



Organochlorine Pesticides and Cardiovascular Dysfunction: Evidence from an Adult Male Wistar Rat Model

*¹Mairiga Abdullahi Alhaji, ²Famiyesin Oluwatoyin Temitope, ¹Michael Oblechor Prosper, ¹Akpulu Stephen Peter and ³Sani Sagir

¹Faculty of Medical Laboratory Science, College of Health Sciences, Federal University of Lafia, Nasarawa State, Nigeria.

²Shehu Idris Institute of Health Science and Technology, Kaduna State University, Kaduna State, Nigeria.

³Department of Medical Laboratory Science, Kaduna State University, Kaduna State, Nigeria.

*Corresponding authors' email: mairigaabdullahi@yahoo.com Phone: +2348060785701

ABSTRACT

Organochlorine pesticides (OCPs) are persistent environmental pollutants widely used in Agriculture. Their potential role in the development of cardiovascular diseases (CVDs) is of growing concern, particularly in regions like Nigeria, where pesticide regulation is limited. The aim of this study is to investigate the effects of organochloride pesticide exposure in the development of cardiovascular disease using adult Wistar rats as a model animal. The study population consisted of 10 adult Male wistar rats (*Rattus norvegicus*), aged 8–10 weeks and weighing 100–190 g. Wistar rats were randomly divided into five groups: a control group and four treatment groups receiving either low-dose or high-dose dichlorodiphenyltrichloroethane (DDT) and endosulfan. The pesticides were administered orally for 21 consecutive days. Serum biomarkers of oxidative stress—catalase, superoxide dismutase (SOD), and malondialdehyde (MDA)—were assessed, Cardiac biomarker (Troponin-I) was assayed using Cardiac Troponin-I (cTnl), Semi- Quantitative Rapid Test kits, alongside histological examination of heart tissues. Statistical analysis was performed using ANOVA and Tukey post hoc tests, with p-values < 0.05 considered significant. High-dose DDT and endosulfan groups showed a marked reduction in catalase levels (1.67 ± 0.14 and 1.64 ± 0.13 , respectively) compared to controls (2.63 ± 0.21), with statistical significance ($p = 0.026$). SOD and MDA levels varied across groups, although changes were not statistically significant. Histological findings indicated myocardial infraction with multiple neutrophilic infiltration, and early signs of fibrosis in high-dose groups. The findings of this study show that exposure to organochloride pesticides, particularly at high doses, causes stress in the cells, reduces catalase activity, and causes structural damage to cardiac tissues in Wistar rats. The regulatory body should strengthen organochlorides pesticides use restrictions and promote safer alternatives, while implementing routine monitoring and public health awareness programs to reduce human exposure and prevent the cardiovascular health risks associated with these persistent environmental contaminants.

Keywords: Organochlorine, Pesticides, Cardiovascular, Wistar rats, dichlorodiphenyltrichloroethane (DDT), endosulfan.

INTRODUCTION

Modern Agriculture uses pesticides widely because they are a cost-effective and efficient approach to increase crop quantity and quality, which ensures food security for the world's expanding population. Regardless of the fact that pesticides are advantageous for crop productivity, their persistent nature and bio magnification can have significant adverse impacts if they are used extensively (Gul *et al.*, 2025).

The widespread use of pesticides in Nigerian agriculture is compounded by a lack of effective training for farmers on the safe handling and application of these chemicals. Many farmers in rural areas continue to use pesticides without proper protective gear, contributing to both direct exposure and contamination of local water sources. Moreover, the inadequate disposal of empty pesticide containers and leftover chemicals further exacerbates environmental contamination. The health risks associated with these practices are not limited to farmers; communities living near farmlands are at increased risk, particularly those relying on locally grown produce and water sources contaminated with pesticide residues.

Pesticides are widely used in agriculture to control pests and improve crop yields, but their environmental and health impacts have raised concerns globally. Among these pesticides, organochloride compounds are of significant concern due to their persistence in the environment and potential for bioaccumulation. Organochlorines, such as DDT

