

Malathion-Induced Metabolic Stress: Tissue-Specific Alterations in Carbohydrate Dynamics of Freshwater Fishes, *Channa punctatus* (Bloch) and *Labeo rohita* (Hamilton)

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ABSTRACT

Pesticide contamination of aquatic ecosystems has become a major environmental concern due to its adverse effects on non-target organisms. Among pesticides, organophosphates such as Malathion are widely used and are known to disrupt metabolic processes in aquatic fauna. The present study investigates the impact of Malathion on carbohydrate metabolism in different tissues of two freshwater fish species, *Channa punctatus* (Bloch) and *Labeo rohita* (Hamilton). Fish were exposed to sub-lethal concentrations of Malathion for varying durations (24, 48, 72, and 96 hours), and alterations in carbohydrate content were assessed in gill, liver, intestine, muscle, and brain tissues using the Lee and Takahashi method. The results demonstrated a progressive and statistically significant decline in carbohydrate levels across all tissues with increasing exposure duration. The liver and brain tissues showed pronounced depletion, indicating their higher metabolic activity and sensitivity to toxic stress. The reduction in carbohydrate reserves suggests enhanced energy utilization to counteract pesticide-induced stress, reflecting a shift in metabolic pathways. Notably, brain tissue exhibited the highest sensitivity in both fish species, highlighting potential neurotoxic implications of Malathion exposure. This study provides important insights into the biochemical responses of freshwater fish to organophosphate toxicity and underscores the utility of carbohydrate metabolism as a sensitive biomarker for environmental monitoring.

Keywords: Carbohydrates, Malathion, Sub lethal concentration, *Channa punctatus*, *Labeo rohita*

INTRODUCTION

Pesticides are widely used in agriculture to control pests, but their indiscriminate use leads to contamination of aquatic ecosystems. Among these, organophosphate pesticides such as Malathion are commonly applied due to their relatively low persistence.

However, their toxicity to non-target organisms, especially fish, has raised serious ecological concerns. Fish are highly sensitive indicators of aquatic pollution and are often used in ecotoxicological studies. Exposure to toxicants can lead to biochemical alterations, particularly in energy metabolism. Carbohydrates play a vital role as immediate energy sources, and their depletion reflects physiological stress conditions. (Fukuto, 1990) reported the mechanism of action of organophosphorus pesticides on AChE inhibition. Celina et al., 2024 studied the organophosphate residues in fruits and the impacts of OP pesticides on human health. Pesticide lifecycle management encompasses a range of elements from legislation, regulation, manufacturing, application, risk reduction, monitoring, and enforcement to disposal of pesticide waste. Extensive research of Berg et al., 2020, discovered huge gaps for most of the selected indicators of pesticide management, suggesting that pesticide efficacy and safety to human health and the environment are likely being compromised at various stages of the pesticide lifecycle and at varying degrees across the globe. Low-income countries generally had the highest incidence of gaps. The research article of Christopher et al., 2025, examined the history of risk assessments of the organophosphate pesticide Chlorpyrifos at the US Environmental Protection Agency (EPA), especially after a ban on household uses in 2020. This article concludes that the agency needs to rethink its risk assessment practices and dependence, as well as more effectively account for financial conflicts of interest in evaluation of policy- relevant science. Aktar, Sengupta and Chowdhury (2009) reported the both benefits and Hazards of pesticides. Organophosphate pesticides such as Malathion are widely used and frequently detected in aquatic ecosystems due to agricultural runoff (EPA 2024). Risks of pesticides on aquatic ecosystems and pesticide management were reported (Abaineh et al., 2024).

