



VITAMIN C AND ZINC SUPPLEMENTATION AS PROTECTIVE SUPPLEMENTATION AGAINST ALUMINUM PHOSPHIDE TOXICITY AMONG WORKERS AT AL-SHARQAT SILO, SALAH AL-DIN GOVERNORATE, IRAQ

Adil Abdulrahman Mustafa

Department of Food Science, College of Agriculture, Tikrit University, Tikrit, Iraq

Correspondence: adelabd083@tu.edu.iq

Abstract. The objective of this study is to evaluate the condition of the work place and pesticide exposure level of workers in Sharqat silo, Salah al-Din Governorate, Iraq, and to propose proper measures to alleviate worker's disease and health problem due to pesticide use and treatment using vitamin C and zinc in the silo at dosage level of 500mg/kg vitamin C and 50mg/kg ZINC. There were five groups of five. The experiment was conducted for 2 months during which the workers in the treatment groups kept on taking the supplement tablets after breakfast. The results indicated that the hemoglobin and red blood cell concentration of the samples were significantly decreased in the untreated samples to 10.60g/dL and 3.87 ($10^6/\mu\text{L}$), respectively. The treated samples had a significant increase, however, when compared to the untreated. The number of white blood cells was significantly increased in the untreated samples and significantly decreased in the treated samples. Function of the kidneys also statistically significantly improved, with the results of increase in creatinine in the T2 group statistically significant. The 47 mg/dl is compared to a healthy control group (T1: 0.43 mg/dl). Levels also dropped in treatments T3, T4 and T5, to 0.64, 0.90 and 0.37 mg/dl, respectively. Regarding urea, the results revealed that the T2 sample had a significant increase to 54.00 mg/dl, while the T3 sample had a significant decrease to 46.67 mg/dl, the T4 sample had a significant decrease to 47.00 mg/dl and the T5 sample had a significant decrease to 41.33 mg/dl. Liver enzymes also showed improvement following treatment; the results showed that AST levels statistically significantly increased in sample T2 (61.67U/L) but decreased statistically significantly in samples T3 (58.00U/L), T4 (31.00U/L) and T5 (15.00U/L). The results also revealed that ALT level had increased significantly in sample T2 to 59.67 U/L, and had decreased significantly in samples T3, T4 and T5 to 53.00, 16.33 and 16.00 U/L respectively. The findings also revealed that sample T2 had a significant increase in the ALP level, which increased to 95.00 U/L, whereas the ALP level in samples T3, T4 and T5 had a statistically significant decrease to 85.00, 48.00 and 43.33 U/L, respectively.

Keywords: Vitamin C, Zinc, Kidney Function, Blood Profile Test, Liver Enzymes

Introduction

Although many health agencies have reservations about the residues left behind by chemical pesticides, the practice of controlling storage pests is one of the most important means of controlling storage pests in most grain storage facilities throughout the world. To date, laws have been passed throughout the world setting maximum allowable limits (PPM) for certain residues from the application of these pesticides. This includes health risks from the pesticides themselves, but also concerns by workers of exposure to air pollution from dust, grain particles and gases generated in the workplace, including phosphine gas emitted from aluminium phosphide pesticides when they come into contact with moisture and air. All of these have contributed to the health of people working in the field at grain silo work sites. Aluminum phosphide is released easily when grain is fumigated during storage and is sold under a number of trade names including Fostoxin, Quickfos and Silfos. It is used in the form of tablets coated with paraffin wax that as soon as they are exposed to atmospheric moisture, releasing