(dichlo-diphenyl- trichloroethane) and lindane, are known for their long-lasting presence in ecosystems and have been linked to a variety of health issues, including cancer and reproductive disorders (Odewale *et al.*, 2021). Research has suggested that exposure to these pesticides may contribute to the development of various health problems, including cardiovascular diseases (CVDs). Cardiovascular diseases, which include conditions like hypertension, heart attack and stroke, have become a leading cause of mortality globally, particularly in low- and middle-income countries (WHO, 2024). Studies have indicated that prolonged exposure to pesticides, either through agricultural work, contaminated food, or environmental exposure, could be a risk factor for cardiovascular pathologies (Zago *et al.*, 2020). Increased use of pesticides primarily in agriculture and community health is associated with increased risks of human exposure to pesticides accompanying various human diseases, including cancer, neurodegenerative diseases, autism, diabetes, obesity and cardiovascular disease (CVD) (Mohammad *et al.*, 2023). In Nigeria, the use of pesticides in agriculture is widespread, with little regulation concerning safe handling and exposure limits. This, coupled with the high incidence of cardiovascular disease in the population, calls for an investigation into the potential link between pesticide exposure and cardiovascular health (Odewale *et al.*, 2021). Several studies have reported elevated levels of pesticide residues in food crops and water sources, contributing to the overall exposure of the Nigerian

population to these harmful substances (Ogar *et al.*, 2024). However, there is a dearth of local studies specifically exploring the effect of organochloride pesticides on the development of cardiovascular diseases in Nigerian populations. Understanding the relationship between pesticide exposure and cardiovascular diseases is critical, particularly in regions like Nigeria, where agricultural practices are the backbone of the economy, and pesticide use is widespread. Therefore, this study was carried out to investigate the effects of organochloride pesticide exposure in the development of cardiovascular disease using adult Wistar rats as a model animal.

MATERIALS AND METHODS

Study Area

The study was conducted in a controlled laboratory setting at the Faculty of Medical Laboratory Science, Federal University of Lafia, Nasarawa State, Nigeria. Lafia is the capital city of Nasarawa State in North-Central Nigeria, located around 8°29'N, 8°31'E. It has a tropical savannah climate with a wet season from April to October and a dry season from November to March, receiving about 1,200–1,645 mm of rainfall annually, an average relative humidity of ~75%, and a mean temperature of 26.7°C. The city's population is estimated at 330,000–509,000 and comprises diverse ethnic groups including Kanuri, Fulani, Gwandara, Alago, Eggon, Tiv, Hausa, and Igbo. Agriculture is the dominant activity, with Lafia serving as a major trading hub for yam, sorghum, millet, cotton, sesame, soybeans, and livestock, while also functioning as the state's administrative, commercial, and educational center.

Experimental Design

Group	Treatment	Dose
Group 1 (Control)	Distilled water	10 mL/kg body weight
Group 2	DDT	10 mg/kg body weight
Group 3	DDT	20 mg/kg body weight
Group 4	Endosulfan	10 mg/kg body weight
Group 5	Endosulfan	20 mg/kg body weight

All treatment doses were calculated based on each rat's body weight (mg/kg body weight) and administered once daily by oral gavage. The pesticides were prepared in distilled water to ensure a constant administration volume of 10 mL/kg body weight across all groups. Rats in the control group received an equivalent volume (10 mL/kg body weight) of distilled water using the same route and procedure to ensure uniform handling and minimize experimental bias.

Sample Collection

At the conclusion of the 21-day exposure period, the rats were humanely euthanized under deep anesthesia to minimize distress. Blood samples were obtained via cardiac puncture using a sterile 5 mL disposable syringe fitted with a 21-gauge needle. The puncture was performed by inserting the needle into the thoracic cavity and advancing it into the left ventricle to ensure adequate blood flow. Approximately 3–5 mL of whole blood was collected from each rat and immediately transferred into EDTA-coated vacutainer tubes to prevent coagulation. The collected samples were then centrifuged at 3,000 rpm for 10 minutes to separate plasma, which was stored at –20 °C until biochemical analysis. Following blood collection, the hearts were carefully excised, rinsed in ice-cold saline to remove residual blood, and preserved in 10% neutral buffered formalin for histopathological examination.

Procurement of Study Animals

The rats for studies were purchased from the Animal House of the Department of Human Anatomy, Benue State University, Makurdi, Nigeria. The rats were housed in new wired cages and acclimatized in the Animal House of the Department of Human Physiology, Faculty of Basic Medical Sciences, Federal University of Lafia, for 14 days before the commencement of the experiment. The rats were weighed during the study; the absolute body weight (BW) before (pre-treatment) and after the experiment, were recorded and statistically compared.

Population and Sampling

The study population consisted of 10 adult male Wistar rats (*Rattus norvegicus*), aged 8–10 weeks and weighing 100–190 g. These rats were selected due to their physiological similarity to humans, making them suitable models for studying pesticide-induced cardiovascular effects.

