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Evaluation of the Impact of Polystyrene Leachates from Food Containers on Serum Lipid Profile in Normal Albino Rats

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ABSTRACT

This study evaluates the impact of polystyrene leachates, administered in the form of polystyrene flour blended into standard rat chow, on the serum lipid profile of normal albino rats, with a specific focus on brain lipid composition. Experimental animals were divided into two groups: Group I (control) received standard rat chow, while Group II was fed chow formulated with polystyrene flour. Lipid analysis revealed that Group II exhibited elevated levels of total cholesterol (TC: 3.01 ± 1.79 µg/mg protein), triglycerides (TG: 1.32 ± 1.88 µg/mg protein), and low-density lipoprotein (LDL: 1.91 ± 0.25 nM/mg protein), alongside a slight reduction in high-density lipoprotein (HDL: 1.30 ± 1.09 mol/mol) compared to the control group (TC: 2.58 ± 0.51, TG: 1.00 ± 2.51, LDL: 1.25 ± 5.21, HDL: 1.39 ± 2.11). These alterations suggest that dietary intake of polystyrene may disrupt lipid metabolism, possibly compromising neuroprotective mechanisms and contributing to lipid imbalances linked to neurodegenerative conditions. The findings underscore the need for further investigation into the long-term effects of dietary contaminants on brain lipid homeostasis and support the development of dietary regulations that limit exposure to synthetic food packaging-derived compounds

INTRODUCTION

Polystyrene is a widely used synthetic polymer, commonly found in packaging materials, including food containers, disposable utensils, and drink cups (1). Due to its low cost, light weight, and insulating properties, polystyrene has become a staple in the food service industry (2). However, concerns have been raised about its potential to leach harmful chemical compounds, especially under conditions of heat or when in contact with oily or acidic foods (3). These leachates may include styrene monomers and oligomers, which are suspected endocrine disruptors and have been linked to various toxicological outcomes (4).

Once ingested, these leachates can enter systemic circulation and may exert adverse effects on metabolic and physiological processes (5). Lipid metabolism, in particular, is sensitive to xenobiotic interference, and alterations in serum lipid profiles are often early indicators of systemic toxicity or metabolic disturbance (6). Previous studies have suggested links between exposure to plastic-related compounds and changes in lipid parameters, including cholesterol and triglyceride levels, which are critical risk factors for cardiovascular disease (7, 8, 9).

The serum lipid profile, including parameters such as total cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL), is a critical biomarker for assessing the risk of cardiovascular diseases (10). Alterations in these lipid parameters can indicate underlying metabolic disturbances, which may be triggered by exposure to environmental toxins such as plastic leachates (11). Animal models, such as albino rats, are effective and ethically acceptable means of studying biochemical alterations induced by environmental toxicants (12). Despite growing concerns over plastic pollution and its biological consequences, there remains a paucity of data specifically addressing the impact of polystyrene leachates on lipid homeostasis in vivo (8).

This study aims to evaluate the effects of polystyrene leachates derived from food containers on the serum lipid profile of normal albino rats. The findings will contribute to the understanding of potential health risks associated with the routine use of polystyrene materials in food packaging and may inform regulatory guidelines concerning consumer safety.

MATERIAL AND METHODS

Sample collection and preparation

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

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Animal experimentation

Twenty (20) healthy albino Wistar rats weighing between 90-120g were used for the study. They were obtained from the animal house of the Department of Biochemistry, Cross River University of Technology, Calabar. The animals were acclimatized for one week and their weights noted before, during and on the last day of experimental treatments. Groups of 10 animals each were housed in cages with the normal day lighting pattern of about 12 hours light (0630-1830 hours) and 12 dark. During this time, they were fed with standard rat pellets (Livestocks Feeds Nig. Ltd; Ikeja, Lagos) and water ad libitum. Animals had free access to standard livestock feed for the normal control as well as the formulated feeds for the experimental groups and tap water ad libitum throughout the experimental period of 30 days. The weight of animals was monitored daily throughout the study.

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 styrene (n=10)
II	Experimental groups fed with normal rat chow with leached styrene 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 and tissues for analysis

For blood samples: 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.

For tissue samples: at the end of the experimental period, the animals were fasted for 8 hours and then sacrificed under chloroform anaesthesia. Brain samples were harvested into labelled sample bottles and stored for use in analysis.

Lipid extraction

Total lipids were extracted according to the method of Folch et al., (13).

Determination of total phospholipid content;

Total phospholipids were determined according to the method of Stewart (1980), based on the formation of a colored complex between phospholipids and ammonium ferrothiocyanate.

Determination of plasmalogens content

Plasmalogen content was determined according to the method of Gottfried and Rapport (14), based on the reaction of the vinyl ether content of plasmalogen with iodine.

Determination of cholesterol levels

Cholesterol levels were determined enzymatically according to the method of Richmond (1973), following a kit protocol (Chronolab references number 101-0576; 101-0593; 101-0526, 101-0440).

