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PROTECTIVE EFFICACY OF *ALLIUM SATIVUM* ON DELTAMETHRIN INDUCED TOXICITY IN REPRODUCTIVE TISSUES OF MALE MICE

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ABSTRACT: Present study was carried out to assess testicular toxicity of pyrethroid insecticide, Deltamethrin (DM) in male Swiss albino mice, *Mus musculus* and to evaluate protective role of *Allium sativum* (AS) in alleviating the detrimental effect of DM. Forty male mice were divided into five experimental groups (8 mice per group) and were categorized : Control- Given distilled water and food *ad libitum*, Vehicle Control (oil)- Given peanut oil, DM treated- Given 1/5th of LD_{50} (6 mg/kg body weight) of DM dissolved in peanut oil via oral gavage, AS-given *Allium sativum* only (200 mg/kg body weight), DM + AS- given Deltamethrin along with *Allium sativum* (6 mg/kg body wt. + 200 mg/kg body wt.). Experiment was conducted for a duration of 45 days. DM caused a significant reduction in body weight, testicular weight, Total Protein, Superoxide Dismutase (SOD), Catalase (CAT), Glutathione (GSH), Glutathione Peroxidase (GPx), Glutathione Reductase (GRx), Glutathione-S- Transferase (GST) and Glycogen content of testis. DM-treated group also showed a significant increase in testicular malondialdehyde (MDA) and Cholesterol concentrations. Conversely, treatment with *Allium sativum* improved the DM- induced oxidative damage and other evaluated indices of testes. Results indicate that DM exerts significant harmful effects on male mice and concurrent administration of *Allium sativum* ameliorates the detrimental effects of DM.

INTRODUCTION: Under the pretext of demographic growth with all its consequences, agricultural production resorts to the use of a varied and a large quantity of insecticides to improve the production and preservation of food stuffs. Thus, the use of insecticides has increased rapidly and is now widespread to the lowest level of agricultural production. Synthetic pyrethroids are modified derivatives of pyrethins, natural substances obtained from flowers of pyrethrum species.

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Concerning to their high bio-efficacy at low concentrations, enhanced photo-stability and relatively low mammalian and avian toxicity pyrethroid insecticides are widely used in agriculture, domestic and veterinary applications than other insecticides, particularly organochlorine, organophosphate and carbamate insecticides.

Deltamethrin [(R, S)] is a type-II pyrethroid synthetic insecticide, which has been widely used to control noxious insects in agriculture, forestry and horticulture. However, a number of studies have demonstrated genotoxic and tumorogenic effects of deltamethrin in mammalian and non-mammalian species [1]. For many pesticides, induction of oxidative stress is one of the main mechanisms of their action. The mechanism of such pathological facts may be prompted by the free radical release and the lipid peroxidation that it

induces. During the past few years, estimation of free radical generation and antioxidants defense has become an important aspect of investigation in mammals for the protection of cells against oxidative damage due to pesticides [2] heavy metals [3] and chemotherapeutic agent toxicities that they generated probably oxygen- reactive species (ROS) which led to oxidative stress.

During pyrethroid metabolism, reactive oxygen species (ROS) are generated and result in oxidative stress in intoxicated animals. The production of ROS is a normal physiological event in various organs including the testis controlling sperm capacitation, acrosome reaction and sperm–oocyte fusion. However, overproduction of ROS can be harmful to sperm and subsequently to male fertility.

The use of garlic (*Allium sativum*) as a therapeutic agent for treatment of a variety of diseases has been advocated for thousands of years. During the past decade, there has been increasing awareness of the potential medicinal uses of garlic; known for a free radical scavenging activities, immune stimulation, curing of cardiovascular diseases, anti-thrombotic, anti-hypertensive, anti-hyperglycemic, anti-hyperlipidemic, anti-cancer, and anti-infectious properties [4-12]. Its potential in combating lifestyle related disorders such as hypercholesterolemia and high blood pressure have made garlic an important functional food with a wide range of popularity, particularly in stressed middle aged men. *Allium sativum* has complex chemistry dominated by organo-sulfur and non-sulfur compounds that give it a characteristic flavor and contribute to its various health benefits.