Sampling Technique

A randomized experimental sampling technique was being employed. The rats were randomly divided into five groups (one control and four experimental) with two rats per group to ensure statistical reliability. Randomization minimized bias and ensured equal distribution of characteristics among groups. The dose levels were based on previously established toxicological data from the World Health Organization (WHO, 2019) and were adjusted according to the weight of the rats.

Biochemical Analysis

Biochemical analysis for serum biological oxidative stress markers by assaying for troponin-1, Malondialdehyde (MDA), superoxide dismutase (SOD), and catalase, was conducted in Biochemistry Division National Veterinary Research Institute (NVRI), VOM.

Histological Studies

Heart tissues were be fixed in 10% formalin, processed, and embedded in paraffin wax. Sections (5 µm thick) were stained with hematoxylin and eosin (H&E) for light microscopic examination in the Teaching Laboratory of faculty of Medical Laboratory Science the slides were analyzed for structural changes such as myocardial necrosis, inflammation, and fibrosis and photo micrograph of stained was conducted in the same department.

Data Analysis

Data were analyzed using Statistical Product and Service Solutions (IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp). *P*-values <0.05 (two-tailed) were considered statistically significant. Descriptive statistics were presented as means ± standard deviations and graphs. Normality of the distribution of the variables was evaluated using Shapiro-Wilk test. One-way analysis of variance was used to test for difference in enzyme activities between

treatment groups and the control followed by John Tukey *post-hoc* test for pair-wise comparisons.

RESULTS AND DISCUSSION

Table 1: Descriptive Statistics and Repeated Measures of Analysis of Variance of Weight of Animals

Weight	Low Dose DDT	High Dose DDT	Low Dose ENDO	High Dose ENDO	F	P
	Mean \pm SD	Mean \pm SD	Mean \pm SD	Mean \pm SD		
Before	137.5 \pm 19.09	112.3 \pm 9.45	121.3 \pm 21.22	116.0 \pm 12.77	113.37 ^a	<0.001
After	162.5 \pm 6.36	134.3 \pm 17.04	149.3 \pm 17.01	142.3 \pm 14.47	1.35 ^b	0.334

This presents the mean body weights of the Wistar rats before and after the 21-day exposure to DDT and endosulfan. Before treatment, the low-dose DDT group had the highest mean body weight (137.5 \pm 19.09 g), followed by the low-dose endosulfan group (121.3 \pm 21.22 g), the high-dose endosulfan group (116.0 \pm 12.77 g), and the high-dose DDT group (112.3 \pm 9.45 g). The difference in initial body weights was

statistically significant (F = 113.37, p < 0.001). After treatment, body weight increased in all groups: low-dose DDT (162.5 \pm 6.36 g), low-dose endosulfan (149.3 \pm 17.01 g), high-dose endosulfan (142.3 \pm 14.47 g), and high-dose DDT (134.3 \pm 17.04 g). However, these differences were not statistically significant (F = 1.35, p = 0.334).

Table 2: Summary statistics for test of difference in enzyme activities across groups

	n	Catalase	Superoxide Dismutase	Malondialdehyde
		Mean \pm SD	Mean \pm SD	Mean \pm SD
Low dose DDT	2	1.78 \pm 0.22	0.22 \pm 0.16	1.07 \pm 0.18
High dose DDT	2	1.67 \pm 0.14*	0.12 \pm 0.03	2.59 \pm 0.64
Low dose Endo	2	2.27 \pm 0.36	0.34 \pm 0.04	1.53 \pm 0.15
High dose Endo	2	1.64 \pm 0.13*	0.11 \pm 0.01	1.61 \pm 1.71
Control	2	2.63 \pm 0.21	0.21 \pm 0.09	1.15 \pm 0.04
F		7.30	2.35	1.09
P		0.026	0.187	0.451

Catalase activity was highest in the control group (2.63 \pm 0.21) and lowest in the high-dose endosulfan group (1.64 \pm 0.13). High-dose DDT also showed reduced catalase activity (1.67 \pm 0.14). This difference was significant (F = 7.30, p = 0.026). Superoxide dismutase activity was highest in the low-dose endosulfan group (0.34 \pm 0.04) and lowest in the high-

dose endosulfan group (0.11 \pm 0.01), but the difference was not significant (F = 2.35, p = 0.187). Malondialdehyde levels were highest in the high-dose DDT group (2.59 \pm 0.64) and lowest in the low-dose DDT group (1.07 \pm 0.18), with no significant difference (F = 1.09, p = 0.451).