Determination of triglycerides levels

Triglycerides levels were also determined enzymatically according to the method of Fossati and Principe (1982), following a kit protocol (Chronolab reference numbers 101-0241; 101-0016; 101-0268; 101-0052 and 101-0053).

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 ± S.D.

RESULTS AND DISCUSSION

The lipid content in the brain of the experimental animals fed with the formulation of polystyrene flour in normal rat chow is presented in Table 1. The lipid profile observed in the brains of experimental animals fed polystyrene flour in combination with normal rat chow reveals significant changes in total cholesterol (TC), triglycerides (TG), high-density lipoprotein (HDL), and low-density lipoprotein (LDL) levels.

Table 1: lipid content in the brain of experimental animals fed with the formulation of polystyrene flour in normal rat chow.

Groups	TC (µg/mg protein)	TG (µg/mg protein)	HDL (mol/mol)	LDL nM/mg protein
I	2.58±0.51	1.00±2.51	1.39±2.11	1.25±5.21
II	3.01±1.79	1.32±1.88	1.30±1.09	1.91±0.25

Values are expressed as mean ± SEM, n = 10; CHL-brain cholesterol content; TPL-brain total phospholipid content; CHL/TPL-molar ratio of CHL TO TPL; PMG-brain plasmalogen content; I-control group fed normal rat chow; II-experimental group fed polystyrene flour in normal rat chow

Group II exhibited increased levels of TC and TG, alongside a notable rise in LDL, while HDL levels slightly decreased compared to Group I. These findings align with existing literature that suggests dietary components can profoundly impact lipid metabolism in the brain. For instance, studies have shown that high cholesterol diets can lead to increased brain cholesterol levels, potentially contributing to neurodegenerative processes (15).

The observed increase in LDL in Group II may indicate altered lipid transport mechanisms, as LDL is primarily responsible for delivering cholesterol to peripheral tissues (16). Moreover, the increase in triglycerides observed in Group II aligns with research indicating that certain dietary fats can elevate triglyceride levels, influencing both peripheral and central nervous system lipid profiles (17). This elevation in triglycerides could be linked to the metabolic burden imposed by the polystyrene flour, which may not be efficiently processed by the body, leading to dysregulated lipid metabolism.

The slight decrease in HDL in Group II is particularly concerning. HDL is known for its role in reverse cholesterol transport and neuroprotection (9). A reduction in HDL levels could diminish the brain's ability to manage cholesterol levels effectively, potentially exacerbating neurodegenerative conditions. This observation supports findings by Saito et al. (18), which indicate that decreased HDL is associated with cognitive decline and increased risk for Alzheimer's disease.

The lipid alterations observed in the brains of animals fed with polystyrene flour suggest potential negative implications for brain health and metabolism. These findings warrant further investigation into the long-term effects of dietary additives on brain lipid composition and overall neurological function. Understanding these relationships could be crucial for developing dietary guidelines to mitigate risks associated with lipid imbalances in the context of neurodegeneration.

CONCLUSION

The study examined the effects of a polystyrene flour formulation on lipid content in the brains of experimental animals. The results showed that animals in Group II had increased levels of total cholesterol (TC) and triglycerides (TG), along with a significant rise in low-density lipoprotein (LDL) and a slight decrease in high-density lipoprotein (HDL) compared to Group I. These findings suggest that dietary components, such as polystyrene flour, can adversely affect lipid metabolism in the brain. The elevation in TC and TG aligns with research indicating that high cholesterol diets can disrupt normal lipid profiles, potentially contributing to neurodegenerative processes. The increase in LDL may reflect altered lipid transport mechanisms, while the reduction in HDL raises concerns about the brain's ability to manage cholesterol effectively, which is crucial for neuroprotection.

The findings of this study indicate that the inclusion of polystyrene flour in the diet significantly alters lipid profiles in the brains of experimental animals, resulting in increased total cholesterol, triglycerides, and LDL levels, along with a decrease in HDL. These changes suggest potential disruptions in lipid metabolism that could have adverse effects on brain health. Given the critical role of lipids in neurological function and disease, further research is necessary to fully understand the long-term implications of dietary additives on brain lipid composition and their association with neurodegenerative disorders. Addressing these effects is essential for informing dietary guidelines and protecting against the risks associated with altered lipid metabolism in the brain.

RECOMMENDATIONS

I. Conduct long-term studies to investigate the chronic effects of polystyrene flour and similar dietary additives on lipid metabolism and brain health, particularly focusing on neurodegenerative disease pathways.
II. Develop and promote dietary guidelines that limit the intake of processed additives, such as polystyrene flour, to minimize potential risks associated with altered lipid profiles.
III. Increase public awareness regarding the potential impacts of dietary choices on neurological health, encouraging informed decisions about food consumption.

By implementing these recommendations, we can better understand and mitigate the effects of dietary factors on brain lipid metabolism and overall neurological health.

CONFLICT OF INTEREST

The author declares no conflict of interest.

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