



Original Research

The Role of Polyethylene Leaching on Liver and Renal Function: Investigating Serum LDH and ALP Levels in Albino Wistar Rats

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ABSTRACT

Polyethylene or polythene is the most commonly produced plastic. It is a polymer, primarily used for packaging. This study investigates the effects of leached polyethylene on serum lactate dehydrogenase (LDH) and alkaline phosphatase (ALP) levels as indicators of tissue health and metabolic function. Rats were divided into two groups, with group I (Control), fed normal rat chow without exposure to polyethylene (n=10), and group II (Experimental groups) fed with normal rat chow with leached polyethylene for 30 days (n=10) supplemented with polyethylene formulations. Result shows that Group I, LDH levels were measured at 198 ± 1.00 ($\mu\text{mol/L}$), while ALP levels were 110 ± 2.56 ($\mu\text{mol/L}$). In contrast, Group II exhibited a slight increase in LDH to 200 ± 3.25 ($\mu\text{mol/L}$) and ALP to 113 ± 2.11 ($\mu\text{mol/L}$) at ($p < 0.05$). The elevated LDH levels in Group II suggest potential tissue stress or damage, indicating that leached polyethylene may adversely affect cellular integrity. Similarly, the increase in ALP levels may reflect alterations in liver function or bone metabolism, further suggesting metabolic disturbances associated with polyethylene exposure. The data indicate that leached polyethylene has a measurable impact on serum metabolic markers in Experimental Group II. The slight increases in both LDH and ALP suggest potential adverse effects on tissue health and metabolic processes, possibly related to inflammation or changes in cellular function. The findings from this research highlight the potential physiological impacts of leached polyethylene on serum metabolic markers, indicating a need for further research to explore the underlying mechanisms and long-term health implications of exposure to such materials. The results contribute to the understanding of how common plastic materials used mostly in packaging can affect biological systems, emphasizing the importance of evaluating their safety in animal models.

INTRODUCTION

Microplastics (MPs) are primarily produced by two sources: products containing plastic powders, such as cosmetics, detergents, sunscreens, and medicine delivery systems, in addition to those produced by breakdown of bigger plastic particles by ultraviolet radiation, mechanical abrasion, biological degradation, and other environmental factors. The predominant presence of MPs in food packaging, manufacturing, etc., increases the susceptibility of their ingestion, whether in animals, aquatic marine life, birds, mammals, and even humans ([Yao et al., 2022](#)). MPs can accumulate in various organisms, including humans. Through many studies, it was confirmed that MPs can pass through body tissues, due to their non-degradable nature and minute size ([Kim et al., 2021](#)). MPs may enter the body of humans through three main routes: oral intake ([Li et al., 2018](#)) of aquatic products and packaged food products ([Ajai et al.,](#)

[2021](#)), dermal exposure ([Ma et al., 2020](#)), and inhalation ([Tong et al., 2019](#)).

Oral route is considered the most common route of MPs exposure ([Ma et al., 2020](#)). Following exposure, MPs are absorbed via epithelial cells of the intestine, then subsequently enter the circulatory system and accumulate in many body cells and organs ([Lind et al., 2013](#)).

Plastics have encompassed a large part of our lives, with plastic production has risen significantly over the past decades. Plastics have been used as an alternative to other materials like glass, metals, paper, and wood ([Yao et al., 2022](#)). It is suggested that by the year 2025, approximately 100–250 million tons will enter surface waters.

However, with massive production comes more pollution and thus more potential hazardous health effects ([Proietti, 2025](#)).

Plastic wastes may be decomposed via hydrolysis, physical/mechanical forces, and ultraviolet light to form tiny particles, also known as microplastics (MPs).

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MPs are small plastic pieces ranging in size from 0.1 mm to 5 mm. Various MPs can be found within the environment. The main component of MPs includes polypropylene (PP), polystyrene (PS), polyvinyl chloride (PVC), and polyethylene (PE), with PE being one of the most prevalent ones (Kim *et al.*, 2021; Tong *et al.*, 2019).

