Protective Effects of Amla (Emblica officinalis) Fruit Pulp Extract and Selenium Against Dimethoate Induced Nephrotoxicity in Wistar Rats

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Received: 2nd January, 2024; Accepted: 22nd March, 2024; Published online: 30th June, 2024

https://doi.org/10.33745/ijzi.2024.v10i01.115

Abstract: The aim of the present study was to investigate histological changes in the kidney of Wistar rats induced by dimethoate and to evaluate the protective role of amla (Emblica officinalis) fruit pulp extract and selenium on dimethoate induced nephrotoxicity. Wistar rats were divided into 6 numerically equal groups and treated as -- Group A: Control; Group B: dimethoate (20 mg/kg b wt.); Group C: dimethoate (20 mg/kg b wt.) and selenium (0.5 mg/kg b wt.); Group D: dimethoate (20 mg/kg b wt.) and amla fruit pulp extract (200 mg/kg b wt.); Group E: selenium (0.5 mg/kg b wt.) and Group F: amla fruit pulp extract (200 mg/kg b wt.). For light microscopic studies, kidney were fixed on 7 and 14 day following the treatments. In 7 day dimethoate (Group B) treated rats kidney exhibited shrinkage of glomeruli. In dimethoate and selenium (Group C) and dimethoate and amla fruit pulp extract (Group D) treated rats for 7 day, kidney exhibited similar changes as noticed in dimethoate (Group B) treated rats. Kidney of rats treated for 7 day with selenium (Group E) and amla fruit pulp extract (Group F) have not shown any histological changes. Vacuolization and degeneration of tubules and glomerulus was noticed in 14 day dimethoate (Group B) treated rats. In dimethoate treated group, hypertrophied glomerulus was noticed. In dimethoate and selenium (Group C) and dimethoate and amla fruit pulp extract (Group D) treated rats there was no shrinkage in glomerulus. Also, tubular degeneration was not noticeable in group C and group D. However, hypertrophied glomerulus and glomerular degeneration was noticed in kidney of group C and group D. In selenium (Group E) and amla fruit pulp extract (Group F) treated rats for 14 day no histological changes were noticed. From present study it can be concluded that dimethoate caused histological changes in kidney of rats. These histological changes can be protected by providing selenium and amla fruit pulp extract.

Keywords: Dimethoate, Amla fruit pulp extract, Selenium, Glomerulus, Kidney, Hypertrophy, Degeneration, Renal tubules, Emblica officinalis


https://doi.org/10.33745/ijzi.2024.v10i01.115

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Introduction

Pesticide is a combination of substances used to prevent, eradicate, repel, or decrease the harm caused by any pest. Pesticides are divided into four main classes according to their chemical composition: organochlorines, organophosphates, carbamates, and pyrethroids (Yadav et al., 2017; Kaur et al., 2019). Dimethoate is an organophosphate insecticide that is used worldwide in agriculture and urban areas due to its high efficacy and rapid environmental degradation (Van Scoy et al., 2016). Dimethoate is widely used, but because it persists in soil and crops, it is unhealthy for both humans and animals. The serum of agricultural workers who are chronically and occupationally exposed to dimethoate has been found to contain dimethoate residues, according to a prior discovery. In both animals and humans, dimethoate poisoning is typically accompanied by a block in neuromuscular transmission. This short-term exposure to dimethoate predominantly results in the inhibition of acetylcholinesterase in the target tissues, which leads to the accumulation of acetylcholine and the activation of muscarinic and nicotinic receptors on the cholinergic system (Saaifi-Ben Salah et al., 2012). Dimethoate intoxication results in cellular damage and oxidative stress, which causes lipid peroxidation and the generation of free radicals (Ben Amara et al., 2013).

