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Effect of ginger on hepatotoxicity and nephrotoxicity induced by malathion in rats

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Abstract

This study aimed to determine the degree to which different doses of ginger can mitigate the adverse effects of malathion. Thirty-five male Sprague-Dawley rats aged 12 weeks weighed between 200 and 220 grams each. Animals were divided into seven groups of equal size, each consisting of five rats. The length of the experiment was restricted to 28 days. Group one served as the control and was given only a standard diet; groups two and three were given malathion alone throughout the experiment (at two doses; 50 mg/kg/day and 200 mg/kg/day, respectively); group four was given 50 mg/kg/day malathion and 400 mg/kg/day ginger; group five was given 200 mg/kg/day malathion and 400 mg/kg/day ginger; group six was given 50 mg/kg/day malathion and 800 mg/kg/day ginger. The results showed that the levels of serum alkaline phosphatase (ALP), alanine aminotransferase (ALT), aspartate aminotransferase (AST), urea, creatinine, uric acid, low-density lipoprotein (LDL), very low-density lipoprotein (VLDL), triglycerides (TG), and total cholesterol (CHOL) were significantly increased in the malathion-treated groups (groups 2 and 3). However, groups 2 and 3 had significantly lower levels of body weight gain (BWG), food intake (FI), and food efficiency ratio (FER) than the control and ginger-treated groups. The histopathological studies revealed that, although some pathological features were observed in the malathion-treated groups, groups treated with different doses of ginger exhibited histopathological changes in liver and kidney tissues. In conclusion, varying doses of ginger could potentially lessen the hepatotoxicity and nephrotoxicity of malathion.

Keywords: Functional food, ALT, AST, Blood lipids, Kidney

1. Introduction:

ORGANOPHOSPHORUS (OP) pesticides, which are widely used in agriculture, medicine, and industry, can cause a wide range of health and behavioral issues in humans and wildlife when used excessively.

Environmental degradation occurs almost immediately after the release of these OP compounds. Following the ban on organochlorines, which have the potential to bioaccumulate and biomagnified, resulting in ecotoxicological effects [1], their concept was developed. An OP pesticide commonly used to eradicate ectoparasites, and household insects, preserve the stored grain and eliminate disease-inducing arthropods and malathion [O, O-dimethyl S-(1,2-dicarcethoxyethyl) phosphonodithioate] is an OP. Butyrylcholinesterase (AChE) and other cholinergic pathways are overstimulated due to the inactivation of serine esterase, a common side effect of this OP agent [2,3].

WITH their lipophilic nature and rapid intestinal assimilation, OPs can cause a wide range of pathological issues, including insufficiency of the immune system, pancreatitis and hepatic disorder, liver disease, and renal damage [4]. Studies show that these OPs are toxic to humans and animals. Regulation of hepatic gene expression could play an essential role in the adaptive response to altered metabolism by altering the capacity of enzymes in relevant metabolic pathways [5].

IN the biotransformation of thin organophosphates, the liver is the primary metabolizing site, and the kidneys play a role in removing toxic products. Toxicological effects of malathion on these tissues are thought to be mediated by reactive oxygen species (ROS) oxidative stress. Molecular oxygen is converted during normal cellular metabolism into reactive oxygen species (ROS) like superoxide anion and peroxides, hydroperoxyl radicals, and hydroperoxyl radicals. ROS are considered a normal part of oxidative metabolism at low or moderate concentrations. At high concentrations, they can cause tissue damage, including lipid and protein oxidation, DNA damage, and enzyme inactivation. It has been suggested that they are also involved in many pathological conditions like cancer and diabetes, heart and lung disease, autoimmune disorders, and neurological problems [6].

FREE radicals can cause a wide range of illnesses, and ginger (Zingiber officinale) is one of the most critical exogenous antioxidants. Oleoresin from ginger roots has been found to contain anti-inflammatory and analgesic properties as well as cardiotonic and antioxidant properties and anti-hepatotoxic properties [7]. For its antioxidant, anti-inflammatory, and anti-cancer properties, ginger is a widely used spice and alternative medicine treatment worldwide. Ginger has also been shown to aid in various detoxifying chemicals and drug-induced stress conditions [8]. The study's main objective was to evaluate ginger's protective effect on kidney and liver biomarkers at different doses and to find the most effective dose for this purpose.