Liu et al., 2024, reported the Organophosphate pesticidal effect and its relationship with dissolved organic matter and its risk assessment. Ecotoxicological effects of pesticides on aquatic organisms were reported (Sarker et al., 2021). Kumar, et al. (2022) researched the oxidative stress and antioxidant responses in fish under pesticide exposure. These compounds exert toxicity primarily through inhibition of acetylcholinesterase, leading to neurophysiological dysfunction (Fukuto, 1990; Colovic et

al., 2013). In addition, pesticide exposure induces oxidative stress and tissue damage in fish (Lushchak, 2011; Monteiro et al., 2006). Livingstone, (2001) reported that contaminant-stimulated Reactive Oxygen Stress (ROS) production and oxidative damage pose a threat to animal health and fitness in the aquatic environment. Previous studies have reported that pesticide exposure leads to alterations in carbohydrate metabolism in fish tissues. However, comparative studies on tissue-specific responses in different fish species remain limited. Therefore, the present study aims to evaluate the effect of Malathion on carbohydrate levels in various tissues of *Channa punctatus* and *Labeo rohita*.

MATERIALS AND METHODS

Experimental Animals: Healthy freshwater fish species *Channa punctatus* and *Labeo rohita* were collected and acclimatized under laboratory conditions for 10 days.

Experimental Design: Fish were divided into control and experimental groups. The experimental groups were exposed to sub-lethal concentrations of Malathion for 24, 48, 72, and 96 hours.

Tissue Collection: After exposure, fish were dissected, and tissues such as gill, liver, intestine, muscle, and brain were collected.

Biochemical Analysis: The toxicity tests were conducted in accordance with standard method (APHA, 1992). Carbohydrate content was estimated using the Lee and Takahashi method.

Statistical Analysis: Data were expressed as mean $\pm$ standard deviation. Statistical analysis was performed using ANOVA to determine significance.

