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# PROTECTIVE ROLE OF *ZINGIBER OFFICINALE* ON DELTAMETHRIN-INDUCED OXIDATIVE STRESS IN GASTRO-INTESTINAL TRACT

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## ABSTRACT

Deltamethrin (DLM) is a type-II synthetic pyrethroid insecticide which is used extensively to get rid of pests in agricultural practices as well as to combat against insect-vector borne disease. Exposure of deltamethrin (DLM) to humans and other animals leads to toxicity of various vital tissues, the present study is an extension to provide primary understanding of sub-chronic toxicity of pyrethroids in digestive tissues by evaluating the oxidative stress induced by the DLM. Moreover, the protective effects of *Zingiber officinale* (ZO) against Gastro-intestinal toxicity in female mice was evaluated. Female Swiss albino mice were divided into seven experimental groups: Group I served as the control group. Group II served as vehicle control (peanut oil) and Group III administered with 100 mg/kg b.wt. ZO only. Group IV and Group V animals were given 3 mg/kg b.wt and 6 mg/kg b.wt of DLM respectively while Group VI and Group VII mice were given 3 mg/kg b.wt. of DLM+100 mg/kg b.wt ZO and 6 mg/kg b.wt of DLM+100 mg/kg b.wt ZO respectively for a period of 45 days to female mice. Results showed that DLM administration increased lipid peroxidation of stomach and intestine and have negative impact Glutathione (GSH) and the activities of antioxidative enzymes including Superoxide Dismutase (SOD), Catalase (CAT), Glutathione peroxidase (GPx) and Glutathione reductase (GRx). Further, co-administration of ZO along with DLM brought the recovery to the normal antioxidant status. Hence, it can be

concluded that ZO has potential benefits and could be able to mitigate DLM induced oxidative stress.

**Keywords: Deltamethrin, Pyrethroids, Oxidative stress, Gastro-intestinal toxicity, *Zingiber officinale*, Antioxidants**

## INTRODUCTION

The plant *Zingiber officinale* commonly known as Ginger is a broad-spectrum herbal remedy recognized and reputed in plethora by traditional literatures of medicine **[1]**. There is a bunch of articles published in last two decades from every corner of the globe to elucidate and demonstrate ginger`s role in treating variety of ailments and health conditions, including dyspepsia **[2, 3]**, cardiovascular conditions **[4-6]**, metabolic irregularities **[7-10]** Immuno-deficiencies **[11, 12]** anti-inflammatory **[1, 13, 14]** and cancer **[15, 16]**.

Deltamethrin is one of the type II pyrethroids, developed in1974 that have more resistance to degradation by light and air, thus making them suitable for use in agriculture compare to their previous counterparts. Deltamethrin binds and interact sodium channels and leads to disorganise nerve impulse transmission in the target organisms like insects and small arahinids. As like other type II pyrethroids, deltamethrin has α-cyano group that causes "long-lasting" sodium channel activation; which means that a sodium channel binds to these insecticides remains open much longer; up to several seconds **[17]**.

Deltamethrin is still widely used throughout the globe even after decades of its first synthesis and is thought to be safe **[18]**. However, Deltamethrin considered to be a "safe pesticide'', recent publications show potential toxicity of the same insecticide **[19-21]**. In Majority of deltamethrin animal toxicities reported, antioxidant status of the cell has been found to be drastically altered as to scavenge free radicals produced **[22]**.

Because of an easy access of toxicants into the GI tract, it can be a victim of variety of chemical substances including pesticides **[23]**. Residues of deltamethrin and related pyrethroids were estimated and found in the range near to Maximum Residue Limit (MRL) from soil samples **[24]**, fruits and vegetables and stored grains **[25]**.

The present study was designed in alignment to provide comprehensive oxidative stress caused by deltamethrin to stomach and small intestine and ameliorative measures by the said gastro-protective antidote of traditional medicine-*Zinziber officinale.*

## MATERIALS AND METHODS

### Housing and care of animals

Healthy, adult, pathogen free, colony bred female 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 approval of using experimental animals was obtained as per the guidelines of the institutional animal ethics committee, under registration No.167/GO/ReBi/S/99/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.

Animals were initially acclimatized for a week before the initiation of experiment. The animals were kept 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 30-60%. Animals were randomized into control and treated groups and were caged separately. Standard chow and water was provided ad libitum. Test chemical Deltamethrin (technical grade) of 98.11% purity was kindly 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.