2. Materials and methods

2.1 Materials

2.1.1 Ginger was bought from the Ministry of Agriculture's Directorate of Agriculture in Giza, Egypt.

2.1.2 The O, O-dimethyl phosphorodithioate of diethyl mercaptosuccinate, also known as malathion (98% active ingredient), was purchased from the Kafr El Zayat company in Egypt for use in the current

study. The malathion was dissolved in corn oil prior to administration to the animals.

2.2 Animals

Thirty-five male Sprague Dawley rats (n=35) were bought from the Animal House Colony of the Agriculture Research Center in Giza, Egypt. Each rat weighed 200–220 grams. Rats were kept in cages that were 22 °C, with 56 % humidity (40 to 70 %), and had a 12-hour light/ 12-hour dark cycle. Rats had unrestricted access to food and water from the tap. The experiment was conducted in a lab at the Faculty of Home Economics, Helwan University, Cairo, Egypt. All associated procedures followed the National Institutes of Health Guiding Principles in the Care and Use of Animals. Rats were divided into two main groups: the experimental group and the control group.

2.3 Methods

2.3.1 Diet

The rats were kept in plastic cages at a set temperature and fed a base diet for two weeks straight to help them acclimate. The basal diet was prepared following the AIN-93 recommendations [9]. The basic diet contains crude protein (20%), crude fat (4%), crude fiber (3.5%), ash (6.0%), salt (0.5%), calcium (1.0%), phosphorus (0.6%), vitamin A (20.0 IU/g), vitamin D (2.2 IU/g), and vitamin E (70.0 IU/kg), as well as trace minerals (i.e. cobalt, copper, iodine, iron, manganese, selenium, zinc, and methyl choline).

2.3.2 Induction of malathion toxicity

For induction of malathion toxicity, malathion was orally administered to the rats at doses of 50 and 200 mg/kg body weight (BW) per day [10] (volume, 1 ml) (1/316 LD50 for malathion). The 50 mg/kg BW of malathion was added at a dose level of 1/10 LD50 (50 mg /kg body weight) in 1,000 ml corn oil. Also, the 200 mg/kg BW of malathion was added at a dose level of 1/40 LD50 (200 mg /kg body weight) in 1,000 ml corn oil [11]. The added doses were calculated directly from commercial grade. The rats were monitored daily for any clinical signs of toxicity, moribund status, and mortality throughout the experiment.

2.3.3 Preparation of ginger extract:

Ginger rhizomes were dried at room temperature and ground into a powder. 400 mg and 800 mg of the powder were macerated for 12 hours at room temperature in 1000 ml of distilled water before being filtered. In the current study, each animal orally gave 1 ml of the final aqueous extract.

2.3.4 Experimental design

The thirty-five rats were divided into the following groups: Group one (CN): control negative were healthy, not infected, and fed basal diet only. Group two (CP1): control positive 1 received the basal diet and oral doses of malathion (50 mg/kg BW). Group three (CP2): control positive 2 received the basal diet and oral doses of malathion (200 mg/kg BW). Group four (Gin1):

received the basal diet, oral doses of malathion (50 mg/kg BW), and ginger (400 mg/kg BW) supplements. Group five (Gin2): received the basal diet, oral doses of malathion (200 mg/kg BW), and ginger (400 mg/kg BW). Group six (Gin3): received the basal diet, oral doses of malathion (50 mg/kg BW), and ginger (800 mg/kg BW). Group seven (Gin4): received the basal diet, oral doses of malathion (200 mg/kg BW), and ginger (800 mg/kg BW). The experiment lasted for 35 days, including a 7-day adaptation period followed by an experimental period of 28 days. Ginger and malathion were both given orally every day throughout the experiment. Grams of feed intake (GFI) was determined by weighing the amounts of diet given, refused and spilled. Feed intake per day was defined as feed intake rate. Body weight was recorded daily and the weight gain per day (daily gain) was defined as weight gain percentage. By the end of the experiment, all rats were sacrificed under diethyl ether anesthetic, and blood samples were collected via the retro-orbital plexus. The serum was separated and stored at -20 °C in a plastic vial until analysis.