phosphine gas (PH₃). It is believed to be a very poisonous pesticide and can be fatal to humans in a couple of minutes, particularly if swallowed from a fresh opened container. It is used for fumigation and as a rodenticide in well-sealed storage facilities (Ezejiofor, 2016). Many workers have died due to high levels of contaminants, while others have suffered from various diseases and health problems, such as blood disorders, skin diseases, and respiratory illnesses (Al-Jubouri, 2019). This fumigation insecticide is a mixture of aluminium phosphide and ammonium carbamate with paraffin as a carrier and is applied to the grain of wheat, barley and sorghum, to warehouses, grain silos and railcars transporting foodstuffs to control insect pests (grain beetles, grain borers, grain and flour moths, weevils and waxworms). It must be used where silos are being filled with grain; the tablets are placed in the openings of the feed pipes and an automatic feeding device is desirable. Some of the most critical parameters for fumigation to be successful include minimizing any gas leakage during fumigation, and the temperature and humidity of the materials being stored (Al-Buraiddi, 2016). Phosphine gas emitted by aluminium phosphide is toxic and fatal: many fatalities have been reported due to phosphine poisoning in humans and workers coming into contact with this gas. Due to the nature of the activities of pest control workers and pesticide sprayers, special attention should be given to monitoring of pesticide level and effects on these workers and sprays and rotation of these workers periodically in their shifts. They also have more direct and concentrated contact with the pesticide than others, and over time unhealthy working conditions and breathing in phosphine gas from aluminum phosphide, a pesticide that is used in the laboratory unit of a grain silo to control grain pests and rodents, have the potential to reduce their immunity to diseases and lead to cumulative health issues. Aluminum phosphide is a threat to life when ingested directly or through inhalation as ingestion results in immediate fatality due to severe shock, myocarditis and multiple organ failure (Singh, 1996). Aluminium phosphide produces phosphine gas in the human body which has several health hazards for human life and various body systems, including the digestive system, liver and kidney; it also targets the central nervous system and the lungs. The symptoms which follow immediate poisoning from aluminium phosphide or inhalation of high concentration of aluminium phosphide are as follows: dizziness, nausea, abdominal pain, chest tightness and general discomfort. The symptoms of poisoning then become much more noticeable: the victim starts to talk of diarrhea, struggles for breath then stops breathing altogether. The blood pressure then drops, skin becomes blue, irregular heartbeat, and finally, death occurs instantly. The difficulty in diagnosis of phosphine gas poisoning lies in the fact that the person suffering from it does not have clear clinical symptoms and so the diagnosis is often difficult even if the person admits to having symptoms. For this reason, doctors have dubbed phosphine gas "the silent killer" because it kills the victim without any and it is difficult to determine the cause of death (Zhang et al., 2023).

Materials and Method

In order to define the problem of the study and get reliable and scientific answers to the problem of the study, a research population was chosen that is relevant to the research topic which is the effect of work conditions on the employees. Based on this, the research site was determined to be Al-Sharqat Silos and the research sample was the employees of the laboratory division at Al-Sharqat Silos. The workers received 500mg of vitamin C (provided by German firm Maddox Pharma) and 50mg of zinc (provided by American firm Nutra Medix). The subjects were asked to take them for 2 months after breakfast starting from the beginning of March to end of May 2025 with their regular dietary habits. The blood samples were taken from the workers and divided into five groups with five workers in each group as follows:

T1 = Working group: people who work at the silo

T2 = Workers at the Al-Sharqat silo who did not receive a treatment

T3 = Workers at the Sharqat silo with vitamin C 500mg.

T4 = Workers at the Sharqat silo who received 50 mg of zinc

T6 = Workers at the Sharqat silo treated with 500 mg of vitamin C + 50 mg of zinc.

Blood Samples

Two tubes were used for the sampling of blood—one with the anticoagulant EDTA for complete blood count (CBC) determinations, and another without serum (which is liquid part of blood and is dissolved in plasma, but doesn't participate in blood clotting process) for biochemical tests. Blood was placed in each tube (approx. 3 mL) and centrifuged in a centrifuge at 3,000 rpm for 15 minutes, the serum was then frozen at -20°C until biochemical tests could be performed.