The most important non-sulfur compound reported in garlic is steroid saponins; one of the potent phytoestrogens [13]. Although garlic has known hypolipidemic and phytoestrogenic effects, its impacts on the male reproductive system have been not clearly defined. Some studies have reported a spermicidal effect of garlic [14], while others demonstrated its beneficial effects in the recovery of testicular functions [15].

Therefore, the present study was carried out with two important objectives, firstly to inspect the deleterious effects of the widely used pyrethroid, Deltamethrin on testis of swiss albino male mice and secondly to investigate the ameliorative potential of crude garlic extract on the same.

MATERIALS AND METHODS:

Animals & Chemicals: Healthy, adult, pathogen free, colony bred male albino mice (*Mus musculus*) of swiss strain weighing between 30 - 40gm obtained from IAEC recognised supplier Cadila Healthcare and Pharmaceutical, Ahmadabad, Gujarat (India) were used for the experiments. The experimental protocol and the number of animals used for the experiments were mentioned in a detailed proposal and approval was obtained as per the guidelines of the institutional animal ethics committee, under registration No. 167/1999/CPCSEA from the Ministry of Social Justice and Empowerment, Government of India and Committee for the purpose of Control and Supervision of Experiments on Animals, Chennai, India.

All the animals were acclimatized for seven days prior to the commencement of experiment. The animals were housed in an air-conditioned animal house at a temperature of 26±2^{o}C and exposed to 10-12 hours of day light and relative humidity of 40-50%. Animals were randomized into control and treated groups and were caged separately. Standard chow (obtained from Amrut laboratory, Baroda, India) and water was provided ad libitum. Test chemical Deltamethrin (technical grade) of 98.11% purity was generously gifted from Meghmani Organics Limited, Ahmadabad (India). All the other chemicals used were procured from Himedia Laboratories, India and Sigma Aldrich (UK). All the chemicals used were of analytical grade.

Experimental Design:

Deltamethrin was administered via oral gavage dissolved in peanut oil at 6mg/kg body weight. The dose was determined on the basis of LD_{50} of deltamethrin in peanut oil i.e. 30 mg/kg body weight[16]. Dose of *Allium sativum* was decided on the basis of previous studies [17].

Animals were divided into following groups:
Group I: Control (given distilled water only);
Group II: Vehicle Control (given only peanut oil);

Group III: Deltamethrin treated (given 6 mg/kg body weight deltamethrin); Group IV: *Allium sativum* treated (200 mg/kg body weight); Group V: Deltamethrin (6 mg/kg body weight) + *Allium sativum* (200 mg/kg body weight).

All the groups were treated for 45 days and at the end of experiment animals were weighed and sacrificed using light ether anesthesia.

Protein estimation:
Protein estimation was done in testis of control and treated mice using standard protocol of Lowry et al. (1951)[18]. Color development was read at 540 nm in Systronics Digital Spectrophotometer 167 against blank.

Cholesterol estimation:
Cholesterol estimation was done in testis of control and treated mice by the method of Zlatkis et al. (1953)[19]. The absorbance was read at 540 nm.

Glycogen:
Glycogen level was estimated in testis of control and treated mice using the method of Seifter et al. (1950)[20]. The percent transmittance was read at 620 nm.

Lipid Peroxidation (LPO) – Thiobarbutiric Acid Reactive Species Assay (TBARS):
TBARS level in testis of control and treated mice were determined by the method of Ohkawa et al. (1979)[21]. This method is based on the formation of red chromophore that absorbs at 532nm following the reaction of thiobarbituric acid (TBA) with malonyldialdehyde (MDA) and other breakdown products of peroxidised lipids collectively called as thiobarbituric acid reactive substances (TBARS).