2.3.5 Biological assessment:

The following formulas were used to calculate the body weight gain (BWG%) and feed efficiency ratio (FER):

BWG (%) = (Final weight – Initial weight) X 100 ÷ Initial weight

FER (GWG/GFI day) = (Grams body weight gain ÷ Grams food intake)/28 day

2.3.6 Biochemical evaluation

2.3.6.1 Liver enzymes

Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT) were determined according to the methods described in Huang et al. [12]. Alkaline phosphates (ALP): were determined by immunosorbent assay according to the method described by Bishop et al. [13].

2.3.6.2 The kidney's functions

Serum creatinine: was determined. By immunosorbent assay, according to Glod et al. [14]. Urea: was determined. By immunosorbent assay according to the method described by Wadehra [15]. Uric acid: was determined. By immunosorbent assay according to the method described by Kageyama [16].

2.3.6.3 Blood lipids

An immunosorbent assay was used to measure total cholesterol (TC) following the Allain et al. method [17]. According to the procedure outlined by van't Hof et al. [18], high-density lipoprotein cholesterol (HDLc) was determined. Using the method outlined by Fossati and Prencipe, triglycerides (TG) were determined [19]. According to the equations given by Lee and Nieman [20], the low-density lipoprotein cholesterol (LDLc) and very low-density lipoprotein cholesterol (VLDL) were calculated.

2.3.7 Histopathological examination

The specimens of tissues from the liver and kidneys were fixed in 10% neutral buffered formalin for 24 hours. A light microscope and digital camera were used to examine six-micron thick paraffin slices stained with hematoxylin and eosin (H and E) 24. (Nikon Instruments, Tokyo, Japan). The histopathological examination was performed at Cairo University's Faculty of Veterinary Medicine's histology lab [21].

2.3.8 Statistical Analysis

Using One-Way ANOVA followed by LSD post hoc analysis in SPSS, the data were statistically compared to determine the significance levels between the experimental rat groups. The data were presented as mean value SD (version 22, Chicago, IL, USA). It was deemed statistically significant if the p 0.05.

3. Results

Data presented in Table (1) showed food intake (FI), food efficiency, and body weight gain (BWG%) after exposure to malathion toxicity and treatment with ginger. As shown, the higher the malathion dose (200 mg/BW), the lowest the BWG (32.45±3.35 g/28 days), FI (17.80±0.20 gram/day), and FER (0.015±0.002). However, compared with CP1 and CP2, the administration of ginger induced an increase in food intake. However, this increment was not enough to significantly increase body weight gain. The analysis of variance (ANOVA) revealed that the difference between groups was statistically significant ($p<0.001$).

Table (1): Effect of ginger by different doses on body weight, food intake and food efficiency ratio of rats' toxicity by malathion and treatment with ginger

Groups	BWG (%)	FI(g/day)	FER (GWG/GFI/day)
CN	43.70±4.07c	22.40±0.24a	0.146±0.003b
CP1	40.35±5.59d	19.60±0.24b	0.155±0.004b
CP2	32.45±3.35e	17.80±0.20a	0.137±0.002b
Gin1	37.84±3.78d	20.40±0.24a	0.139±0.002b
Gin2	38.85±2.65b	20.80±0.20a	0.140±0.002c
Gin 3	43.56±3.39b	20.40±0.24a	0.160±0.001a
Gin 4	40.55±6.04c	21.80±0.20a	0.139±0.003b

All values represented as Mean±SE. Means with different subscript in the column are significantly different(P<0.05) CN: Control negative, CP1: Control positive 1 (50 mg malathion /kg BW), CP2: Control positive 2 (200 mg malathion /kg BW), Gin1: Ginger 1 (50 malathion and 400 mg/kg BW), Gin 2: Ginger 2 (200 malathion and 400 mg/kg BW), Gin3: Ginger 3 (50 malathion and 800 mg/kg BW), Gin 4: Ginger 4 (200 malathion and 800 mg/kg BW)