Although PE, PP, and PS-MPs were thought to be predominantly found in the oceans, a recent study found that landfill plastic pollution was approximately 4–23 times that of plastic pollution found in the ocean (Rudolph *et al.*, 2021). MPs' toxicity may be associated with Plastics themselves, or the additives found within them, as well as the adsorbed organic pollutants on the surfaces of MPs. MPs toxicity has been documented to affect many organs, including liver, kidneys, brain, and reproductive organs (Kim *et al.*, 2021). The pathophysiology of MPs toxicity in mammals is complex and is not yet extensively studied.

MPs' exposure is found to be associated with the induction of oxidative stress, cytotoxicity, and inflammation. They also interfere with energy and lipid metabolism and induce sub-cellular organ dysfunction (Matthews *et al.*, 2021). The toxicity of MPs may be enhanced by co-pollutants adsorbed on their surface. MPs beads' toxicity is determined by their size or type of plastic (Ma *et al.*, 2020). Blood and hematological parameters are an excellent means to determine toxic exposure of a substance and the overall subject health. The most abundant cells in the blood are the red blood cells (RBCs). In addition to anemia, impaired RBCs can cause hypoxia-related symptoms and various other health issues. When toxic xenobiotics enter the body, they will most likely affect RBCs. It has been reported that MPs cause apoptosis and necrosis in *Danio rerio* RBCs (Mekawy *et al.*, 2011), and in amphibians, *Physalaemus cuvieri* tadpoles. PS-MPs were also recently found to affect mice RBCs adversely (Zheng *et al.*, 2019).

One of the main concerns about MPs is how they can affect DNA and their role as mutagenic and epigenetic pollutants. There has been growing concern about possible genotoxicity to humans induced by MPs (Sun *et al.*, 2021). Since these substances are microscopic, they can pass through the cell membrane and reach DNA, causing DNA damage. Until now, little is known about the exact mechanism of MPs-associated genotoxicity but increased genetic defects have been linked to the increased reactive oxygen species (ROS). MPs' exposure was found to reduce the antioxidant defenses of the cells, with a subsequent increase of ROS (Alwutayd *et al.*, 2025). ROS can induce DNA strand breakage, thereby increasing the risk of chronic disorders and cancer (Shi *et al.*, 2022). Genotoxicity encompasses different forms of harm done to the genome, including mutagenic lesions, chromosomal rearrangements and/or breakage, and numerical chromosome aberrations. Gel electrophoresis, or

comet assay, is one of the means used to analyze genotoxicity. MPs genotoxicity was previously documented in fish, and recently in mice (Zheng *et al.*, 2019).

Among the most intriguing research areas is epigenetic toxicology, which studies epigenetic changes induced by environmental exposures. Gene expression changes caused by epigenetic factors occur without alterations in DNA sequence. There is evidence that some environmental toxins influence the epigenome by changing DNA methylation, modifying histone proteins, and affecting chromatin structure and mRNA expression.

Plastic pollution, particularly the leaching of chemicals from polyethylene into food, poses a growing concern for public health. Polyethylene is widely used in food packaging due to its durability and versatility. However, under certain conditions, such as high temperatures or prolonged storage, chemicals from polyethylene can leach into food. These leached substances may have detrimental effects on consumers' health, especially when ingested over long periods. Lactate dehydrogenase (LDH) and alkaline phosphatase (ALP) are critical enzymes in the body. LDH is involved in energy production and is a marker for tissue damage, while ALP plays a key role in liver function and bone metabolism. Alterations in the serum levels of these enzymes can indicate underlying health issues such as liver damage, bone disorders, or other systemic toxicities.

This study aims to investigate the effects of leached polyethylene on the serum levels of LDH and ALP in normal albino rats. By exposing these rats to food contaminated with leached polyethylene, we seek to determine if there are significant changes in these enzyme levels. The findings will provide insights into the potential health risks associated with the consumption of food stored in polyethylene packaging, contributing to a better understanding of the implications for human health and guiding safer food packaging practices. Understanding these effects is crucial for developing guidelines to minimize health risks associated with plastic food packaging and ensuring food safety for consumers.