Superoxide Dismutase (SOD):
Activity of SOD in testis of control and treated mice was estimated by modified spectrophotometric method of Kakkar et al. (1984)[22]. The formazan formed at the end of reaction indicates presence of enzyme. One unit of enzyme activity is defined as the enzyme concentration required to inhibit 50% of the optical density of chromogen formed in one minute at 560nm under the assay condition.

Catalase (CAT):
Catalase activity in testis of control and treated mice was assayed by the modified method of Sinha (1972) [23].

Glutathione (GSH):
The concentration of glutathione in testis of control and all treated groups of mice was assayed by the method of Ellman (1959) [24]. Glutathione (GSH) present in the tissue oxidizes 5, 5' – dithiobis – (2 nitrobenzoic acid, (DTNB) to form yellow coloured complex which can be read at 412nm. The absorbance is proportional to amount of GSH. Absorbances of unknown samples were plotted against concentration with respect to standards. Glutathione levels were expressed as µg/100 mg fresh tissue weight.

Glutathione Peroxidase (GPx):
Activity of GPx was estimated in testis of control and treated animals by Rotruck et al (1973) [25].

Glutathione Reductase (GRx):
The estimation of glutathione reductase in testis was done by the method of Carlberg and Mannervik (1985) [26].

Glutathione-S-Transferase (GST):
Glutathione-S-transferase activity was measured in testis of control and treated group animals by modified method of Habig et al. (1974) [27].

Statistical Analysis:
All the data are expressed as Mean±SEM. Statistical analysis was performed using the trial version of Graphpad Prism 6.0 software. Comparison between groups was made by one-way analysis of variance taking significance at $P<0.05$ followed by Student's t-test taking significance at ***$p<0.001$, **$p<0.005$ and *$p<0.01$. Tukey's honestly significance difference (HSD) post hoc test was used for comparison among different treatment groups ($P<0.05$).

RESULTS:
Body weight: Terminal body weight of DM treated group for 45 days exhibited significant reduction ($p<0.001$) as compared to control mice. AS treated mice showed a recovery towards normal values and the differences were non-significant. Similarly,

mice treated with DM along with AS recorded a non-significant reduction in body weight values, values being lower than only AS treated but higher than DM treated mice (Table 1).

Organ weight: Testis weight of DM treated mice after 45 days recorded a significant fall ($p<0.001$) as compared to control mice. AS only and DM + AS group registered a non-significant reduction in tissue weight, with former group exhibiting greater recovery trend than the latter (**Table 1**).

TABLE 1: SHOWING BODY WEIGHT AND ORGAN WEIGHT IN CONTROL AND TREATED MICE.

	Control	Oil	DM	AS	DM + AS	P
Body Wt. (gm)	43.20 ± 1.37	44.52 ± 0.8NS	28.87±1.44***	42.33±1.45NS	38.9±1.8NS	0.0001
Testis (mg)	121.32±1.43	120 ± 1.5NS	85.66± 2.02***	119.9±1.2NS	105.6±1.21NS	0.0001

Values are represented as Mean ±S.E., *p<0.01, **p<0.05, ***p<0.001, NS – non significant. Analysis of variance at P<0.05 level.

Oxidative stress parameters:

LPO (TBARS) level in testis of experimental mice was significantly elevated ($p<0.001$) as compared to control mice after termination of experiment. However, activity of SOD and CAT was significantly reduced ($p<0.001$) in testis of DM treated group animals after 45 days. AS only and DM + AS treatment restored the values towards control group and the differences were non-significant with control values (**Table 2**).

TABLE 2: SHOWING OXIDATIVE PARAMETERS IN TESTIS OF CONTROL AND TREATED MICE.