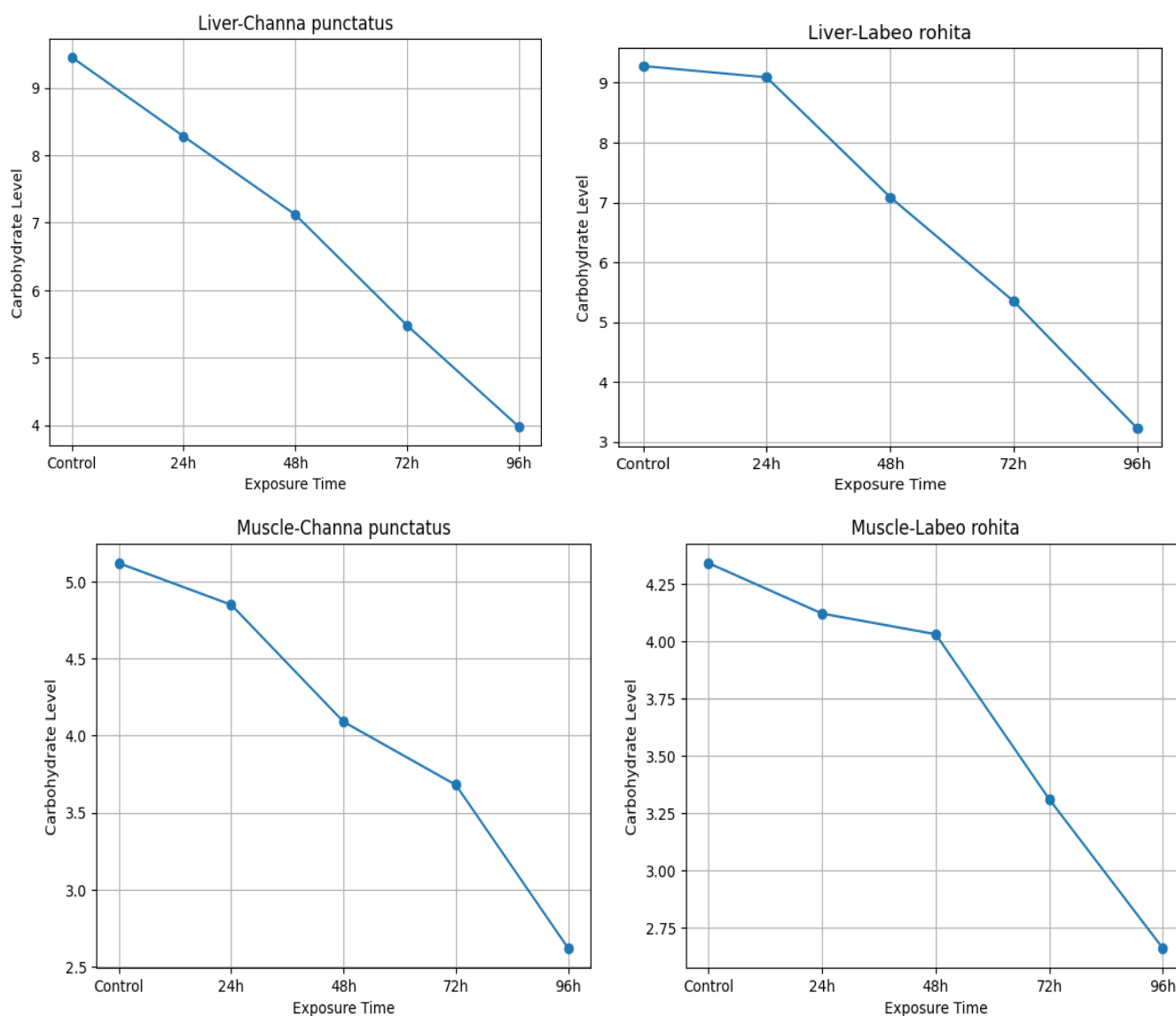
RESULTS AND DISCUSSION

The results indicated a significant decrease in carbohydrate levels in all tissues of both fish species with increasing exposure duration. In *Channa punctatus*, liver carbohydrate levels decreased from 9.45 ± 0.30 in control to 5.28 ± 0.30 at 96 hours, while brain tissue showed a decrease from 6.12 ± 0.32 to 3.57 ± 0.27 .

Table 1. Carbohydrate levels (mg/g tissue) in fish exposed to Malathion

Tissue	Control	24H	48H	72H	96H	%Decrease
Liver – <i>Channa punctatus</i>	9.45±0.30	8.28±0.31*	7.12±0.42	5.48±0.36	3.98±0.30	57.88
Liver – <i>Labeo rohita</i>	9.28±0.40	9.09±0.40	7.09±0.40*	5.35±0.40*	3.23±0.30*	50.56
Muscle – <i>Channa punctatus</i>	5.12±0.33	4.85±0.28	4.09±0.32	3.68±0.32	2.62±0.32	48.82
Muscle – <i>Labeo rohita</i>	4.34±0.40	4.12±0.40*	4.03±0.30	3.31±0.40*	2.66±0.40*	51.42

Note: * indicates statistically significant difference ($p < 0.05$)

**Fig.1 :** Carbohydrate levels (mg/g tissue) in fish exposed to Malathion

In *Labeo rohita*, liver carbohydrate levels declined from 9.28 ± 0.42 in control to 5.23 ± 0.22 at 96 hours, and brain tissue decreased from 5.32 ± 0.31 to 3.10 ± 0.18 . Overall, brain tissue showed maximum depletion compared to

other tissues. Maximum percentage of shooting was observed on medium supplemented with 3 mg BAP + 1 mg IAA /lit. The earlier workers Sadhana Agarwal (1988) Jin and Mingwang (1990) proposed 5mg BAP+ 1mg IAA/ lit

and 2.5 mg BAP +1 mg IAA / lit respectively as best shooting supplement. Bahatee et al (1994) worked with four varieties of *C. annuum* and suggested four different media supplements 4mg BAP+0.5 mg IAA/ lit for variety Agni, 6mg KN+ 0.5 mg IAA/ lit for variety Jwala, 5mg BAP + 0.5 mgIAA/ lit for variety Tej and 6 mg BA +0.5mg IAA / lit for variety G4.