**Rationale for Selection of Doses**

Technical grade Deltamethrin was dissolved in peanut oil and administered via oral gavage at two dose concentrations: Low Dose (3 mg/kg body weight) and High Dose (6 mg/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 **[26]**.

Crude extract of *Zinziber officinale* (ginger) was prepared from rhizomes purchased in bulk from the market. The rhizomes were peeled and then sliced into pieces, ground into a fine paste. Working solution was then prepared by dissolving 5 gm of this paste in 100 ml of deionized water, where 1 ml of the extract contained 50 mg of crude *Zingiber officinale*. Freshly prepared *Zingiber officinale* extract was then administered to mice at a dose level of 100 mg/kg body weight accordingly. Dose of the *Zingiber officinale* was based on previous studies **[27]**.

**Experimental design**

Studies on the effect of deltamethrin at two dose concentrations were carried out and compared with control (untreated) and vehicle treated (peanut oil only) mice as per the experimental protocol. *Zinziber officinale* was administered along with the low dose and high dose of deltamethrin to investigate mitigative potency of the same. The animals were treated orally using a

gavage. Control animals were provided only distilled water throughout the study and the vehicle control animals were given 0.2 ml peanut oil. The duration of the treatment was 45 days.

**Animals were divided into following groups**:

Group-I: Control (given distilled water only)

Group-II: Vehicle Control (given only peanut oil)

Group-III: *Zingiber officinale* treated (100 mg/kg body weight)

Group-IV: Low dose deltamethrin treated group (3 mg/kg body weight)

Group-V: High dose Deltamethrin treated group (6 mg/kg body weight)

Group-VI: Low dose deltamethrin treatment + *Zinziber officinale*

Group-VII: High dose deltamethrin treatment + *Zinziber officinale*

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

**Parameters studied**

***Protein estimation***

Protein estimation was done in stomach and intestine of control and treated mice using standard protocol of Lowry *et al* . (1951) [28]. Colour development was read at 540 nm in Digital Spectrophotometer.

***Lipid Peroxidation (LPO) – Thiobarbutiric Acid Reactive Species Assay (TBARS)***

TBARS level in stomach and intestine of control and treated mice were determined by the method of Ohkawa *et al* . (1979) **[29]**. This method is based on the formation of red chromophore that absorbs at 532 nm 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 stomach and intestine of control and treated mice was estimated by modified spectrophotometric method of Kakkar etal. (1984) **[30]**.

***Catalase (CAT)***

Catalase activity in stomach and intestine of control and treated mice was assayed by the modified method of Sinha (1972) **[31]**.

***Glutathione (GSH)***

The concentration of glutathione in stomach and intestine of control and all treated groups of mice was assayed by the method of Ellman (1959) **[32]**. Glutathione (GSH) present in the tissues 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 stomach and intestine of control and treated animals by Rotruck *et al* (1973) **[33]**.

***Glutathione Reductase (GRx)***

The estimation of glutathione reductase in stomach and intestine was done by the method of Carlberg and Mannervik (1985) **[34]**.

***Glutathione-S-Transferase (GST)***

Glutathione-S-transferase activity was measured in stomach and intestine of control and treated group animals by modified method of Habig *et al* . (1974) **[35]**.

**Statistical analysis**

For each parameter, minimum of 6 replicates were done and the results were expressed as Mean ± Standard Error (S.E.). The data was then statistically analysed by Analysis of Variance (One way - ANOVA) taking significance at $p<0.05$ level by Graphpad Prism 7.0 software. Sidak's post hoc test was used for comparison among different treatment groups ($p<0.05$).

## RESULTS

**Gravimetric Indices**

**Terminal Body weight**:

The body weight of mice reduced significantly in both the deltamethrin treatment groups, in Group-IV and Group-V in order of $p<0.001$ when compared to Group-I control **(Table 1)**. Ameliorative co-treatment *Zingiber officinale* of bring significant recovery in the body weight in Group-VI and Group-VII in order of $p<0.001$ when compared with Group-IV and V **(Table 1)**.

**Stomach weight**:

The weight of stomach was found to be decreased non significantly in Group-IV and significantly in Group-V ($p<0.001$) when compared to the control, where as co-treatment of *Zingiber officinale* with Low dose DLM treatment showed non-significant recovery in stomach weight compared to Low dose group Group-IV. Co-treatment of *Zingiber officinale* with High Dose DLM showed significant weight increased at the order of $p<0.001$ when compared to Group-V **(Table 1)**.