Table (2) shows the effect of malathion toxicity and ginger treatment on serum liver enzymes (AST, ALT, and ALP) in rats. The serum AST enzyme levels in the CP1 and CP2 groups increased to 26.67±2.73 and 27.34±3.28 U/l, respectively, which may result in liver inflammation. Furthermore, serum ALT enzyme levels in the CP1 and CP2 groups increased to 45.33±1.85 and 47.67±3.17 U/L, respectively. It was also reported that serum ALP enzyme levels increased to 144.33±10.49 and 203.33±0.79 U/l for the CP1 and CP2 groups, respectively. However, ginger administration

(particularly in the Gin2 and Gin 3 groups) significantly improved all liver enzymes to levels comparable to the normal control group.

Table (2): Effect of exposure to malathion toxicity and treatment with ginger on AST, ALT and ALP.

Groups	AST (U/l)	ALT (U/l)	ALP (U/l)
CN	21.33±1.20b	32.33±4.40d	133.33±19.28d
CP1	26.67±2.73a	45.33±1.85a	190.67±0.88a
CP2	27.34±3.28a	47.67±3.17a	203.33±0.79a
Gin1	22.70±3.29b	34.43±1.76d	155.33±1.45c
Gin2	21.00±0.57b	32.35±7.31d	149.67±0.88c
Gin 3	22.67±2.90b	36.00±1.15c	144.33±10.49c
Gin 4	22.33±1.45b	33.67±0.88d	165.67±0.88b

All values represented as Mean±SE. Means with different subscript in the column are significantly different(P<0.05) CN: Control negative, CP1: Control positive 1 (50 mg malathion /kg BW), CP2: Control positive 2 (200 mg malathion /kg BW), Gin1: Ginger 1 (50 malathion and 400 mg/kg BW), Gin 2: Ginger 2 (200 malathion and 400 mg/kg BW), Gin3: Ginger 3 (50 malathion and 800 mg/kg BW), Gin 4: Ginger 4 (200 malathion and 800 mg/kg BW)

Table (3) showed the effect of exposure to malathion toxicity and treatment with ginger on serum urea, uric acid, and creatinine in rats. It is evident that due to oral administration of malathion without treatment, blood urea increased to 45.66±1.20 and 47.67±6.17 g/l, respectively, among CP1 and CP2 groups. Also, uric acid increased to 3.37±0.14 and 3.73±0.57 mg/dL, respectively, among CP1 and CP2 rats. Serum creatinine (mg/dl) also increased dramatically to 1.80±0.11 and 1.90±0.05 mg/dL, respectively, among CP1 and CP2 rats. However, intervention with ginger, especially Gin 2 group, resulted in some improvements, and the results of the Gin 2 group were the best and the closest to the corresponding values of the CN group.

Table (3): Effect of exposure to malathion toxicity and treatment with ginger on serum urea, serum uric acid and serum creatinine.

Groups	Urea (g/L)	Uric Acid (mg/dL)	Creatinine (mg/dL)
CN	40.33±2.03d	2.23±0.03c	1.37±0.03c
CP1	45.66±1.20b	3.37±0.14a	1.80±0.11a
CP2	47.67±6.17a	3.73±0.57a	1.90±0.05a
Gin1	45.67±1.20b	2.47±0.14b	1.63±0.09b
Gin2	42.33±1.45c	2.13±0.09c	1.43±0.07c
Gin 3	45.33±6.98b	2.27±0.03c	1.60±0.05b
Gin 4	44.00±2.08b	2.23±0.06c	1.57±0.03b

All values represented as Mean±SE. Means with different subscript in the column are significantly different(P<0.05) CN: Control negative, CP1: Control positive 1 (50 mg malathion /kg BW), CP2: Control positive 2 (200 mg malathion /kg BW), Gin1: Ginger 1 (50 malathion and 400 mg/kg BW), Gin 2: Ginger 2 (200 malathion and 400 mg/kg BW), Gin3: Ginger 3 (50 malathion and 800 mg/kg BW), Gin 4: Ginger 4 (200 malathion and 800 mg/kg BW)