Complete Blood Count (CBC)

Complete blood count (CBC) tests were conducted with a Blood Count (CBC Complete) device which is a multichannel analyzer that is very critical for diagnostic testing in clinical laboratories. A blood sample was taken from the patient and put in an EDTA tube to prevent clotting and then mixed well in the tube. RBC, WBC and HB were part of the CBC tests.

Renal Function Assessment

A ready to use kit was purchased from the French company BIOLABO to measure creatinine. The steps were carried out according to the steps for the kit. Absorbance was measured by a spectrophotometer at 490 nm and the concentration of creatinine was determined by Tietz (1994) according to the following equation:

$$\text{Creatinine concentration } \left(\frac{\text{mg}}{\text{dL}} \right) = \frac{\text{Absorbance of the sample}}{\text{Absorbance of the standard solution}} \times \text{concentration of the standard solution}$$

Urea Assay

Urea was determined with a ready to use kit from the French company BIOLABO and the method was followed according to the instructions given with the kit. Tietz (1994).

Determination of the function of the liver

The level of liver enzymes, such as ALT, AST and ALP, were determined by using a ready-to-use kit produced by the French company BIOLABO and followed the instructions given with the kit (Tietz, 1994).

Statistical Analysis

Data obtained were statistically analyzed by SAS (2001) software and an analysis of variance (ANOVA) was carried out. Arithmetic means were compared to determine differences using Duncan's Multiple Range Test at $P < 0.05$ and $P < 0.01$ (Duncan and Mahaffey, 1994).

Results and Discussion

The table (1) indicates the effect of vitamin C and zinc given orally to workers of the Sharqat silo on the kidney function. It revealed statistically significant differences between the treatment group (T2) and healthy control (T1) with mean creatinine levels of 1.47 vs 0.43 mg/dl respectively. The treatment groups T3, T4 and T5 showed decline in creatinine levels, being 0.64, 0.90 and 0.37 mg/dl respectively. The results indicated that there was a statistically significant increase on T2 sample (54.00 mg/dl), while there was a statistically significant decrease on T3, T4 and T5 samples (46.67, 47.00 and 41.33 mg/dl, respectively) in regard of urea. This rise in blood urea and creatinine could be attributed to a decrease in glomerular filtration rates caused by the continuous fumigation with pesticides such as Aluminium phosphide and fumigation gases which enter through inhalation, ingestion or dermal absorption, thereby causing decrease in glomerular filtration rate and damaging the structure of the nephron, which consequently reduces the activity of the nephron (Uhegbu, Imo, 2015). Vitamin C is also a strong antioxidant that can act as a free radical scavenger and a reactive oxygen species (ROS) scavenger. The vitamin C is low pH and has environment enhancing properties; White blood cells (WBC) can actively accumulate it in a concentration dependent

way. It is noteworthy that it can inhibit growth of *Staphylococcus aureus* and *Streptococcus* even under neutral pH level, which is beneficial for immune enhancement and a decrease in toxicity due to pesticide exposure (Mousavi & Heimesaat, 2019). Also the findings were consistent with findings of Hamed et al. (2023) which showed that Vitamin C had positive effects on the reduction of the toxic effects caused by periodic and routine handling of chemicals.

Riaz, M., & Yousafzai (2017) also observed in this study a statistically significant increase ($p < 0.05$) in serum urea and creatinine levels in male white rabbits, which is a typical indicator of kidney damage resulting from exposure to the pesticide flonicamid. In mammals, serum creatinine concentration is regarded as one of the most sensitive and specific markers of kidney injury. The findings of this study revealed that urea and creatinine levels were raised in all pesticide exposed rabbits but were normal in rabbits given vitamin C. Urea is excreted from the blood into the urine by glomerular filtration, and is excreted; thus, when the kidneys are damaged, their ability to filter out urea and excrete it in the urine is decreased, causing a rise in the amount of urea in the blood. Consumption of zinc supplement showed an improvement in kidney function after cadmium toxicity by decreasing blood creatinine and urea level in line with our current study as mentioned by Morshedi et al., (2014).