**Small Intestine Weight:**

The intestinal weight of mice reduced significantly in both the deltamethrin treatment groups, in Group-IV and Group-V in order of $p<0.001$ when compared to control Group-I (Table-1). Co-treatment of *Zingiber officinale* with DLM brought significant recovery in the intestinal weights in order of $p<0.001$ in both Group-VI and Group-VII when compared with Group-IV and V (Table-1).

**Bio-chemical and Oxidative stress parameters:**

**Total Protein:**

Total protein content of stomach and intestine showed significant reduction in both the deltamethrin treatment groups, in Group-IV and Group-V in order of $p<0.001$ when compared to control Group-I **(Table 2 and 3)**. Co-treatment of *Zingiber officinale* with DLM significant regain in the protein content of stomach and intestine in order of $p<0.001$ in both Group-VI and Group-VII when compared with Group-IV and V **(Table 2 and 3)**.

**Lipid peroxidation(LPO):**

The lipid peroxidation of stomach was found to be elevated significantly in Group-IV ($p<0.033$) and highly significantly in Group-V ($p<0.001$) when compared to the control, where as co-treatment of *Zingiber officinale* with Low dose DLM treatment showed non-significant decrease in LPO in stomach compared to Low dose group, Group-IV. Co-treatment of *Zingiber officinale* with High Dose DLM showed significant decrease in LPO at the order of $p<0.001$ when compared to Group-V **(Table 2)**.

The LPO level of intestine increased significantly in both the deltamethrin treatment groups, in Group-IV and Group-V in order of $p<0.001$ when compared to control Group-I (Table-3). Co-treatment of *Zingiber officinale* with DLM brought significant decrease in the intestinal lipid peroxidation in order of $p<0.001$ in both Group-VI and Group-VII when compared with Group-IV and V **(Table 3)**.

**Superoxide Dismutase (SOD):**

The activity of SOD in stomach was found to be decreased non-significantly in group IV($p<0.033$) and highly significantly in Group-V ($p<0.001$) when compared to the control, where as co-treatment of *Zingiber officinale* with Low dose DLM (Group-VI) and High Dose DLM (Group-VII) indicated non-significant increase in SOD activity in stomach compared to Group-IV to Group-V **(Table 2)**.

SOD activity in intestine showed significant reduction in both the deltamethrin treatment groups, in Group-IV and Group-V in order of $p<0.001$ when compared to control Group-I (Table-1). Co-treatment of *Zingiber officinale* with DLM showed highly significant upsurge in SOD activity in intestine in order of $p<0.001$ in both Group-VI and Group-VII when compared with Group-IV and V **(Table 3)**.

**Catalase (CAT):**

The catalase activity in stomach decreased non-significantly in both the DLM treated groups, Group IV and Group-V when compared to the control, where as co-treatment of *Zingiber officinale* with Low dose DLM (Group-VI) and High Dose

DLM (Group-VII) showed non-significant increase in activity of catalase in stomach compared to Group-IV to Group-V **(Table 2)**.

The activity of catalase in intestine was found to be decreased non-significantly in both the DLM treated groups Group-IV and Group-V when compared to the control, where as Co-treatment of *Zingiber officinale* with low dose DLM (Group-VI) showed non-significant increase in catalase activity compared to Group-IV and highly significant increase in CAT activity in intestine was observed in order of $p<0.001$ in Group-VII when compared with Group-V **(Table 3)**.

**Glutathione(GSH):**

The glutathione level in stomach reduced significantly in both the deltamethrin treatment groups, in Group IV and Group V in order of $p<0.001$ when compared to Group-I control **(Table 2)**. Whereas the level of GSH in intestine reduced significantly in both the deltamethrin treatment groups, in Group-IV in order of $p<0.002$ and Group-V in order of $p<0.001$ when compared to Group-I control. Ameliorative co-treatment *Zingiber officinale* with DLM showed non-significant recovery in GSH level of both the organs in Group VI and significant recovery in Group-VII in order of $p<0.001$ when compared with Group-IV and V **(Table 3)**.

**Glutathione Peroxidase($GP_X$):**

The glutathione peroxidase activity in stomach decreased significantly in Group-IV in order of $p<0.002$ and highly significantly in Group-V in order of $p<0.001$ when compared to Group-I control **(Table 2)**. The glutathione peroxidase activity in intestine reduced significantly in both the deltamethrin treatment groups, in Group-IV and Group-V in order of $p<0.001$ when compared to Group-I control (Table-3). Co-treatment of *Zingiber officinale* with DLM significantly increased the activity of GPx in stomach and intestine in order of $p<0.001$ in both Group-VI and Group-VII when compared with Group-IV and V (Table-3).