A trace element selenium is necessary for healthy physiological functions. The amino acid selenocysteine (Sec), a component of the trace element selenium (Se), is co-translationally integrated into the polypeptide chain (Zoidis, 2018). Due to its beneficial antioxidant characteristics, the trace element selenium (Se) has been used as a dietary supplement to enhance health. Because it plays a role in enhancing antioxidant defence, immunological functions, and metabolic homeostasis, it may reconstruct progressive and spontaneous biochemical and physiological changes that could result in disease prevention and healthy ageing (Burk, 2002). The amino acid selenocysteine is essential for the manufacture of a variety of selenoenzymes, including glutathione peroxidase, iodothyronine deiodinases (regulating thyroid hormone activity), and thioredoxin reductases, which regenerate antioxidant systems (Barciela et al., 2008). Se prevents the apoptosis and mitochondrial malfunction brought on by ROS. Se is found in high concentrations in renal tissue, which can shield the kidney against lipid peroxidation (Gunes et al., 2018). The present study was aimed to investigate the protective effects of amla fruit pulp extract and selenium against dimethoate induced nephrotoxicity in Wistar rats.

Materials and Methods

Male Wistar rats were purchased from Asia Scientific Emporium, Varanasi, India. The animals were housed in polypropylene cages and were acclimatized for two weeks prior to different treatments. During acclimation and experimental period, rats were provided food and tap water ad libitum. Experimental design was approved by Research Degree Committee, D.D.U. Gorakhpur University, Gorakhpur, India.

Dimethoate (30 EC) was purchased from local fertilizer shop and dissolved in distilled water for use in experiment. Sodium selenite was purchased from Eastern Scientific Emporium (Gorakhpur, India) and dissolved in distilled water for experimental use. The Amla fruit, Emblica officinalis or Phyllanthus emblica also known as Indian gooseberry or amla. The fruit is the most significant portion of the plant and is used to treat a variety of ailments (Baliga and Dsouza, 2011). According to reports, the fruit possess expectorant, purgative, spasmyloitic, hypoglycemic, hepatoprotective, and hypolipidemic activity (Mirunalini and Krishnaveni, 2010). According to earlier research, amla extract is helpful in avoiding both age-related renal failure (Yokozawa et al., 2007) and acute kidney dysfunction (Tasanarong et al., 2014).
*officinalis* were purchased locally. The amla fruits pulp were washed thoroughly with water and dried in hot air oven at 40 °C. After drying, these were cut into small pieces, dried and powdered. Powdered amla fruits pulp were mixed with 90% ethanol in 1:20 ratio (w/v) and kept at orbital shaker for 48 h. Then the samples were filtered with Whatman grade No. 1 filter paper. The filtrates were dried in oven at 40 °C. For use, the dried residues of amla fruits pulp extract were dissolved with ethanol to provide desired dose to be given to rats.

**Experimental design:**

The acclimatized rats were divided into 6 groups (A-F), each group containing 20 rats. The rats were treated (at 10:00 am throughout experiment) as follow:

- **Group A (Control):** No treatment was given
- **Group B (Dimethoate treated rats):** These rats were given daily dose of dimethoate (20 mg/kg b wt.)
- **Group C (Dimethoate + Selenium):** These rats were given daily dimethoate (20 mg/kg b wt.) and Selenium (0.5 mg/kg b wt.)
- **Group D (Dimethoate + Amla fruit pulp extract):** These rats were given daily dimethoate (20 mg/kg b wt.) and amla pulp extract (200 mg/kg b wt.)
- **Group E (Selenium):** These rats were given daily selenium (0.5 mg/kg b wt.)
- **Group F (Amla fruit pulp extract):** These rats were given only amla fruit pulp extract (200 mg/kg b wt.)

Rats were sacrificed 24 h after last dose on 7th and 14th day after initiation of the experiment under light ether anesthesia. Rats were fasted overnight before sacrifice. Kidneys were fixed in Bouin’s fluid. These fixed tissues were dehydrated in an ethanol gradient, treated with clearing agent xylene, infiltrated and embedded in paraffin wax, sectioned at 6 µm, and mounted on glass slides. The slides were stained with hematoxylin and eosin (HE) for light microscopic examination.