Data presented in Table (4) showed the effect of exposure to malathion toxicity and treatment with ginger on serum HDLc, VLDL, LDL, triglycerides, and total cholesterol. It was clear that due to malathion, the HDLc level among CP1 and CP2 groups was significantly lower than in other groups (52.00±0.58 and 50.00±0.57 mg/dL, respectively). On the other hand, serum

VLDL, LDL, triglycerides, and total cholesterol increased significantly among the CP1 and CP2 groups. However, administration of ginger, especially Gin1 and Gin3, improved the levels of LDL, VLDL, TG, and TC.

Table (4): Effect of exposure to malathion toxicity and treatment with ginger on HDL, VLDL, LDL, triglycerides (TG) and total cholesterol (TC).

Groups	HDL (mg/dL)	VLDL(mg/dL)	LDL(mg/dL)	TG (mg/dL)	TC (mg/dL)
CN	60.67±1.45c	18.47±0.64b	58.00±3.51e	89.33±2.85c	79.33±5.84e
CP1	52.00±0.58d	22.13±2.21a	76.00±5.03a	117.00±7.94b	98.00±5.51b
CP2	50.00±0.57e	23.20±1.51a	78.00±8.14a	147.67±36.0a	103.00±13.07a
Gin1	54.00±0.58a	14.47±0.71d	61.00±3.05d	75.66±0.88d	75.00±4.35f
Gin2	58.00±1.00b	17.60±0.53b	65.00±0.57d	83.00±1.53c	87.00±4.51c
Gin 3	58.33±1.34b	16.77±0.43c	63.00±1.53d	78.33±2.73d	78.00±1.15e
Gin 4	56.33±0.88b	18.20±0.31b	67.66±3.84c	85.33±0.33c	88.00±5.50c

All values represented as Mean±SE. Means with different subscript in the column are significantly different(P<0.05) CN: Control negative, CP1: Control positive 1 (50 mg malathion /kg BW), CP2: Control positive 2 (200 mg malathion /kg BW), Gin1: Ginger 1 (50 malathion and 400 mg/kg BW), Gin 2: Ginger 2 (200 malathion and 400 mg/kg BW), Gin3: Ginger 3 (50 malathion and 800 mg/kg BW), Gin 4: Ginger 4 (200 malathion and 800 mg/kg BW)

Figs 1 to 7 showed the histopathological examination of the kidneys. It could notice (Fig 1) that the photomicrograph of the kidneys of rats from the CN group showed the normal histological structure of renal parenchyma (H & E X 400). In contrast, Fig. (2) showed a photomicrograph of the kidney of the rat CP1 group and showed proteinaceous material in the lumen of renal tubules. The picture in Fig. (3) showed a photomicrograph of the kidney of a rat from the CP2 group. It revealed congestion of renal blood vessels and focal interstitial hemorrhage. However, Fig. (4) showed that the Gin1 group had necrobiosis of some renal tubular epithelial lining and congestion of renal blood vessels. Fig (5) showed that Gin2 had congestion of renal blood vessels. Fortunately, histopathological analysis of kidneys of Gin 3 and Gin 4 groups showed no histopathological changes.