Table 1. The Effect of Oral Administration of Vitamin C and Zinc on Kidney Function in Workers at the Al-Sharqat Silos

Treatments	S. Cr (mg/dl)	B.Urea (mg/dl)
T1	0.43 ± 0.02 ^d	41.00 ± 5.29 ^c
T2	1.47 ± 0.38 ^a	54.00 ± 3.61 ^a
T3	0.64 ± 0.32 ^c	46.67 ± 2.52 ^b
T4	0.90 ± 0.44 ^b	47.00 ± 3.61 ^b
T5	0.37 ± 0.06 ^d	41.33 ± 1.53 ^c

*Different lowercase letters within the same column indicate statistically significant differences at the 0.05 significance level.

(T1 = Control group (people who are not doing work in the silo), T2 = Workers who are not treated in the Al-Sharqat silo, T3 = Workers treated with 500 mg of Vitamin C in the Al-Sharqat silo, T4 = Workers treated with 50 mg of Zinc in Al-Sharqat silo, T5 = Workers treated with 500 mg of Vitamin C + 50 mg of Zinc in Al-Sharqat silo).

There was an effect of oral vitamin C and zinc supplementation on the blood profile of workers in Al-Sharqat silo as displayed in table (2) below. The hemoglobin level in the T2 sample was significantly lower (10.60) than that in the other samples, which were significantly higher: T3 (12.63), T4 (13.13) and T5 (13.60). The results also indicated that there was a statistically significant decrease in the level of red blood cells in the T2 group (3.87) compared with the other groups T3, T4 and T5, which showed statistically significant increases of 4.26, 4.67 and 4.83, respectively. The results also revealed that the values of white blood cells increased in the treatment group T2 to 11.75 while it decreased significantly in T3 (6.53), T4 (536), and T5 (562). The effect of aluminum phosphide on blood parameters in control group and among field workers responsible for the control and spraying of the pesticide (aluminum phosphide): The results showed that there was a statistically significant decrease in hemoglobin and red blood cells in all blood samples of field workers responsible for aluminum phosphide pest control and spraying operations compared with the control group. This is due to the constant exposure to pesticides and the fumes from pesticides which get into the body through inhalation, ingestion or absorption, causing changes in the blood composition. It has the ability to cause coagulation and clumping of red blood cells (RBCs) due to chemical reaction, and this leads to blood clots and stops the oxygen from reaching the organs in the body (Nicholson, 2016). Muafia et al. (2021) found that the pesticide "flonicamid" caused white blood cells to

increase in the blood of rabbits exposed to it; this suggests that the pesticide entered into the bloodstream of rabbits and caused the increase in white blood cells in the blood, which also indicated that the body's immune system responded to the toxic substances found in the pesticide. The loss of red blood cells and hemoglobin could be due to a reduction in red blood cell production due to the toxic effect of the pesticide on blood forming organs, or to an increase in red blood cell destruction due to toxic materials. The same study found that oral intake of vitamin C (500mg/kg) blood parameters of rabbits exposed to flonicamide had decreased, approaching to the control rabbits. In addition, the hemoglobin decrease could be correlated with a fall in Red Blood Cell (RBC) count. This is in agreement with the findings of Riaz, M. and Yousafzai (2017) who observed a higher concentration of white blood cells after exposure to malathion for 30 days at a dose of 20 mg/kg. The findings of the study were also consistent with Shakooriet et al. (1992) who observed a decrease in white blood cells, red blood cells and hemoglobin levels after exposure to the pesticide Danatol. Abdullahi (2010) demonstrated that zinc was beneficial in the improvement of red blood cell and hemoglobin levels and in the decrease of white blood cell levels, owing to its role in tissue regeneration and repair, improvement of immune status and reduction of oxidative stress in rats exposed to certain concentration of the pesticide chlorpyrifos, which belongs to the class of pesticides known as phosphate based insecticide.