Comparison of catalase activity on the serum of wistar rats

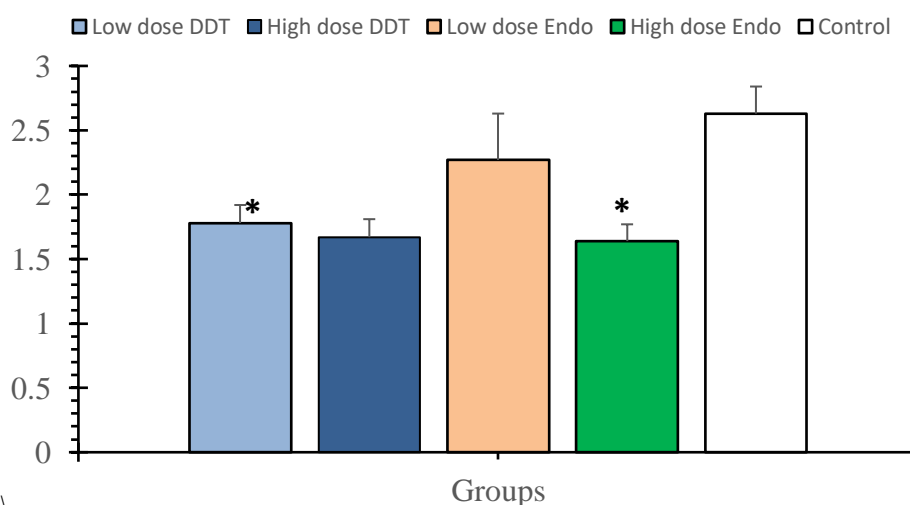


Figure 1: Comparison of catalase activity on the serum of wistar rats

This figure shows catalase activity was highest in the control group (2.63 \pm 0.21), followed by low-dose endosulfan (2.27 \pm 0.36). Lower activities were observed in low-dose DDT (1.78

\pm 0.22), high-dose DDT (1.67 \pm 0.14), and high-dose endosulfan (1.64 \pm 0.13), indicating reduced antioxidant activity with higher pesticide exposure.

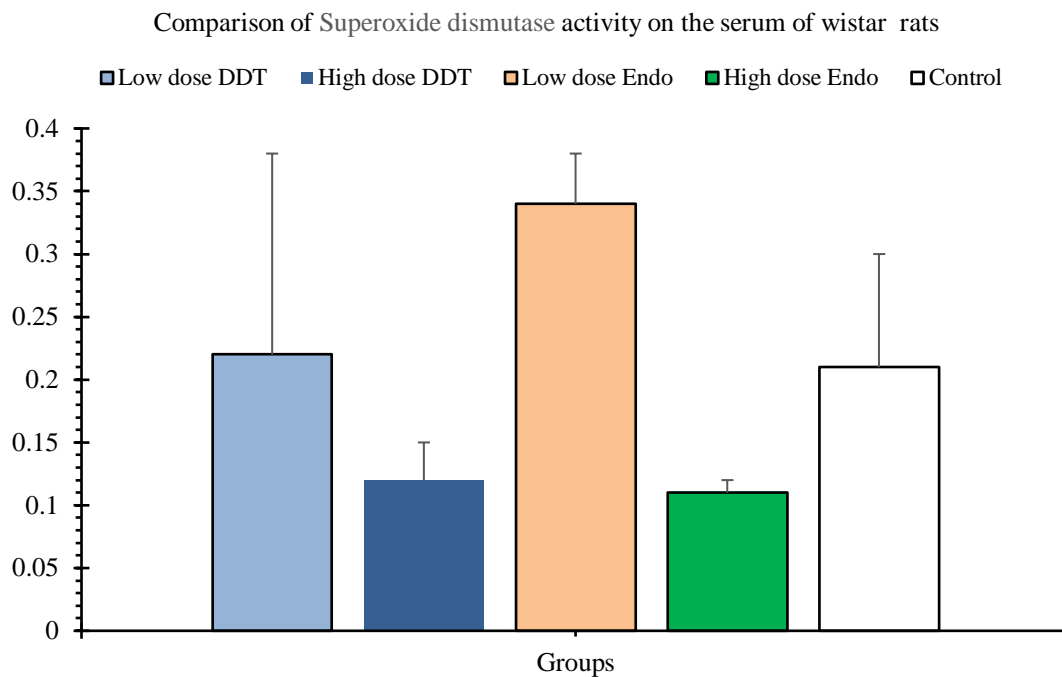


Figure 2: Comparison of Superoxide dismutase activity on the serum of wistar rats

This figure 2 shows that superoxide dismutase activity was highest in the low-dose endosulfan group (0.34 ± 0.04) and lowest in the high-dose endosulfan group (0.11 ± 0.01).