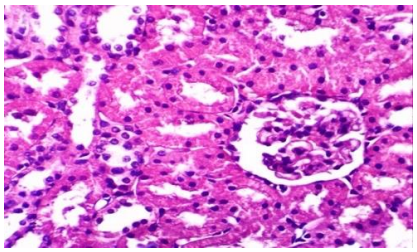

Fig. (1): Kidney of CN group

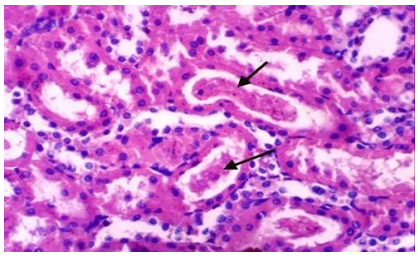

Fig. (2): Kidney of CP1 group

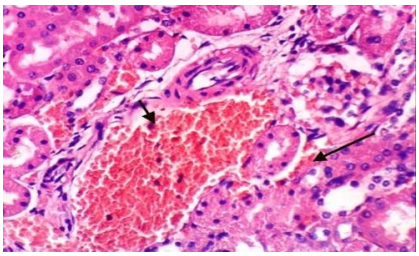

Fig. (3): Kidney of CP2 group

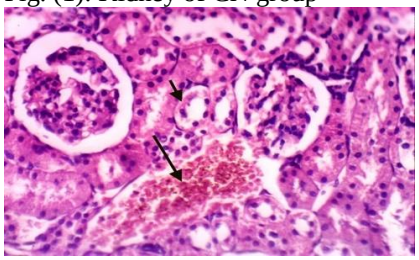

Fig. (4): Kidney of Gin1 group

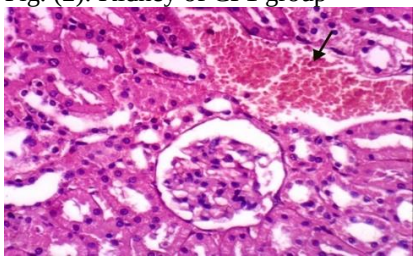

Fig. (5): Kidney of Gin2 group

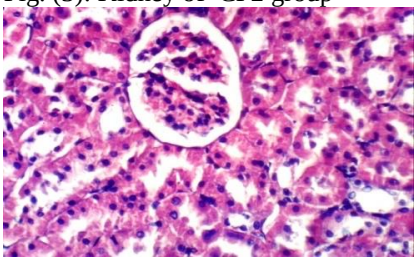

Fig. (6): Kidney of Gin3 group

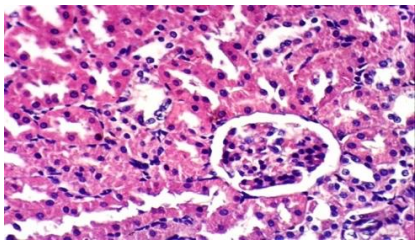
Fig. (7): Kidney of Gin4 group

Figs 8to 14 showed the histopathological examination of the liver, as shown in Fig. (8); the liver of rats from the CN group showed the normal histological structure of hepatic lobule (H & E X 400). On the other hand, Fig. (9) showed oval cell proliferation and portal infiltration with inflammatory cells among the CP1 group. Moreover, Fig. (10) showed cytoplasmic vacuolization of hepatocytes and fibroplasia in the portal triad among the CP2 group. However, rats treated with ginger showed some improvement but still have some histological changes, as Fig. (11) showed portal infiltration with few inflammatory cells among the Gin1 group. Moreover, Fig. (12) showed cytoplasmic vacuolization of some hepatocytes and slight edema in the portal triad of the Gin2 group. Fig. (13) showed that rats from the Gin3 group slightly activated Kupffer cells. Finally, Fig. (14) showed the liver of the rats from Gin 4 group, and it could be noticed that there was a binucleation of hepatocytes.