	Control	Oil	DM	AS	DM + AS	P
LPO (nanomoles of MDA/100 mg tissue weight)	67.02 ± 1.13	67.91±1.24NS	92.02±2.81***	69.52±2.71NS	75.18±3.16NS	0.0001
SOD (units/mg protein)	0.41 ± 0.03	0.41 ± 0.02NS	0.22 ± 0.03***	0.41±0.02NS	0.33± 0.02 NS	.0001
CAT (µmoles H_2O_2 consumed/mg protein)	10.06 ± 0.16	10.03±0.18NS	8.64 ± 0.20***	9.97±0.25NS	9.22± 0.21 NS	0.0001

Values are represented as Mean ±S.E., *p<0.01, **p<0.05, ***p<0.001, NS – non significant. Analysis of variance at P<0.05 level.

Protein: Total protein content of testis also registered a significant reduction ($p<0.001$) after 45 days in DM treated group. AS and DM + AS treatment group exhibited non-significant reduction, with former exhibiting greater recovery potential than the latter (**Table 3**).

Glycogen:

Testicular glycogen content recorded significant depletion ($p<0.001$) after 45 days in DM treated group. AS only and DM + AS treated group rendered the same result as that of other parameters (**Table 3**).

Cholesterol: Cholesterol concentration of testis was found to be elevated significantly ($p<0.001$) after 45 days of DM administration. AS only and DM + AS treatment brought down the cholesterol content towards control values and difference observe was non-significant (**Table 3**).

TABLE 3: SHOWING TOTAL PROTEIN, GLYCOGEN AND CHOLESTEROL LEVEL IN TESTIS OF CONTROL AND TREATED MICE.

	Control	Oil	DM	AS	DM + AS	P
Protein (mg/100mg tissue wt.)	12.94± 0.16	12.98±0.14NS	11.94 ± 0.05***	12.96±0.1NS	12.6±0.31NS	0.0007
Glycogen (µg/mg tissue wt)	406.94±7.7	414.02±6.3NS	329.7±13.01***	410.75 ±8.54	349.8±14.3NS	0.0001
Cholesterol (mg/100mg tissue wt)	0.4 ± 0.008	0.41±0.005NS	0.45 ± 0.006***	0.42± 0.03NS	0.43 ± 0.04NS	0.0003

Values are represented as Mean ±S.E., *p<0.01, **p<0.05, ***p<0.001, NS – non significant. Analysis of variance at P<0.05 level.

Antioxidant Enzymes –Testicular GSH level registered significant fall ($p<0.001$) after 45 days in DM treated mice as compared to control mice. Similarly activities of GPx, GRx and GST recorded a significant ($p<0.001$) descent after 45 days in testis of DM treated mice as compared to control. AS only and DM + AS treatment brought about an upsurge in the values and obtained results were comparable to control as the mean differences were found to be non-significant (**Table 4**).

TABLE 4: SHOWING GSH, GPx, GRx and GST ACTIVITY IN TESTIS OF CONTROL AND TREATED MICE.

	CONTROL	OIL	DM	AS	DM + AS	P
GSH (µg/100mg tissue wt.)	47.54±0.74	46.78 ± 0.54NS	38.2±1.54***	49.5±2.5NS	42.8± 2.6NS	0.0007
GPx (GSH consumed/mg protein)	6.20 ± 0.15	6.21 ± 0.15 NS	4.92± 0.12***	5.95±0.13 NS	5.78±0.32NS	0.0001
GRx (moles NADPH oxidized/min/ mg protein	1.27 ± 0.05	1.27 ± 0.06 NS	0.89± 0.04***	1.25±0.02 NS	1.11±0.06 NS	0.0001
GST (units/mg protein)	0.28 ± 0.02	0.27 ± 0.02 NS	0.15± 0.01***	0.28±0.02 NS	0.23±0.01 NS	0.0003

Values are represented as Mean ±S.E., *p<0.01, **p<0.05, ***p<0.001, NS – non significant. Analysis of variance at P<0.05 level.

DISCUSSION: Body weight and organ weight are an essential benchmark for the toxicological studies. In our study DM instigated a significant reduction in body weight as well as testis weight after 45 days of exposure. Previous studies have also shown similar reduction in body weight when Deltamethrin was fed to Broiler Chicks. It was suggested that anorectic properties of deltamethrin as well as poor feed conversion efficiency was responsible for reduction in body weight [28].