Although enzyme activity declined in the high-dose groups, the differences were not statistically significant ($p = 0.187$).

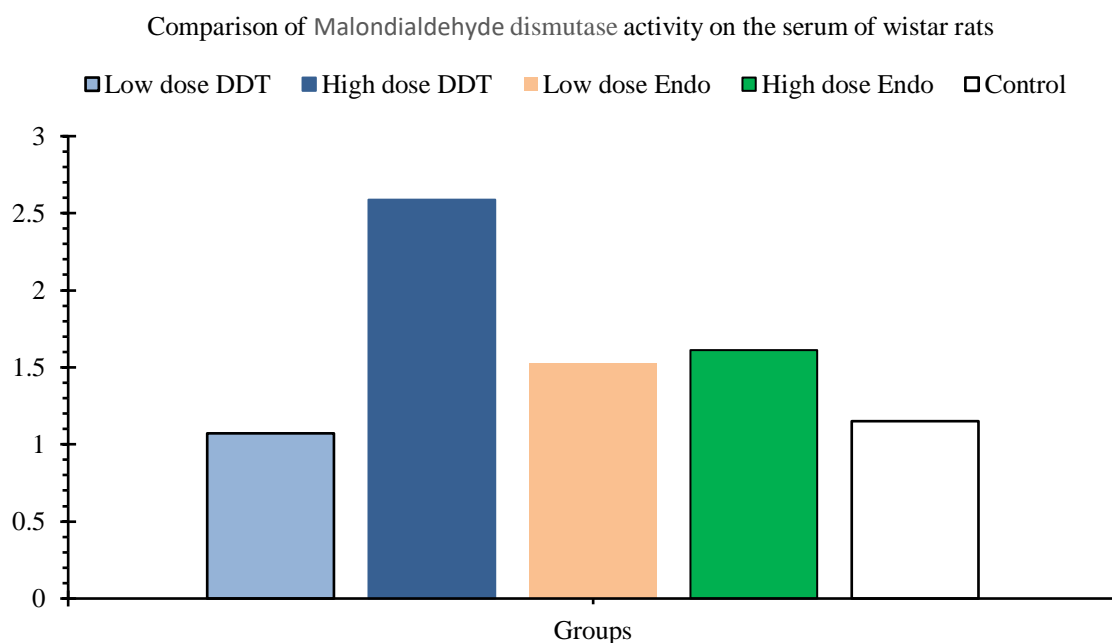


Figure 3: Comparison of Malondialdehyde dismutase activity on the serum of wistar rats

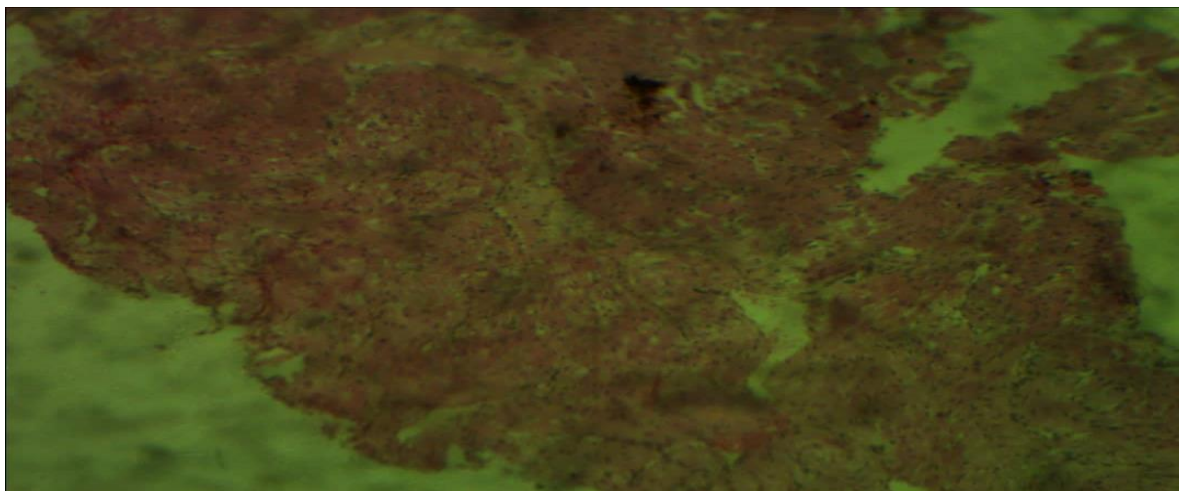


Figure 4: A Photomicrography of Heart Section of Control Group section shows well outlined endocardium, myocardium and epicardium lining. Haematoxylin and Eosin staining: $\times 40$