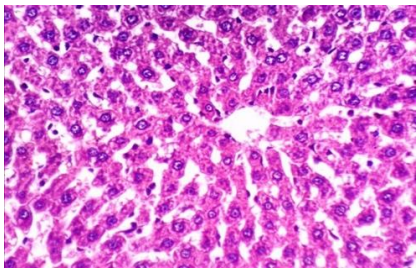
Fig. (8): Liver of rat from CN group

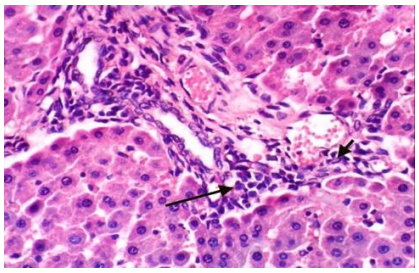
Fig. (9): Liver of rat from CP1 group

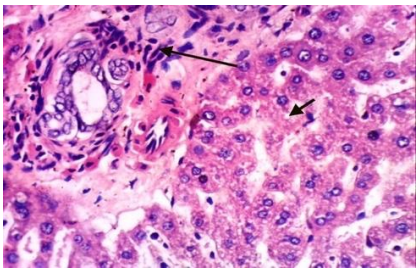
Fig. (10): Liver of rat from CP2 group

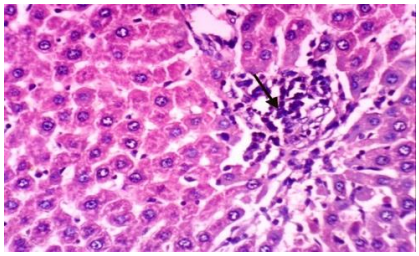
Fig. (11): Liver of rat from Gin1 group

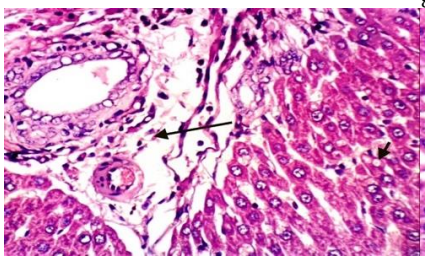
Fig. (12): Liver of rat from Gin2 group

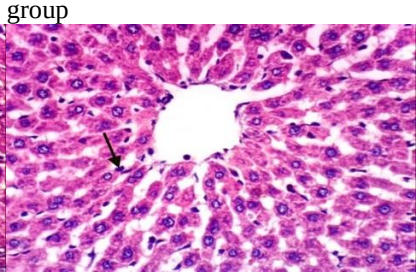
Fig. (13): Liver of rat from Gin3 group

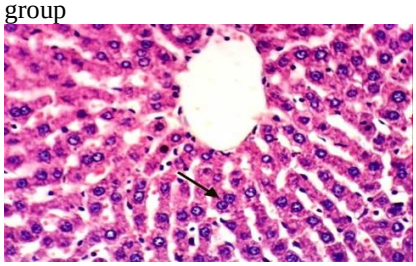
Fig. (14): Liver of rat from Gin4 group

4. Discussion:

Organophosphorus insecticides (Ops) are the most numerous and diverse class of insecticides. The widespread use of Ops insecticides in agricultural was associated with a potential risk to humans, animals, plants, and the environment, resulting in severe acute and chronic poisoning [22]. Indeed, the toxicity of Ops insecticides harms a variety of organs and systems, including the liver, kidney, nervous system, immune system, and reproductive system [23,24]. The liver is one of the organs affected by malathion toxicity, and the results of the current study showed that rats given malathion had lower BWG, FI, and FER. The deterioration worsened as the malathion dose was increased. However, ginger administration increased BWG and FI. These findings are consistent with those of Daly [25], who found that malathion (at either 359 or 415 mg/kg/day) increased body weight gain in males and females of Fischer-344 rats. The National Toxicology Program [26] and Slauter [27] obtained similar results in their male and female animal studies.

As demonstrated by the results, malathion increased liver enzymes significantly (i.e., AST, ALT, and ALP). Hepatic damage can be diagnosed by analyzing specific biochemical parameters in blood serum levels. The release of intracellular enzymes like transaminases and serum alkaline phosphatase is a highly sensitive and dramatic indicator of hepatocyte damage [28]. Hepatic necrosis is always associated with high activities of these enzymes, which indicate cellular leakage and loss of the liver cell membrane's functional integrity [29,30]. Damage to the liver and changes in hepatic functions were linked to elevated AST and ALP activities [31]. Inflammatory and necrotic reactions could be causing this increase in enzyme levels in the blood, which would indicate cytoplasmic release [32].

It was clear that administering ginger in various doses improved all liver enzymes, and the higher the ginger dose, the more significant the reduction in liver enzyme levels. These findings are consistent with those of Sakr et al. [33] who found that treating animals with ginger water extract and adriamycin improved the histological changes caused by adriamycin and resulted in a significant increase in ALT and AST activity. Furthermore, Videira et al. [34] reported that transaminases such as ALT and AST are significant cytolysis markers in the liver. In line with the current study, Kalender et al. [1] discovered that malathion treatment increased the activities of ALT, AST, and ALP in the serum of male albino rats compared to the control group.