**Results**

There are numerous nephrons in kidney of control rats. These nephrons consist of a dilated portion having renal corpuscle; the proximal tubule; loop of Henle and the distal tubule. The renal corpuscles contain the glomerulus which is a tuft of capillaries. Each glomerulus is surrounded by the Bowman’s capsule (Fig. 1). An urinary space is present between the glomerulus and Bowman’s capsule. The epithelium of proximal tubule is lined by simple cuboidal or columnar cells whereas the epithelium of distal tubule is lined by simple cuboidal cells.
In 7 day dimethoate (Group B) treated rats the glomeruli are noticed to be shrunken which resulted into more space between the Bowman’s capsule and glomerulus (Fig. 2). In dimethoate and selenium (Group C) and Dimethoate and Amla fruit pulp extract (Group D) treated rats for 7 day, kidney exhibited similar structural changes as seen in dimethoate (Group B) treated rats. In Selenium (Group E) and Amla fruit pulp extract (Group F) treated rats there was no histological changes.

Vacuolization and degeneration of tubules (Fig. 3) and glomerulus (Fig. 4) was noticed in 14 day Dimethoate (Group B) treated rats. In Dimethoate treated group, hypertrophied glomerulus was noticed (Fig. 5). In Dimethoate and Selenium (Group C) and Dimethoate and Amla fruit pulp extract (Group D) treated rats there was
no shrinkage in glomerulus. Also, tubular degeneration was not noticeable in group C and group D. However, hypertrophied glomerulus and glomerular degeneration was noticed in kidney of group C and group D. In selenium (Group E) and (Group F) treated rats the histological structure of kidney was almost similar to control rats.

Discussion

Dimethoate exposure to rats caused kidney alterations which is evident by occurrence of shrunken glomeruli after 7 day treatment and glomerular degeneration, hypertrophy of glomeruli and tubular degeneration after 14 day exposure. Glomerular shrinkage (as observed in 7 day dimethoate treated rats) has also been noticed by few workers after exposure to various toxicants/chemicals - paraquat (Abdel-Mageid, 1994), Lithium (Sharma and Iqbal, 2005), chlorpyrifos (Tripathi and Srivastav, 2010, Raina and Hamid, 2013), cadmium (Tripathi and Srivastav, 2011), 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (Ciftci et al., 2012), Triazophos (Sharma and Sangha, 2014), Endosulfan (Khan, 2014), Silver (Rodr et al., 2017), Malathion (Mamun et al., 2015), Abmactin (Moqbel et al., 2017), Mercuric chloride (Langeswaran et al., 2018), MCLR (Srivastava et al., 2020), Aluminium chloride (Okail et al., 2020), Cypermethrin (Srivastava et al., 2021), Bisphenol-A (Ishtiaq et al., 2022), and Chromium (Baiomy et al., 2023).

In the present study degeneration of glomeruli has been noticed after dimethoate exposure. This is in agreement with the studies of other investigators who have also reported glomerular degeneration in vertebrates such as fish -- after treatment with chlorpyrifos (Srivastava et al., 1990), deltamethrin (Cengiz, 2006), cadmium (Wangsongsak et al., 2007), microcystin (Atencio et al., 2008), and cypermethrin (Korkmaz et al., 2009); chick -- after treatment with cypermethrin (Aslam et al., 2009); and rat -- after treatment with paraquat (Lamfon and Al-Rawi, 2007), chlorpyrifos (Tripathi and Srivastav, 2010; Raina and Hamid, 2013), cadmium (Tripathi and Srivastav, 2011), lead (El-Newesy and El-Sayed, 2011), gentamicin (Alrifi et al., 2012), deltamethrin (El- Gerbed, 2014), triazophos (Sharma and Sangha, 2014), abmactin (Moqbel et al., 2017), MCLR (Srivastava et al., 2020), cypermethrin (Srivastava et al., 2021), and Chromium (Baiomy et al., 2023). Dimethoate provoked glomerular degeneration which may decrease glomerular filtration rate as suggested by Barrouillet et al. (1999) who have also noticed decrease in GFR in their in vitro studies of cadmium exposure.