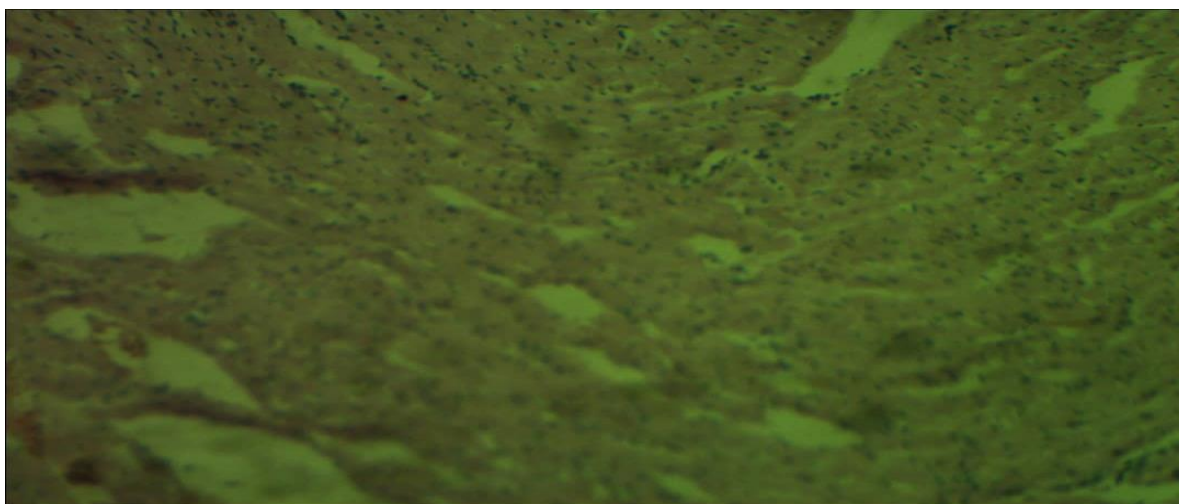


Figure 5: A photomicrography of Heart Section of Low Dose DDT Heart section shows mild myocardial infraction with dense neutrophil infiltrate. Haematoxylin and Eosin staining: $\times 40$

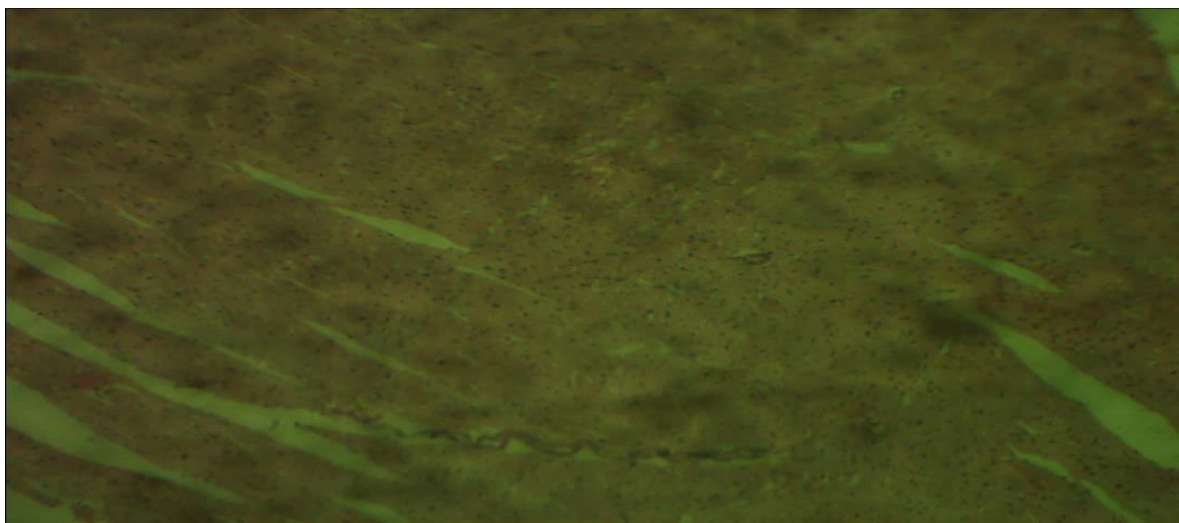


Figure 6: A photomicrography of Heart Section of High Dose DDT Heart section shows myocardial infraction with multiple neutrophilic infiltration. Haematoxylin and Eosin staining: $\times 40$