Other previous reports have also indicated a decline in body and organ weight due to administration of Deltamethrin and other pyrethroids in experimental animals [29, 30, 31]. The observed weight loss could also be attributed to reduced food intake i.e. loss of appetite in the treated groups. Reduced body weight might also be the consequence of direct cytotoxic effect of the pesticide on somatic cells or indirectly through the central nervous system which controls food and water intake and regulates the endocrine function[31].

According to Salman et al. (2010) weight of reproductive organ is an essential benchmark for risk assessment in toxicological studies and testicular size is the best primary tool for assessment of spermatogenesis, since the tubules and germinal elements account for approximately 98% of the whole testicular mass [32]. Decline in testicular weight might be due to the decline in serum testosterone levels (as obtained in our unpublished work). Our findings on reduced testicular weight also corroborates to that of earlier workers who observed a similar reduction in the weight of testis, epididymis, seminal vesicle and prostrate in Deltamethrin (EC) exposed Sprague Dawley rats for a period of 35 days[33, 34, 35].

Reduction in protein content is suggestive of disturbances in protein metabolism and/or altered physiology. Thus, decreased protein content may be attributed to stress mediated immobilization of these compounds to fulfill increased requisite for energy to cope with environmental conditions exposed by the toxicant [36].

Cholesterol is an important precursor in the synthesis of steroid hormones and its requirement for normal activity of testis is well established. Present investigation revealed hypercholesterolemia in DM treated mice. Increased cholesterol level is correlated to decreased androgen concentration resulting in impaired spermatogenesis.

Also, increased testicular cholesterol content indicates unavailability of pituitary gonadotrophins for steroidogenesis. Increased cholesterol content in testis and liver and a concomitant decrease in serum testosterone level of rodents exposed to different pyrethroids has also been reported earlier [37, 38]. Likewise, reduced testosterone level in serum has also been observed in our work (unpublished

data). Rationale might be the effect of DM on the activity of two steroidogenic enzymes, viz. 3β- and 17β- hydroxysteroid dehydrogenase resulting in impaired androgen synthesis that is the conversion of Δ^5 androstenediol to testosterone and disruption of steroidogenesis. Although pyrethroids posses wide mammalian–insect toxicity ratio yet disruption of endocrine function upon sub acute or chronic exposure is a common aftermath.

Glycogen is an imperative source of energy for general body metabolism. In the present study treatment with Deltamethrin resulted in significant depletion of glycogen content in testis of exposed mice, suggesting impaired glucose metabolism. Reduction in total glycogen content might have occurred owing to its utilization to detoxify the insecticide or its metabolites through the process of glucuronidation, a process by which toxic metabolites combine with glucose phosphate and are excreted from liver through bile. Further, this decrease may also be attributed to an increase in the activity of enzymes (phosphorylase-a and phosphorylase-b) involved in glycogen breakdown (glycogenolysis) for glucuronidation process or to provide glucose into circulatory system to meet energy requirement of cells under stress. Glycogen reserves can also be reduced by secreting high amount of catecholamines. The above results are in good agreement with some earlier toxicity studies on different pyrethroids by various workers [31, 38, 39, 40].

Deltamethrin induced discernible oxidative stress response in mice as measured by increased LPO in our study. Oxidative damage has been recognized as one of the primary causes of sub-cellular toxicity of pesticides. Studies on pyrethroid insecticides have also suggested a putative role for free radicals in LPO and other oxidative stress-mediated injuries [41]. LPO is a marker of oxidative damage, which plays an important role in the toxicity of many xenobiotics including pesticides. MDA is a stable end product of LPO and therefore can be used as an indirect measure of the cumulative LPO.