**Glutathione Reductase (GRx):**

GRx activity found to be significantly elevated in stomach in Group-IV ($p<0.033$) and highly significantly in Group-V ($p<0.001$) when compared to the control, where as co-treatment of *Zingiber officinale* with Low dose DLM treatment showed non-significant increase in GRx in stomach compared to Group-IV. Co-treatment of *Zingiber officinale* with High Dose DLM showed significant increase in GRx activity in the order of $p<0.033$ when compared to Group-V **(Table 2)**.

The activity of GRx in intestine reduced significantly in both the deltamethrin

treatment groups, in Group-IV and Group-V in order of p<0.001 when compared to Group-I control (Table-3). Whereas Co-treatment of *Zingiber officinale* with low dose DLM (Group-VI) showed significant increase in catalase activity in order of p<0.002 compared to Group-IV and highly significant increase in CAT activity in intestine was observed in order of p<0.001 in Group-VII when compared with Group-V **(Table 3)**.

**Glutathione S Transferase (GST):** GST activity non-significantly decreased in stomach in Group-IV and highly significantly decreased in Group-V (p<0.001) when compared to the control, where as co-treatment of *Zingiber officinale* with Low dose DLM treatment showed non-significant increase in GST in stomach compared to Group-IV. Co-treatment of *Zingiber officinale* with High Dose DLM showed significant increase in GRx activity in the order of p<0.002 when compared to Group-V **(Table 2)**.

GST activity in intestine of mice reduced non-significantly in both the deltamethrin treatment groups, in Group-IV and Group-V when compared to Group-I control **(Table 1)**. Ameliorative co-treatment *Zingiber officinale* showed non-significant recovery in the body weight in Group-VI and Group-VII when compared with Group-IV and V **(Table 3)**.

**Table 1: Showing body weight (gm), stomach weight (gm) and intestinal weight of control, Deltamethrin and *Zingiber officinale* treated mice after 45 days**

| Weight | Group-I | Group-II | Group-III | Group-IV | Group-V | Group-VI | Group-VII |
|---|---|---|---|---|---|---|---|
| Body | 34.18±0.48 | 34.25± 0.552NS | 34.52 ±0.736NS | 26.33±0.603*** | 24.02±0.601*** | 32.63±0.536### | 32.38±0.240### |
| Stomach | 0233±0.002 | 0.236±0.002NS | 0.230±0.001NS | 0.225 ±0.001NS | 0.216±0.001*** | 0.229±0.002ns | 0.229±0.002### |
| Intestine | 1.23±0.002 | 1.237±0.0016NS | 1.236±0.002NS | 1.190±0.0018*** | 1.178±0.023*** | 1.220±0.008### | 1.215±0.001### |

Values are represented AS Mean ± S.E., Analysis of variance at P<0.05 level
Comparison of Group-I with Group-II, III, IV and V; *p<0.033, **p<0.002, ***p<0.001, NS – non significant
Comparison of Group-IV and V with Group-VI and VII respectively; #p<0.033, ##p<0.002, ###p<0.001, ns – non significant

**Table 2: Showing Total Protein, Glutathione, Superoxide dismutase (SOD), Catalase, Glutathione Reductase and Glutathione Peroxidase activities in Stomach of control, Deltamethrin and *Zingiber officinale* treated mice for 45 days**