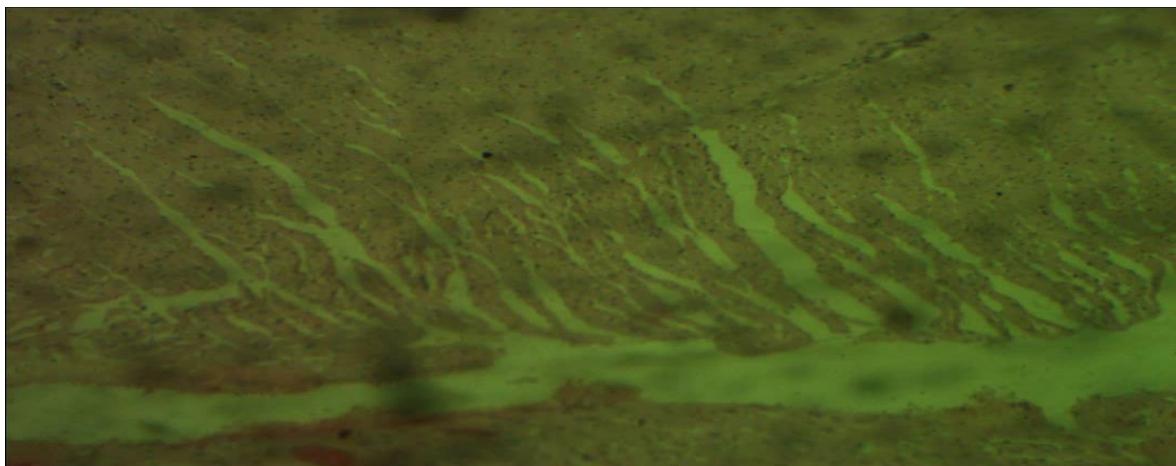


Figure 7: A photomicrography of heart section of low dose endosulfan Heart section shows mild myocardial infraction with dense neutrophil infiltrate Haematoxylin and Eosin staining: $\times 40$

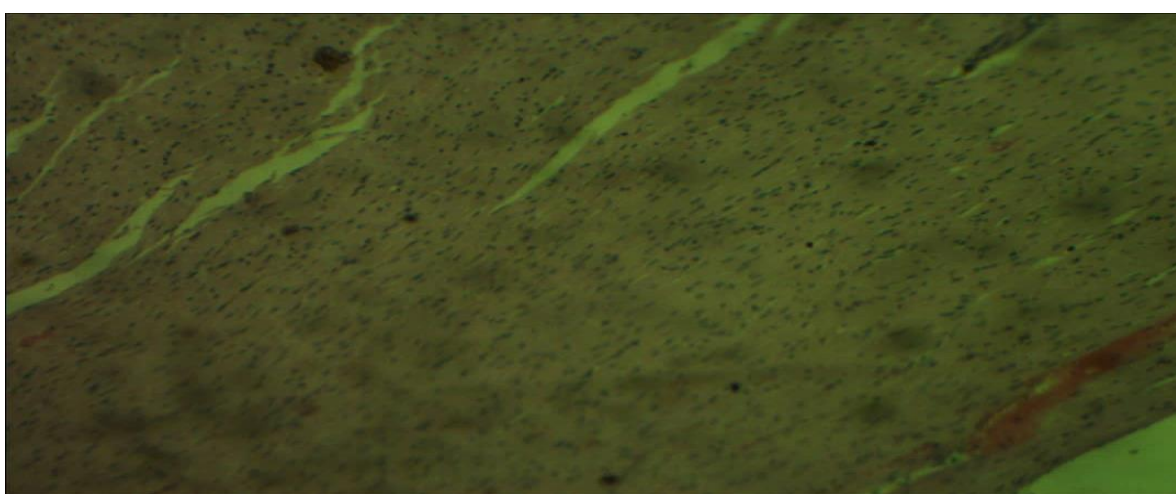


Figure 8: photomicrography of Heart Section of High Dose endosulfan Heart section shows myocardial infraction with multiple neutrophilic infiltration. Haematoxylin and Eosin staining: $\times 40$

Discussion

The study indicates that exposure to DDT and endosulfan did not significantly affect body weight, as all treatment groups gained weight after the 21-day exposure, with no significant difference in final body weight ($F = 1.35$, $p = 0.334$). This finding contrasts with Alva *et al.* (2012), who reported marked biochemical and pathological alterations following endosulfan exposure, suggesting that differences in dose and exposure duration may account for the variation.