In the present study the observed tubular degeneration after dimethoate treatment is in conformity with similar observation made by other investigators from vertebrates after toxicant/chemicals exposure --- fish (chlorpyrifos--Srivastava et al., 1990; cadmium--Wangsongsak et al., 2007; microcystin-- Atencio et al., 2008; Rabergh et al., 1991; Kotak et al., 1996.
cypermethrin-- Ayoola and Ajani, 2008); chick (cypermethrin-- Aslam et al., 2009); quail (lead-- Almansour et al., 2008); wood mouse and whitetoothed shrew (landfill leachates containing toxic metals -- Sanchez-Chardi et al., 2009); monkey (lead-- Colle et al., 1980); mice -- (chlorpyrifos-- Thijsse et al., 2007, microcystin-- Rangel et al., 2014; Al-Sultan et al., 2015; Al-Majeed et al., 2016); rabbit (fluoride -- Shashi et al., 2002); rat (chlorpyrifos -- Aughey et al., 1984; Karmakar et al., 1986; Gatta et al., 1989; Brzoska et al., 2003; Abdel-Moneim and Said, 2007; Kukner et al., 2007; Jihen et al., 2008; Tripathi and Srivastav, 2010; Raina and Hamid, 2013; Tanvir et al., 2016; microcystin-- Hooser et al., 1989; Srivastava et al., 2020; metal mixture -- Jadhav et al., 2007; paraquat -- Damain et al., 1992; Abdel Mageid, 1994; Lamfon and Al-Rawi, 2007; cypermethrin -- Muthuviveganandavel et al., 2008; Srivastava et al., 2021; fenthion -- Kerem et al., 2007; cigarette smoke -- Kuru et al., 2009; cadmium-- Tripathi and Srivastav, 2010; Brozska et al., 2003; Lead --EI-Newesy and EI-Sayed, 2011, Gentamicin --Abdel-Raheem et al., 2009, Alrifi et al., 2012; 2,4-D-- Tayeb et al., 2012; zinc-- Faddah et al., 2012; streptozotocin-- Omara et al., 2012; Monosodium glutamate-- Dixit et al., 2014; Deltamethrin-- El-Gerbed, 2014; Endosulfan-- Khan, 2014; Lead acetate-- Aksu et al., 2017; Abmactin--Moqbel et al., 2017; Cymoxanil -- Ahmed et al., 2020; Polystyrene nanoparticle-- Ahmed et al., 2022; Chromium--Baiomy et al., 2023; Arsenic-- Irak et al.,2024). In contrast there is no change in kidney morphology after bifenthrin exposure to fish (Velisek et al., 2009).

In dimethoate treated rats the observed glomerular hypertrophy is strengthened by similar findings in rats after exposure to toxicants/chemicals-- Abdel-Raheem et al. (2009); Tayeb et al. (2012); Mansour and Mossa (2010); Raina and Hamid (2013); Omara et al. (2012); Morya and Vachhrajani (2014); Tripathi and Srivastav (2010); Srivastava et al. (2020); Srivastava et al. (2021).

Hydrolc changes occurred in kidney tubule after toxicant exposure may be the plausible reason for the vacuolization and degeneration of tubules which have been noticed in dimethoate treated rats. The changes after pump transport of tubular cells caused by toxicant and provoke physiological disturbances in kidney. Sanchez-Chardi et al. (2009) have suggested that tubular dilation may be a compensatory mechanism for failure of excretory function.

**Conclusion**

It can be concluded from the present study that exposure of dimethoate adversely affect the kidney structure of rats. The histological changes caused by dimethoate in kidney could be protected by supplementation of selenium and amla fruit pulp extract. Giving dietary supplements including amla fruit pulp extract and selenium to organisms exposed to dimethoate is advised in order to reduce their toxic symptoms.

**References**


Aksu DS, Sağlam YS, Yiklim S and Aksu T. (2017) Effect of pomegranate (*Punica granatum* L.) juice on kidney, liver, heart and testis histopathological...


Al-Majeed MIA, Al-Sultan EYA and Abbas AAK. (2016) Toxic effects of low concentration of cyanotoxin (Microcystin-LR) on mice and study of protective efficacy of the antioxidants vitamins (C&E) and \textit{Capparis spinosa} L. root extract. J Natural Sci Res. 6: 34-42.


Gatta A, Bazzerla G, Amodio P, Menon F, Angeli P,