Table 2. The Effect of Oral Administration of Vitamin C+ and Zinc on Blood Parameters in Workers at the Al-Sharqat Silos

Treatments	HB (g/dL)	RBC ($10^6/\mu\text{L}$)	WBC ($10^6/\mu\text{L}$)
T1	13.43 $\pm$ 0.75 ^a	4.37 $\pm$ 0.12 ^a	6.71 $\pm$ 0.05 ^b
T2	10.60 $\pm$ 1.28 ^c	3.87 $\pm$ 0.15 ^c	11.75 $\pm$ 1.02 ^a
T3	12.63 $\pm$ 0.80 ^b	4.26 $\pm$ 0.25 ^b	6.53 $\pm$ 0.96 ^b
T4	13.13 $\pm$ 0.95 ^a	4.67 $\pm$ 0.76 ^a	5.36 $\pm$ 0.20 ^c
T5	13.60 $\pm$ 0.70 ^a	4.83 $\pm$ 0.42 ^a	5.62 $\pm$ 0.58 ^c

*Different lowercase letters within the same column indicate statistically significant differences at the 0.05 significance level.

(T1 = Control group (people not employed at the silo), T2 = Employees at the Sharqat silo without treatment, T3 = Employees at the Sharqat silo that are treated. T4 = Workers at the Sharqat silo treated with 500 mg of vitamin C, T5 = Workers at the Sharqat silo treated with 500 mg of vitamin C + 50 mg of zinc).

The effect of oral administration of Vitamin C and zinc on liver enzymes in workers at Al-Sharqat silo is shown in Table (3). The results indicated that there was a statistically significant increase in the level of AST in sample T2, which is 61.67 U/L, and the decrease was statistically significant in sample T3, T4 and T5 at 58.00, 31.00 and 15.00 U/L respectively. The results also indicated that there was a gross increase in ALT level in sample T2 with a score of 59.67U/L and a gross decrease in sample T3 with a score of 53.00U/L, T4 16.33U/L and T5 16.00U/L respectively, which were all statistically significant. The results also indicated that the ALP level in sample T2 was 95.00 U/L which was increased significantly while sample T3, T4 and T5 had levels of 85.00, 48.00 and 43.33 U/L, respectively, which were decreased significantly. Pesticides are a part of our everyday life, being used across the agricultural fields, warehouses, home and education facilities to kill or repel pests. These compounds are in many forms, commonly known as chemical forms, the most significant of which are organophosphates. These are pesticides which have a wide range of activity and are applied to kill insect pests. Organophosphates, though useful, are one of the most prevalent causes of pesticide poisoning in the world. Organophosphates are inhibitors of acetylcholinesterase, causing an ongoing hyperexcitability of the nicotinic and muscarinic receptors at the neuromuscular junction. Exposure to organophosphates results in side effects, including abdominal pain, diarrhea,

vomiting, muscle weakness, confusion, central nervous system disorders, and even death. Organophosphates also have the ability to stimulate the production of reactive oxygen species in cells and thereby cause oxidative stress. Free radicals are neutralized by the body's antioxidant defense system. Vitamin C is a significant endogenous antioxidant which is capable of scavenging a large number of free radicals by donating the electrons to them. This results in a decrease of reactive oxygen species, and thus prevents oxidative stress. Therefore, it can be considered an important part of the daily diet, which may provide a protective benefit against oxidative stress caused by organophosphates and pathological conditions in humans (Rajak et al., 2022).