| Parameter | Group-I | Group-II | Group-III | Group-IV | Group-V | Group-VI | Group-VII |
|---|---|---|---|---|---|---|---|
| Protein | 13.90±0.012 | 13.8±0.012NS | 14.25±0.016** | 13.33±0.008*** | 13.04±0.013*** | 13.91±0.012### | 13.88±0.018### |
| LPO | 63.02±0.154 | 64.03±0.259NS | 62.63±0.210NS | 67.28±0.774* | 73.03±0.167*** | 64.20±0.471ns | 67.55±1.392### |
| SOD | 0.575±0.018 | 0.5719±0.019NS | 0.595±0.019NS | 0.504±0.014NS | 0.4710±0.016*** | 0.568±0.007ns | 0.520±0.007ns |
| CAT | 25.61±0.840 | 25.40±1.028NS | 27.31±1.384NS | 23.94±0.89NS | 22.28±0.723NS | 25.11±0.666ns | 24.00±1.047ns |
| GSH | 36.73±0.521 | 37.10±0.465NS | 37.42±0.479NS | 34.18±0.206*** | 32.60±0.214*** | 35.28±0.267ns | 34.91±0.142*** |
| GPx | 9.627±0.199 | 9.693±0.120NS | 9.733±0.186NS | 8.515±0.199** | 7.910±0.169*** | 9.430±0.158# | 9.155±0.235### |
| GRx | 1.335±0.025 | 1.345±0.022NS | 1.343±0.022NS | 1.228±0.014*** | 1.147±0.021*** | 1.293±0.0012ns | 1.262±0.018## |
| GSH | 0.416±0.0164 | 0.406±0.013NS | 0.426±0.0172NS | 0.365±0.007NS | 0.315±0.0175*** | 0.396±0.0118ns | 0.385±0.009# |

Values are represented as Mean ± S.E., Analysis of variance at P<0.05 level
Comparison of Group-I with Group-II, III, IV and V; *p<0.033, **p<0.002, ***p<0.001, NS – non significant
Comparison of Group-IV and Group-V with VI and VII respectively; #p<0.033, ##p<0.002, ###p<0.001, ns – non significant

**Table 3: Showing Total Protein, Glutathione, Superoxide dismutase (SOD), Catalase, Glutathione Reductase and Glutathione Peroxidase activities in intestine of control, Deltamethrin and *Zingiber officinale* treated mice for 45 days**

| Parameter | Group-I | Group-II | Group-III | Group-IV | Group-V | Group-VI | Group-VII |
|---|---|---|---|---|---|---|---|
| Protein | 12.58±0.014 | 12.50±0.012NS | 12.68±0.024NS | 11.88±0.025*** | 11.38±0.014*** | 12.49±0.016### | 12.23±0.020### |
| LPO | 64.15±0.215 | 64.41±0.172NS | 61.25±0.664NS | 73.51±0.359*** | 77.06±0.444*** | 69.57±1.599ns | 70.85±0.363## |
| SOD | 0.635±0.007 | 0.631±0.006NS | 0.661±0.013NS | 0.569±0.008*** | 0.536±0.006*** | 0.634±0.005### | 0.590±0.003### |
| CAT | 27.55±0.423 | 27.35±450NS | 28.73±0.619NS | 25.43±0.478NS | 25.43±0.478*** | 22.74±0.557ns | 26.95±0.361### |
| GSH | 60.47±0.532 | 61.17±0.423NS | 61.40±0.520NS | 57.17±0316** | 54.25±0.525*** | 59.27±0.608ns | 58.10±1.043### |
| GPx | 13.72±0.039 | 13.72±0.035NS | 13.80±0.101NS | 12.00±0.142*** | 11.31±0.222*** | 13.14±0.246# | 12.75±0.293## |
| GRx | 1.528±0.017 | 1.530±0.026NS | 1.560±0.014NS | 1.407±0.0114*** | 1.350±0.014*** | 1.522±0.070## | 1.492±0.020### |
| GST | 0.632±0.007 | 0.634±0.022NS | 0.649±0.014NS | 0.602±0.000* | 0.599±0.006** | 0.630±0.004ns | 0.622±0.018ns |

**Values are represented AS Mean ± S.E., Analysis of variance at P<0.05 level**
**Comparison of Group-I with Group-II, III, IV and V; *p<0.033, **p<0.002, ***p<0.001, NS – non significant**
**Comparison of Group-IV and Group-V with VI and VII respectively; #p<0.033, ##p<0.002, ###p<0.001, ns – non significant**

## DISCUSSION

In present study, significant decline in body and organ weight has been observed after the end of 45 days Deltamethrin treatment, suggesting quantitative toxicity. Similar such notable reduction in body and organ weights were observed by number of scholars **[36-40]**. In the study, protein content of the stomach and intestine was also found to be decreased following DLM treatment. This decline in protein content may also be attributed to the affected protein digestion in stomach and further absorption of amino acids in the intestine. The decline in body and organ weight may be the direct effect of pesticides to the tissues or indirectly through the hypothalamic hunger centres in the brain **[41]**. Further, the decrease in protein content may also be indicating the higher damage to repair ratio affecting the normal digestive integrity.