DM treated rats had a high concentration of MDA in the testicular tissues indicative of the generation of LPO which can lead to loss of membrane structure and function. These results were similar to those of Samah et al. (2012) who reported DM induced LPO production in testis [42]. Pesticide induced LPO has previously also been reported by few other workers in recent times [43, 44].

The DM induced reduction in testicular CAT activity seen in the present work might reflect less capacity of testicular mitochondria and microsomes to eliminate H_2O_2. Catalase is a heme-containing enzyme that catalyzes the disproportionation of hydrogen peroxide into water and oxygen. This enzyme is important in the removal of hydrogen peroxide generated by SOD. Stress conditions in which free radical generation occurs result in the depletion of CAT activity.

Present results are in good agreement with those reported by few earlier studies with different pyrethroids who pointed out that drop in CAT activity could be explained by the flux of superoxide radicals due to the oxidative stress caused by pollutant exposure [45, 46, 47]. This depression of antioxidant enzyme activities reflects failure of the antioxidant defense mechanisms to overcome the influx of ROS induced by DM exposure that leads to the accumulation of free radicals and facilitates the enhancement of LPO, which in turn increases the oxidative damage. The current data are also in accordance with previous results which have reported a decreased activity of antioxidant enzymes in pyrethroids exposed rats [48, 49].

SOD is a group of metalloenzymes that plays a vital antioxidant role and constitutes the primary defense against the toxic effects of superoxide radical in aerobic organisms. Depletion of antioxidant enzyme activity could be attributed to direct effect on the enzyme by DM-induced ROS generation either by reduction of the enzyme substrates and/or by down-regulation of transcription and translation processes.

The decrease observed in SOD activity in our study could be explained by oxidative stress caused by DM exposure which could contribute to DM induced toxicity. This might also be the result of excessive superoxide radical production or a direct action of pesticides on the synthesis of the enzyme. SOD is considered the first line of defense against

deleterious effects of free radicals in the cell by catalyzing the dismutation of superoxide radicals to hydrogen peroxide and molecular oxygen. Decreased SOD activity is suggestive of accumulation of superoxide anion radical in testis tissue which in turn could be responsible for increased LPO. Thus, our results extend support to previous reports suggesting that pesticide intoxication generally impairs the testicular antioxidant defense system and induces lipid peroxidation in experimental animals and humans [50].

The present study demonstrated that in general, exposure of mice to DM pesticide decreased the level of antioxidant enzymes, phase II enzymes and GSH level, and increased the TBARS level. This situation may result in the impairment of antioxidant mechanisms and metabolic detoxification. The decrease in antioxidant enzyme levels is interpreted as indirect inhibition of them by their binding with oxidative molecules produced during pesticide metabolism after exposure. DM treatment led to a significant decrease in GSH levels in testis compared with control group. GSH is an important naturally occurring antioxidant, which prevents free radical damage and helps detoxification by conjugating with chemicals.

Under oxidative stress, GSH is consumed by GSH related enzymes to detoxify the peroxides produced due to increased lipid peroxidation. It also acts as a substrate and co-substrate in many essential enzymatic reactions involving GPx, GRx and GST. A decrease in the GSH level not only impairs cells' response to oxidants but also changes the functions of inflammatory cells. In the present study, the observed decreases in GPx, GRx and GST enzymes may be a consequence of depleted GSH stores. Similarly, increases in lipid peroxidation and a concomitant depletion in GSH level after pesticide exposure, suggests that the increased peroxidation may be a consequence of depleted GSH stores. GPx catalyses the reduction of H_2O_2 and lipid hydro peroxides at the expense of GSH.

We observed a clear inhibition of GPx activity in testis of DM-intoxicated mice. Monteiro et al. (2006) pointed out that enzyme activity can be decreased by negative feedback from excess substrate or by damage induced by oxidative modification [51]. A reduction in GPx activity in a given tissue could indicate that its antioxidant capacity was exceeded by the amount of hydroperoxide products generated. Thus, inhibition of GPx activity and reduced GSH level might reflect a possible failure of the antioxidant system in testis of DM-exposed mice. Similarly significant decrease in GRx activity in our study might be ascribed to DM induced damage to tertiary structure of enzyme. It is well known that GST catalyzes the conjugation of reduced glutathione to electrophiles and protects cellular components from oxidative insult. It is also known to bind strongly to hydrophobic compounds like pyrethroids.