The Findings indicated that workers who fumigate private grain storage silos had elevated levels of liver enzymes, and workers who were responsible for pest control and spraying operations using aluminum phosphide had elevated levels of liver enzymes. This is due to their constant contact with pesticides and the gases off-gassing from them that go into the body through inhalation, ingestion, or absorption, causing the liver enzymes to build up, and weakening the body's immune system in the battle against disease, thus giving them the potential to become susceptible to a variety of diseases over time (Nicholson, 2011). But after 2 months of vitamin C and zinc, the workers' test results significantly improved and their markers dropped. Vitamin C exerts its effect on the reduction of cisplatin-induced liver toxicity through two mechanisms: firstly, by preventing cisplatin-induced lipid peroxidation, vitamin C might prevent or decrease the oxidative damage, and secondly, by modifying the antioxidant defense system by scavenging free radicals, which reduce the chemical activity of free radicals. Moreover, Vitamin C can help to preserve liver glutathione (Cuddihy et al., 2008), which is an endogenous free-radical scavenger that protects cells from lipid peroxidation by free radicals, in chemically-induced liver toxicity in mice. Moreover, liver enzyme levels returned to normal levels by Goel et al., (2000), zinc is part of over 300 enzymes many of which are used in the metabolic process in the liver to neutralize toxins (Hosui et al., 2018).

Table 3. Effect of Oral Administration of Vitamin C and Zinc on Liver Enzymes in Workers at the Al-Sharqat Silage Plant.

Treatments	AST (U/L)	ALT (U/L)	ALP (U/L)
T1	25.67 ± 3.79 ^b	28.00 ± 2.65 ^c	54.00 ± 6.56 ^c
T2	61.67 ± 7.64 ^a	59.67 ± 6.43 ^a	95.00 ± 13.23 ^a
T3	58.00 ± 7.55 ^{ab}	53.00 ± 6.08 ^{ab}	85.00 ± 13.23 ^{ab}
T4	31.00 ± 8.54 ^{bc}	16.33 ± 3.06 ^d	48.00 ± 2.65 ^d
T5	15.00 ± 5.57 ^c	16.00 ± 3.61 ^d	43.33 ± 1.53 ^d

*Different lowercase letters within the same column indicate statistically significant differences at the 0.05 significance level.

The control group (T1) consisted of people not working at the silo, the group without any treatment (T2) consisted of workers at the silo without any treatment, the group who were treated with vitamin C (T3) consisted of workers at the silo who were treated with 500 mg of vitamin C, and the group who were treated with zinc (T4) consisted of workers at the silo who were treated with 50 mg of zinc, and the group treated with vitamin C + zinc (T5) consisted of workers at the Al-Sharqat silo who were treated with 500 mg of vitamin C + 50 mg of zinc.

Conclusion

This study concludes that vitamin C and zinc supplementation, particularly when combined, was associated with improvements in blood parameters and kidney and liver function indicators among workers exposed to aluminum phosphide at Al-Sharqat Silo. The combined supplementation group showed the most favorable overall results, suggesting a potential protective effect against pesticide-related toxicity. However, further studies with larger sample sizes and stronger research designs are needed to confirm these findings.