LPO is an oxidative damage to cellular membranes **[42]** which is accomplished by malondialdihyde (MDA) mediated peroxidation of polyunsaturated fatty acids. The present study revealed increased in LPO of the stomach and intestine, which is in accordance with the study in fish model where high levels of LPO observed in all tested tissues of fish which exposed to DLM **[43]**. Similar studies of increasing membrane lipid damage after DLM exposure in tissues were reported in murine models **[38, 39, 44]**. Deltamethrin induced lipid damage is not only common in animals but also found in plants. Soyabeans treated with deltamethrin showed dose dependent increased level of LPO.

Deltamethrin is known to disrupts the antioxidant indices in both *in vitro* and *in vivo* models **[22]**. Antioxidant status of the cell is mainly linked with antioxidant defence unit, which comprises of enzymatic antioxidants like Superoxide dismutase(SOD), Catalase (CAT),

Glutathione peroxidase (GPx), Glutathione reductase (GRx) and Glutathione S transferase (GST) and non-enzymatic antioxidants which includes Glutathione, thiol etc. There are studies which showed that DLM caused oxidative stress by breaking oxidative balance in the cell **[45, 46]** In the present study, the tested digestive organs of mice showed significant reduction in SOD, CAT, GPx, GRx and GST activities well as reduction in GSH level.

SOD (Superoxide Dismutase) is an important antioxidant which effectively break the superoxide radicals and changes(mutate) them to into $H_2O_2$ and molecular oxygen. This liberated $H_2O_2$ then converted to water and oxygen by the enzymes catalase and GPx **[47]**. In the present study, the activity of these three antioxidant enzymes viz. SOD, catalase and $GP_X$ in stomach and intestine was observed to be reduced which can be direct effects of increase amount of ROS following deltamethrin exposure to female mice. In agreement to our study, Sayeed (2003) **[43]** showed decreased activity of CAT and GPx in the gills of fish and similar pattern of decreased activity in SOD and CAT reported by Dinu (2010) **[48]** in fish *Carassius auratus*. Contrary to our study, Guiloski (2013) **[49]** observed no effects on the antioxidative enzymes activity and LPO level as well.

Glutathione (GSH-reduced glutathione) is a cofactor of certain antioxidant enzymes like glutathione peroxidase (GPx), glutathione reductase (GRx) and glutathione –S-transferase(GST) to attack free radicals and bring peroxides to minimal level of damage Hence the altered activity of these antioxidant enzymes can be the consequences of glutathione status. In present study the levels of glutathione and activity of glutathione peroxidase (GPx), glutathione reductase (GRx) and glutathione-S-transferase (GST) was observed to be reduced significantly in dose dependent manner. Kumar (2004) reported that deltamethrin caused significant alterations in these antioxidant enzymes as well as corresponding GSH depletion in murine thymocytes **[50]**. Similar such study also confirmed increased ROS production and decreased in the activity of GST, GRx and GPx activity **[48]**.

Modern scientific research has shown that ginger (*Zinziber officinale*) has profound therapeutic effects including antioxidant defence, an ability to inhibit the formation of inflammatory molecules or by directly providing anti-inflammatory effects. Some of the active compounds of *Zinziber officinale* are reported to increase digestion, absorption, relieve constipation and flatulence by enhancing muscular activity in the gastro-intestinal tract **[50]**. The effect of

ginger and its preparations is credited to antioxidant activity of its major components namely Zingerone, gingerdiol, Zingiberene, gingerols and shogoals **[51]**. In present study, *Zinziber officinale* showed significant recovery in the antioxidant defence unit of the stomach and intestine by restoring the normal level of GSH as well as regaining the original activity of the enzymatic antioxidants like i.e., SOD, CAT, GPx, GRx and GST. These results are in agreement of the previous study which has revealed significant restoration of antioxidant enzymes and glutathione in kidney by *Zinziber officinale* in rats exposed to Lead **[52].** Thus, *Zinziber officinale* has been observed to act as a potent mitigative agent in deltamethrin induced gastro-intestinal toxicity.

## CONCLUSION

Results of the present investigation clearly indicate deltamethrin induced gastro-intestinal toxicity. Further, *Zinziber officinale* being a natural compound contains various properties of being a wonder drug. The present study reveals that administration of *Zinziber officinale* along with deltamethrin could prevent the toxic influences of deltamethrin and thus may prove to be an effective ameliorative agent. Thus, *Zinziber officinale* was found to be a good mitigating agent against deltamethrin raised toxic manifestations and hence can be used as a supplement with field workers exposed to deltamethrin.

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