MATERIAL AND METHODS

Sample collection and preparation

Polyethylene (plastics) was purchased at the popular super market at Watt Calabar South Cross River State Nigeria. The styrene was leached into boiled water for about 1 hour 30 minutes. Thereafter, the leached water was stored in a cool dry place to feed the experimental animals. The leached polyethylene in water was administered to the rats *ad libitum*.

Animal experimentation

A total of 20 healthy albino Wistar rats, weighing between 90–120g, were selected for the study. These rats were sourced from the animal house of the Department of Biochemistry at

Cross River University of Technology, Calabar. They were allowed to acclimatize for one week, during which their weights were recorded at the beginning, throughout, and on the final day of the experimental treatments. The rats were housed in groups of 10 in cages, under a natural light-dark cycle of 12 hours each (6:30 AM to 6:30 PM light, 6:30 PM to 6:30 AM dark). They were provided with standard rat pellets (Livestocks Feeds Nig. Ltd; Ikeja, Lagos) and water *ad libitum*. Both the control group and the experimental groups had unrestricted access to either the standard feed or the formulated experimental feed, as well as tap water, throughout the 30-day experimental period. Animal weights were monitored daily during the study.

Experimental procedures

The twenty (20) albino *Wistar* rats weighing 90-120g were randomly grouped into two (2) experimental groups of ten (10) rats each. Rats had free access to standard livestock feed for the normal control as well as the experimental groups and tap water *ad libitum* throughout the experimental period of 30 days as follows:

GROUPS	ADMINISTRATION
I	Control, fed normal rat chow without exposure to polyethylene (n=10)
II	Experimental groups fed with normal rat chow with leached polyethylene for 30 days (n=10)

The experimental feeding lasted for thirty (30) days. On the thirty-first (31st) day, the animals were sacrificed and the tissue of interest was collected and stored accordingly for analysis.

Collection and preparation of blood for analysis

At the end of the experimental period, the animals were fasted for 8 hours and then sacrificed under ketamine anesthesia. Blood samples were collected via cardiac puncture and transferred into labeled tubes for analysis.

Estimation of serum activity of alkaline phosphatase

The reagent enzyme activity was measured using photometrically. (Direct colorimetric Endpoint Method, 1995).

Estimation of serum activity of lactate dehydrogenase

The LDH method used is based on the DGKCH recommendations (from pyruvate). This reagent uses pyruvate and is based on the method of Henry *et al.*, 1964

Statistical analysis

The means and standard deviations were calculated for all parameters under investigation. Statistical differences between the experimental and control groups were determined using one-way analysis of variance followed by Student's t-test. Values were considered significant at $p < 0.05$. Results are presented as mean \pm S.D

RESULTS AND DISCUSSION

The effect of feeding polyethylene mixed into normal rat chow on two specific serum enzymes in rats is summarized in Table 1

Table 1: Shows levels of some metabolites in the serum of experimental animals fed with formulations of polyethylene in normal rat chow

Experimental Group	LDH ($\mu\text{mol/L}$)	ALP ($\mu\text{mol/L}$)
I	198 \pm 1.00	110 \pm 2.56
II	200 \pm 3.25	113 \pm 2.11

Values are expressed as mean \pm SEM, $n = 10$; LDH-serum lactate dehydrogenase levels; ALP-serum alkaline phosphatase levels; I-control group fed normal rat chow; II-experimental group fed polyethylene in normal rat chow

The serum metabolite levels of Lactate Dehydrogenase (LDH) and Alkaline Phosphatase (ALP) in the experimental animals provide insights into the physiological effects of polyethylene formulations in their diet.

