Res 2015; 6(4): 1711-1720.
29. Anderson H, Larsen S, Splid H, Christenson ND. Multivariate statistical analysis of organ weights in toxicity studies. Toxicol 1999; 136: 67.
30. Rana SV, Rekha S, Seema V. Protective effects of few antioxidants on liver function in rats treated with cadmium and mercury. Ind J Exp Biol 1996; 34:177-179.
31. Yiin SJ, Chern CL, Sheu JY, Tseng WC, Lin TH. Cadmium induced renal lipid peroxidation in rats and protection by selenium. J Toxicol Environ Health 1999; 57(6): 403-413.
32. Al-Attar AM. Antioxidant effect of vitamin E treatment on some heavy metal-induced renal and testicular injuries in male mice. Saudi J of Biol Sci 2011; 18: 63-72.
33. Morshedi R, Ahmedizadeh M, Angali KA. Protective effects of zinc supplementation on renal toxicity in rats exposed to cadmium. Jundishapur J Health Sci 2014; 6(3): e21717.
34. El-Demerdash FM, Yousef MI, Kedwany FS, Baghdadi HH. Cadmium- induced changes in lipid peroxidation, blood hematology, biochemical parameters and semen quality of male rats: protective role of vitamin E and ß-carotene. Food Chem Toxicol 2004; 42: 1563-1571.
35. Sidhu P, Garg ML, Dhawan DK. Protective role of zinc in nickel induced hepatotoxicity in rats. Chem Biol Interact 2004; 150: 199-209.
36. Sidhu P, Garg ML, Morgenstern P, Vogt J, Butz T, Dhawan DK. Ineffectiveness of nickel in augmenting the hepatotoxicity in protein deficient rats. Nutr Hospital 2005; 20: 378-385.
37. Harper HA, Rodwell VW, Mayes PA, Cochrum KC, Grodsky GM, Martin, DW, Jr, Tyler DD, Wallin JD. Review of Physiological Chemistry. Los Altos, California, USA: Lange Medical Publications; 1979, p 702.
38. Gaurav D, Preet S, Dua KK. Protective effect of *Spirulina platensis* on cadmium induced renal toxicity in Wister rats. Arch Appl Sci Res 2010; 2(1): 390-397.
39. Noonan CW, Sarasua SM, Campagna D, Kathman SJ, Lybarger JA, Mueller PW. Effects of exposure to low levels of environmental cadmium on renal biomarkers. Environ Health Perspect 2002; 110: 151-155.
40. Chawla R. Practical Clinical Biochemistry: Methods and Interpretations. New Delhi (India): Jaypee Brothers Publishers; 2003.
41. Jadhav SH, Sarkar SN, Patil RD, Tripathi HC. Effect of Subchronic Exposure via drinking water to a mixture of Eight Water-contaminating metals: A biochemical and histopathological study in male rats. Arch Environ Contamin Toxicol 2007; 53: 667-677.
42. Kodama M, Ogata T, Yamamori K. Acute toxicity of zinc to rainbow trout Salmo gairdneri. Bull Japanese Soc of Sci Fish 1982; 48: 593.
43. Amer M, Areida S. Protective effect of liv-plus. A herbal formulation against hepatotoxicity induced by carbon

tetrachloride and thioacetate in male rats. J Egypt Ger Soc Zool 2004; 44(A): 199-219.
44. Choi JH, Rhee SJ. Effects of vitamin E on renal dysfunction in chronic cadmium-poisoned rats. J Med Food 2003; 6(3):209-215.
45. Damek-Poprawa M, Sawicka-Kapusta K. Histopathological changes in the liver, kidney and testes of bank voles environmentally exposed to heavy metal emissions from the steelworks and zinc smelter in Poland. Environ Res 2004; 96(1): 72-78.
46. Jemai H, Lachkar HA, Messaoudi I, Kerkeni A. Effect of zinc pre-treatment on blood glutathione, serum zinc and kidney histological organization in male rats exposed to cadmium. J Trace Elem Med Biol 2010; 24(4): 277-288.
47. Dudley RE, Gammal LM, Klaassen CD. Cadmium-induced hepatic and renal injury in chronically exposed rats: likely role of hepatic cadmim-metallothionein in nephrotoxicity. Toxicol Appl Pharmacol 1985; 77(3):414-426.
48. Sudo J, Hayashi T, Kimura S, Kakuno K, Terui J, Takashima K, Soyama M. Mechanism of nephrotoxicity induced by repeated administration of cadmium chloride in rats. J Toxicol Environ Health 1996; 48(4): 333-348.
49. Dorian C, Klaassen CD. Protection by zinc-metallothionein (ZnMt) against cadmium metallothionein-induced nephrotoxicity. Fundamen Appl Toxicol 1995; 26(1): 99-106.
50. Thijssen S, Maringwa, J, Faes C, Lambrichts I, Kerkhove EV. Chronic exposure of mice to environmentally relevant, low doses of cadmium leads to early renal damage, not predicted by blood or urine cadmium levels. Toxicol 2007; 229(1-2):145-156.
51. Renugadevi J, Prabu SM. Naringenin protects against cadmium-induced renal dysfunction in rats. Toxicol 2009; 256(1-2): 128-134.
52. Carmia B. Antioxidant health effects of aged garlic extract. J Nutr 2001; 131:1010-1015S.
53. Yang CS, Chhabra SK, Yan Hong J, Smith TH. Mechanism of inhibition of chemical toxicity and carcinogenesis by diallyl sulfide (DAS) and related compounds from garlic. J Nutr 2001; 131: 1041S-1045S.
54. Nakagawa S, Kasuga S, Matsuura H. Prevention of liver damage by aged garlic extract. Phytother Res 1989; 3: 50-53.
55. Prasad K, Laxdal VA, Yu M, Raney BL. Antioxidant activity of allicin, an active principle in garlic. Mol Cellular Biochem 1995; 148: 183-189.
56. Rao AV, Agarwal S. Bioavailability of lycopene form tomato products and their possible role prevention of cancer. Nutr Canc 1998; 31: 199-203.
57. Reifen R, Nissenkorn A, Matas Z, Bujanover Y. 5-ASA and lycopene decrease the oxidative stress and inflammation induced by iron in rats with colitis. J Gastroenterol 2004; 39: 514-519.
58. Toniolo P, Van Kappel AL, Akhmedkhanov A, Ferrari P, Kato I, Shore RE, Riboli E. Serum carotenoids and breast cancer. American J Epidemiol 2001; 153: 1142-1147.

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