References

- Abdullahi, A. (2010). Chlorpyrifos-induced alteration of hematological parameters in Wistar rats: Ameliorative effect of zinc. *Research Journal of Environmental Toxicology*.
- Aljubouri, M. E., & Abdulazeez, Q. M. (2019). Effect of emitted pollutants from crude oil refining on biochemical blood variables of in-site workers. *Journal of Engineering Science and Technology*, 14(6), 3114–3130.
- Cuddihy, S. L., Parker, A., Harwood, D. T., Vissers, M. C., & Winterbourn, C. C. (2008). Ascorbate interacts with reduced glutathione to scavenge phenoxyl radicals in HL60 cells. *Free Radical Biology and Medicine*, 44(8), 1637–1644.
- Duncan, P., & Mahaffey. (1994). Erythrocytes. In *Veterinary laboratory medicine* (3rd ed., pp. 21–34). Iowa State University Press.
Note: Verify the authors' full names and order.
- El-Gendy, K. S., Aly, N. M., Mahmoud, F. H., Kenawy, A., & El-Sebae, A. K. H. (2010). The role of vitamin C as antioxidant in protection of oxidative stress induced by imidacloprid. *Food and Chemical Toxicology*, 48(1), 215–221.
- Ezejifor, T. N. (2016). Hematological indicators of exposure to petroleum products in petroleum refining and distribution industry workers in Nigeria. *Journal of Clinical Toxicology*, 6(1), 1–13.
- Goel, A., Chauhan, D. P., & Dhawan, D. K. (2000). Protective effects of zinc in chlorpyrifos induced hepatotoxicity: A biochemical and trace elemental study. *Biological Trace Element Research*, 74(2), 171–183.
- Hamed, I. A., Sherif, R. M., El-Sheikh, E. S. A., Aldawek, A. M., & Shalaby, A. A. (2023). Protective effect of vitamin C against thiamethoxam-induced toxicity in male rats. *Open Veterinary Journal*, 13(10), 1334.
- Hosui, A., Kimura, E., Abe, S., Tanimoto, T., Onishi, K., Kusumoto, Y., . . . Hiramatsu, N. (2018). Long-term zinc supplementation improves liver function and decreases the risk of developing hepatocellular carcinoma. *Nutrients*, 10(12), Article 1955.
- Morshedi, R., Ahmadizadeh, M., & Ahmadi Angali, K. (2014). Protective effects of zinc supplementation on renal toxicity in rats exposed to cadmium. *Jundishapur Journal of Health Sciences*, 6(3), 1–4.
- Mousavi, S., Bereswill, S., & Heimesaat, M. M. (2019). Immunomodulatory and antimicrobial effects of vitamin C. *European Journal of Microbiology and Immunology*, 9(3), 73–79.
- Muafia, S., Abdul, Q., Naqi, H., Shamma, F., & Sajid, R. A. (2021). Assessment of ameliorative effects of vitamin C and E supplementation on hematology indices, oxidative stress and antioxidant enzyme status of renal tissue in flonicamid intoxicated male rabbit. *Pharmacologyonline*, 3, 753–767.
- Nicholson, L. B. (2016). *Essays in biochemistry* (pp. 275–301).
Note: The chapter title, book or journal details, and publisher information need verification.
- Rajak, P., Roy, S., Ganguly, A., Mandi, M., Dutta, A., Das, K., . . . Biswas, G. (2022). Protective potential of vitamin C and E against organophosphate toxicity: Current status and perspective. *Journal of Ecophysiology and Occupational Health*, 22(3), 141–154.
- Riaz, M., & Yousafzai, A. M. (2017). Toxic effects of insecticides malathion and cypermethrin on hematological parameters in blood of male rabbits (*Oryctolagus cuniculus*). *Journal of Entomology and Zoology Studies*, 5(3), 154–158.
- Shakoori, A. R., Aslam, F., Sabir, M., & Ali, S. S. (1992). Effect of prolonged administration of insecticide (cyhalothrin/karate) on the blood and liver of rabbits. *Folia Biologica*, 40, 91–99.
- Singh, S., Singh, D., Wig, N., Jit, I., & Sharma, B. K. (1996). Aluminum phosphide ingestion—A clinico-pathologic study. *Journal of Toxicology: Clinical Toxicology*, 34(6), 703–706.
- Tietz, N. W., Burtis, C. A., & Ashwood, E. R. (1994). *Tietz textbook of clinical chemistry*. Saunders.
- Uhegbu, F. O. (2015). Renal protective effect of ethanolic leaf extract of *Gongronema latifolium* Benth in acetaminophen-induced renal toxicity rats. *American Chemical Science Journal*,

8(3),

Note: Verify the complete page range.

Zhang, J. L., Qiang, H. S., & Xiang, P. (2023). Research progress on symptoms, first aid and toxicology of phosphine poisoning. Fudan University Journal of Medical Sciences, 50(5), 771–779.

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