Moreover, these findings are consistent with those of Badr et al. [35]. They discovered that ginger extract treatment significantly reduces serum ALT and AST activities in tumor-induced mice. Ginger treatments had a hepatoprotective effect, and ginger may protect against oxidative hepatocyte damage, which lowers lipid peroxidation in the liver. The antioxidant effect of ginger may explain why it provided significant protection against metalaxyl-induced hepatotoxicity [36].

Ginger's antioxidant and free radical scavenging properties may help to prevent liver damage caused by metalaxyl [37]. Through antioxidant and anti-inflammatory mechanisms, ginger may shield rats from hepatic damage from

metalaxyl. The results raise the possibility that ginger will become a staple food in areas where pesticide toxicity is possible [28].

The chemical components of ginger, such as gingerol, shogaol, paradol, and oleoresins, are responsible for various pharmacological effects. Think about how much safer and more potent ginger is as a medicine. Ginger has been shown to have pharmacological effects like hepatotoxicity [38].

One of the organs that experimental animals attacked by organophosphorus compounds are the kidney [24]. The oral administration of malathion in the current study significantly raised the blood levels of urea, uric acid, and creatinine. The hepatocytes' cytoplasmic vacuolization, fibroplasia in the portal triad, oval cell proliferation, and portal infiltration with inflammatory cells are also signs of degenerative changes in the renal tissues.

These results are consistent with earlier research [39], which revealed that a subject who consumed approximately 514 mg/kg of malathion experienced mild renal insufficiency and protein in the urine (measured by creatinine clearance). In a different instance, Crowley and Johns [40] discovered that white blood cells, protein, and sugar could all be found in the urine after consuming 600 mg/kg of malathion. According to Healy, an 18-month-old boy who consumed malathion showed increased secretion of ketone bodies and glucose in the urine [41]. According to this study, Eraslan et al. found that the toxic effects of malathion on the kidneys or an increase in purine degradation may be responsible for an increase in uric acid levels [42]. Indicating kidney dysfunction, malathion exposure also caused an increase in creatinine and urea levels [43]. Ginger is a prime example of an antioxidant that lowers oxidative stress and the generation of free hydroxyl radicals [44].

The ginger rhizome contains various aromatic compounds, including volatile and nonvolatile oils, spicy substances (gingerols, shogaols), starchy and saccharide carbohydrates, proteins, coloring agents, trace minerals, etc. Ginger's most abundant component is starch, which lowers urea, uric acid, and creatinine [37].

Despite the fact that malathion administration led to dyslipidemia, it was evident from the study that LDL, VLDL, TG, and TC levels rose when ginger was administered, particularly Gin1 and Gin3. These findings align with those of Lasram et al. [5]. They found that acute exposure to malathion disrupts lipid metabolism by increasing LDL and TG contents and may be a critical factor in the onset of atherosclerosis and cardiovascular diseases. According to Basiak and Walter [45], cholesterol may play a significant role in how an organophosphorus insecticide interacts with a biological membrane. A change in the structural organization of phospholipids or competition for the same or similar interaction sites may cause cholesterol action.

Bhandari et al. [46] reported that ginger was discovered to have hypocholesterolemic effects and cause a decrease in body weight, total serum cholesterol, and serum alkaline phosphatase in adult male rats. This is in line with the study's findings. Since ginger has antioxidant properties, eating a diet high in cholesterol will not cause cholesterol levels to rise [46].

5. Conclusion:

The exposure to organophosphorus malathion caused a decrease in FI which caused a decrease in FER and a change in the tissue composition of both kidneys and liver. Decreased FER and liver can alter body weights, liver and kidneys, and alter biochemical markers such as ALT, AST, ALP, renal urea, creatinine, and uric acid. Attenuation of toxicity induced by malathion was observed by adding ginger during exposure to this pesticide.

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Conflict of interest

The authors declare that they have no conflict of interest regarding this study.

Author contribution

El-Soauly RE have contributed to carry the practical part, chemical analysis, collecting and analyzing data. All authors participated in the biological experiments, writing, revising and editing the manuscript.

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