The observed lactate dehydrogenase (LDH) levels of 198 \pm 1.00 $\mu\text{mol/L}$ in Group I and 200 \pm 3.25 $\mu\text{mol/L}$ in Group II suggest a marginal increase in Group II. LDH is released into the bloodstream during tissue damage, particularly in conditions involving hypoxia or cell death. The slight elevation in LDH levels in Group II could indicate a stress response associated with the polyethylene formulation (Wang *et al.*, 2025; Banaee *et al.*, 2025; Huang *et al.*, 2025). Similar findings have been reported in studies where exposure to various dietary additives led to elevated LDH levels, suggesting potential tissue stress or damage (Shah *et al.*, 2015; Altahrawi *et al.*, 2025).

However, the minimal difference may not be clinically significant, warranting further investigation into the specific effects of polyethylene on tissue integrity. Alkaline phosphatase (ALP) levels were also slightly higher in Group II (113 \pm 2.11 $\mu\text{mol/L}$) compared to Group I (110 \pm 2.56 $\mu\text{mol/L}$). Elevated ALP levels can be indicative of liver dysfunction, biliary obstruction, or bone disorders. While the increase is not substantial, it raises questions about the metabolic impacts of polyethylene. Previous studies have shown that various dietary components can influence liver enzyme levels (Kim *et al.*, 2021). In this context, the observed increase in ALP may reflect alterations in hepatic metabolism due to the presence of

polyethylene in the diet, although further studies are needed to confirm these effects and their implications for liver health.

The results are consistent with existing literature on the impacts of synthetic materials in diets, which have been associated with metabolic disruptions and tissue responses (Li *et al.*, 2018). The findings suggest that while polyethylene formulations may not lead to drastic changes in LDH and ALP levels, their potential long-term effects on health and metabolism should be considered. The data indicate a need for further exploration of the effects of polyethylene formulations on liver function and overall metabolic health. While the changes in LDH and ALP levels are minimal, they may signal underlying physiological responses that merit deeper investigation to understand the implications of synthetic additives in animal diets.

CONCLUSION

The analysis of serum metabolites in experimental animals fed with graded formulations of polyethylene shows that, Lactate Dehydrogenase (LDH) levels were slightly elevated in Group II ($200 \pm 3.25 \mu\text{mol/L}$) compared to Group I ($198 \pm 1.00 \mu\text{mol/L}$). LDH is an enzyme released during tissue damage, and the small increase in Group II may indicate a potential stress response to the polyethylene formulation. Alkaline Phosphatase (ALP) levels also showed a minor increase in Group II ($113 \pm 2.11 \mu\text{mol/L}$) compared to Group I ($110 \pm 2.56 \mu\text{mol/L}$). ALP is associated with liver and bone health, and the increase could suggest metabolic changes linked to the dietary formulation.

The study examining serum metabolite levels in experimental animals fed polyethylene formulations indicates that while there are slight increases in both Lactate Dehydrogenase (LDH) and Alkaline Phosphatase (ALP) in the group receiving the polyethylene diet, the differences are minimal. LDH elevation suggests potential tissue stress, while the increase in ALP may indicate changes in liver function or metabolic processes. These findings highlight the necessity for further investigation into the long-term effects of polyethylene in diets, particularly regarding metabolic health and tissue integrity. Although the immediate implications are not alarming, understanding the cumulative effects of synthetic additives on animal health remains crucial for future dietary recommendations and safety assessments.

The following recommendations can be put to place to enhance understanding of the relationship between diet, and health,

- i. Conduct extended studies to assess the chronic effects of polyethylene formulations on metabolic health, tissue integrity, and overall well-being in experimental animals.
- ii. Investigate the underlying mechanisms by which polyethylene may influence LDH and ALP levels, as well

as other metabolic pathways, to understand potential health implications.

- iii. Incorporate comprehensive liver function tests and histopathological examinations in future studies to determine any potential liver damage or dysfunction associated with polyethylene intake.
- iv. Explore the effects of varying concentrations and types of polyethylene in the diet to determine threshold levels that may lead to significant metabolic changes.

These recommendations aim to deepen the understanding of polyethylene's effects on health and to inform future dietary practices and safety standards.

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