DISCUSSION

The observed decrease in carbohydrate levels indicates increased metabolic demand under pesticide stress. Fish utilize carbohydrate reserves to meet the energy requirements needed to cope with toxic stress. The liver, being the primary metabolic organ, showed significant depletion due to its role in detoxification. The brain exhibited the highest sensitivity, which may be attributed to the neurotoxic nature of Malathion. These findings are consistent with previous studies reporting biochemical alterations in fish exposed to pesticides. The depletion of carbohydrates suggests a shift toward alternative energy pathways such as protein and lipid metabolism. Findings of Lohitha Ramya Dorraju et al., 2026 demonstrated that pesticide exposure disrupts antioxidant defense systems, alters metabolic and enzymatic activities, induces genotoxic and endocrine effects, and impairs tissue integrity, collectively contributing to ecological imbalance and biodiversity loss.

Fish biomarker in toxicity evaluation such areas include the Cytochrome P450 enzymes, oxidative stress and damage, heat shock proteins, and hormonal disruption testing reported (Patrick Omoregie et al., 2026). Fish bioaccumulation and biomarkers in environmental risk assessment was reported (Van der Oost et al., 2003). This study reveals that Fish bioaccumulation markers may be applied in order to elucidate the aquatic behaviour of environmental contaminants, as bioconcentrators to identify certain substances with low water levels and to assess exposure of aquatic organisms. Fish are used as bio-indicators, playing an important role in monitoring heavy metals pollution (Authman et al., 2015; Adams Ovie et al., 2024). Fenthion induced toxicity on gill tissue of *Clarias garipinus* is reported (Peace et al., 2015). Nwani et al., 2013 investigated the Chlorpyrifos effects on behaviour, biochemical and haematological parameters of *Clarias*

garipinus. (Venkateswara Rao et al., 2020, 2021) investigated the Malathion induced toxicological studies on biochemical parameters of fresh water fish *Channa punctatus* and *Labeo rohita*. Tissue- specific antioxidative responses Studies of (Kavitha et al., 2009, 2007, 2008) on toxicological effects of profenofos, monocrotophos, chlorpyrifos in different fishes and the results exposes that an increase in lipid peroxidation (LPO) and alteration in antioxidant enzymes (SOD, CAT) in the present study indicates oxidative stress induced by Malathion exposure, consistent with recent findings demonstrating ROS-mediated cellular damage in fish. Josef Velisek et al., 2012 investigated the effect of terbutryn on early life stages of common carp (*Cyprinus carpio* L.). Fishes are Potential Biomarkers for Evaluating the Ecotoxicity of Contaminants of Emerging Concern and Legacy Pollutants reported (Guilherme Malafaia et al., 2024). Long term exposure of Emaectin benzoate on *Labeo rohita* caused histopathological alteration, and amino acid- fatty acid profiling (Vikas Kumar et al., 2025). Liver structural alterations accompanying chronic toxicity in fishes reported by (Hinton et al., 1990). Effects of Malathion on rainbow trout (*Oncorhynchus mykiss*) was investigated (Velisek et al., 2009). Fish can be used as bioindicator of aquatic pollution (Authman, 2015, Singh, et al., 2023). Previous studies have reported that pesticide exposure leads to alterations in carbohydrate metabolism in fish tissues. However, comparative studies on tissue-specific responses in different fish species remain limited. Therefore, the present study aims to evaluate the effect of Malathion on carbohydrate levels in various tissues of *Channa punctatus* and *Labeo rohita*.

CONCLUSION

The present study demonstrates that Malathion exposure leads to significant alterations in carbohydrate metabolism in freshwater fish. The reduction in carbohydrate levels indicates metabolic stress, with brain tissue being the most affected. These findings highlight the ecological risk of pesticide contamination and emphasize the importance of biochemical biomarkers in environmental monitoring.

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