Allium sativum (AS) significantly improved the evaluated parameters albeit not all were identical to control levels. AS ameliorated the reduction in body weight, testis weight and DM induced oxidative damage of testes. The significant protective effect of fresh garlic extract against testicular toxicity of DM in male mice could be explained primarily due to the capability of garlic to inhibit the interaction of potential mutagens with DNA molecules in testicular germ cells and prevent any alteration. Secondly, biological constituents of garlic may hinder the process of lipid peroxidation and formation of lipid peroxides and other reactive oxygen species (ROS) in the semen and/or the plasma membrane of spermatozoa, owing to the strong as well as free radical scavenging properties of garlic organosulphur ingredients.

With respect to the cholesterol lowering property of garlic, it has been suggested that some constituents of garlic may act as inhibitors for some enzymes such as hydroxyl methyl glutaryl CoA reductase, which participates in cholesterol synthesis [52]. As seen in the present study, fresh garlic extract can lower the testicular cholesterol level to a significant extent. It also increases the plasma antioxidant capacity and oxidation resistance by increasing antioxidant enzymes activities and decreasing the plasma malondialdehyde level, which is an important indicator of lipid peroxidation.

Previous workers have reported that treatment with *Allium* sp. followed by acute ethanol intoxication restored and increased the activities SOD, GSH, G-

Rx and TAA in liver of exposed animals [53]. Thereby, confirming the antioxidant capacity of fresh *Allium* homogenates. Similar amelioration of enzymatic and non-enzymatic antioxidants by *Allium sativum* has also been reported in the liver of mice suffering from coccidiosis [54]. Indeed, garlic prevents the toxicant induced loss of GSH and decrease of activities of catalase and SOD as observed in the present work.

In accordance, Kiruthiga et al. (2007) have found that garlic significantly decreased lipid peroxidation and increased GSH, catalase and SOD[55]. The possible mechanism underlying the preventive activity of garlic as noticed in present study could primarily be by virtue of its powerful antioxidant activity as manifested by the competency to diminish Deltamethrin-induced reactive oxygen species and LPO generation.

In accordance with the present results of garlic induced elevation in glycogen levels in test tissues, earlier workers observed a similar escalation in liver glycogen of female rats [56]. It is reported that garlic acts as a hypoglycemic agent [57]. Therefore, it is assumed that administration of garlic increases response of insulin and also promotes the conversion of the inactive form of glycogen synthetase to the active form and enhances conversion of blood glucose into glycogen. The hypoglycemic effect might be due to an increase in the insulin response during feeding, probably due to enhanced transport of blood glucose to the peripheral tissues. The abolition of this effect due to ingestion of garlic may inhibit some steps in the formation of glucose or in the deposition of this glucose as liver glycogen [56].

Increased level of total protein in *Allium sativum* extract treated groups suggests the ability of garlic to stimulate the regeneration of tissues. Garlic has been reported to increase protein synthesis in damaged tissues and improve the functional status of the cells [58]. This effect probably reflects the potential ability of garlic to protect the protein manufacturing machinery from Deltamethrin induced cellular damage.

CONCLUSION: Based on the aforementioned data, we conclude that Deltamethrin is a toxic chemical pesticide that produced significant testicular toxicity in treated male mice as revealed by the severely affected parameters and the altered gravimetric indices. Furthermore, this investigation fundamentally cleared the protective and/or ameliorative role played by garlic extract against the testicular toxicity incurred by DM. The current data reveals that garlic administration possesses conspicuous modulating effects and is capable to overcome the oxidative stress and subsequently rectify the biochemical perturbations induced by the DM administration through its antioxidant properties.

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