Catalase activity was significantly reduced in the pesticide-treated groups ($F = 7.30$, $p = 0.026$). The control group recorded the highest catalase activity (2.63 ± 0.21), whereas the high-dose DDT (1.67 ± 0.14) and high-dose endosulfan (1.64 ± 0.13) groups showed the lowest values. This finding agrees with Kalender *et al.* (2004) and Alva *et al.* (2012), who reported that endosulfan exposure suppresses antioxidant enzymes, thereby promoting oxidative stress and cardiotoxicity.

Although superoxide dismutase activity decreased from 0.21 ± 0.09 in the control group to 0.12 ± 0.03 and 0.11 ± 0.01 in the high-dose DDT and high-dose endosulfan groups, respectively, the difference was not statistically significant ($F = 2.35$, $p = 0.187$). This also contrasts with Kalender *et al.* (2004) and Alva *et al.* (2012), who observed significant reductions in SOD activity following endosulfan exposure. Malondialdehyde (MDA) levels were highest in the high-dose DDT group (2.59 ± 0.64) but were not significantly different

across the groups ($F = 1.09$, $p = 0.451$). Despite the lack of statistical significance, the elevated MDA level suggests increased lipid peroxidation following high-dose pesticide exposure. This observation aligns with Kalender *et al.* (2004), who reported increased lipid peroxidation and oxidative tissue damage in endosulfan-treated Wistar rats.

CONCLUSION

The findings of this study show that exposure to organochloride pesticides particularly at high doses, causes stress in the cells, reduce catalase activity, and causes structural damage to cardiac tissues in Wistar male rats. These changes are signs of early cardiovascular pathology. The study backs up the idea that chronic or high-dose exposure to organochloride pesticides may be a significant risk factor in the development of cardiovascular diseases.

REFERENCES

Adeyemi, J. A., Ukwenya, V. O., Arowolo, O. K., & Olise, C. C. (2021). Pesticides-induced cardiovascular dysfunctions: Prevalence and associated mechanisms. *Current Hypertension Reviews*, *17*(1), 27–34. <https://doi.org/10.2174/1573402117666210111102508>

Alva, S., Damodar, D., D'Souza, A., & D'Souza, U. J. A. (2012). Endosulfan induced early pathological changes in

- vital organs of rat: A biochemical approach. *Indian Journal of Pharmacology*, 44(4), 512–515.
- Gul, S., Chashoo, H. F., Hanief, F., Abubakr, A., Malik, M. M., & Hamid, I. (2025). *Pesticide biomagnification: A comprehensive exploration of environmental dynamics and human health implications*. In J. K. Sundaray, M. A. Rather, I. Ahmad, & A. Amin (Eds.), *Food Security, Nutrition and Sustainability Through Aquaculture Technologies*. Springer. https://doi.org/10.1007/978-3-031-75830-0_16
- Kalender, S., Kalender, Y., Ogutcu, A., Uzunhisarcikli, M., Durak, D., & Açıkgoz, F. (2004). Endosulfan-induced cardiotoxicity and free radical metabolism in rats: The protective effect of vitamin E. *Toxicology*, 202(3), 227–235.
- Odewale, G. O., Sosan, M. B., Oyekunle, J. A. O., & Adeleye, A. O. (2021). Human health risk assessment of dichlorodiphenyltrichloroethane (DDT) and hexachlorocyclohexane (HCH) pesticide residues in fruits and vegetables in Nigeria. *Environmental Science and Pollution Research*, 28(25), 33133–33145. <https://doi.org/10.1007/s11356-021-12747-7>
- Ogah, C., Oganah-Ikujenyo, B., Onyeaka, H., Ojapah, E., Adeboye, A., & Olaniran, T. (2024). Organophosphate pesticide residues in fruits and vegetables in Nigeria: Prevalence, environmental impact, and human health implications. *Environmental Science and Pollution Research*. <https://doi.org/10.1007/s11356-024-35591-x>
- Pal, R., Ahmed, T., Kumar, V., Suke, S. G., Ray, A., & Banerjee, B. D. (2009). Protective effects of different antioxidants against endosulfan-induced oxidative stress and immunotoxicity in albino rats. *Indian Journal of Experimental Biology*, 47(12), 992–997.
- World Health Organization. (2019). *The WHO recommended classification of pesticides by hazard and guidelines to classification 2019*. World Health Organization.
- World Health Organization. (2024). *Cardiovascular diseases (CVDs): Fact sheet*. World Health Organization.
- Zago, A. M., Faria, N. M. X., Fávero, J. L., Meucci, R. D., Woskie, S., & Fassa, A. G. (2020). Pesticide exposure and risk of cardiovascular disease: A systematic review. *Global Public Health*, 17(12), 3944–3966. <https://doi.org/10.1080/17441692.2020.1808693>

