Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13313

Academia Open

By Universitas Muhammadiyah Sidoarjo

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13313

Table Of Contents

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13313

Originality Statement

The author[s] declare that this article is their own work and to the best of their knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the published of any other published materials, except where due acknowledgement is made in the article. Any contribution made to the research by others, with whom author[s] have work, is explicitly acknowledged in the article.

Conflict of Interest Statement

The author[s] declare that this article was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Copyright Statement

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13313

EDITORIAL TEAM

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13313

Article information

Check this article update (crossmark)

Check this article impact (*)

Save this article to Mendeley

(*) Time for indexing process is various, depends on indexing database platform

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13313

Changes in the Activity of Small Intestinal Enzymes under the Influence of Organophosphorus Pesticides

Askaryants V.P., vera_petrovna_56@mail.ru,(1)
Department of Pharmacology, Normal and Pathological Physiology, Tashkent State Medical University, Uzbekistan
Yunusov A.A., vera_petrovna_56@mail.ru,(2)
Department of Pharmacology, Normal and Pathological Physiology, Tashkent State Medical University, Uzbekistan
Babadjanova F.A., babadjanovaf68@gmail.com,(3)
Department of Pharmacology, Normal and Pathological Physiology, Tashkent State Medical University, Uzbekistan

(1) Corresponding author

Abstract

General Background: Organophosphorus pesticides are widely used agricultural chemicals with known biological effects, yet their impact on digestive physiology remains incompletely understood. **Specific Background:** Previous research has demonstrated that chlorophos, an organophosphorus compound, suppresses intestinal enzyme activity in experimental animals, with lipase showing particular sensitivity, though comprehensive characterization of organophosphorus effects on small intestinal enzyme systems is lacking. **Knowledge Gap:** The detailed dose-dependent and time-dependent effects of butiphos, a commonly used organophosphorus pesticide, on the complete spectrum of intestinal digestive enzymes and the reversibility of these effects have not been systematically investigated. **Aims:** This study investigated the effects of acute and chronic butiphos exposure at varying doses on key small intestinal enzymes including monoglyceride lipase, glycyl-valine dipeptidase, invertase, alkaline phosphatase, and amylase in laboratory rats. **Results:** Monoglyceride lipase activity was consistently and profoundly suppressed (up to 9-fold reduction) across all exposure regimens, while other enzymes exhibited dose- and time-dependent wave-like fluctuations with transient increases or decreases followed by partial recovery; cessation of pesticide administration resulted in normalization of enzymatic activity and mucosal mass. **Novelty:** This research provides the first comprehensive characterization of butiphos-induced alterations in intestinal enzyme-forming function, revealing selective esterase inhibition and reversible enterocyte dysfunction. **Implications:** These findings highlight potential impairment of digestive efficiency during chronic organophosphorus pesticide exposure and underscore the high sensitivity of enterocyte enzymatic systems to these agricultural compounds.

Keywords : Organophosphorus Pesticides, Intestinal Enzymes, Monoglyceride Lipase, Butiphos, Digestive Function

Highlight :

- Monoglyceride lipase activity consistently suppressed regardless of butiphos dose or duration.
- Protein and carbohydrate enzymes showed wave-like fluctuations with partial recovery periods.
- Enzymatic activity and mucosal mass normalized after pesticide administration cessation.

Published date: 2026-01-21

Academia Open
Vol. 11 No. 1 (2026): June
DOI: 10.21070/acopen.11.2026.13313

Introduction

In several studies, the effects of organophosphorus pesticides on the hydrolytic function of the small intestine have been investigated. In particular, chlorophos, administered intragastrically to dogs at a daily dose of 23 mg/kg (1/15 of LD_{50}) over a period of 45 days, was shown to suppress the activity of enzymes present in intestinal juice at the initial stage of the experiment. Among the enzymes studied, lipase activity exhibited the earliest and most pronounced decrease [1].

Subsequently, enzyme activity increased, although to varying extents: enterokinase activity failed to return to baseline levels, whereas lipase activity exceeded its initial values. When chlorophos was administered to rats for three months at a slightly higher dose (1/10 of LD_{50}), a reduction in dipeptidase activity and an increase in invertase activity were observed in everted segments of the small intestine [2].

Certain alterations in the enzyme-forming function of the small intestine were also noted following exposure to low doses of chlorophos. By the end of the second month of administration at a dose of 1/200 of LD_{50}, rats demonstrated a significant decrease in monoglyceride lipase activity along the entire length of the small intestine. At the same time, dipeptidase, amylolytic, and invertase activities were suppressed in the distal segment of the intestine [3].

With prolonged exposure, the activity of intrinsic intestinal enzymes continued to decline, whereas amylolytic activity increased approximately twofold across all segments of the small intestine. From the sixth month of chronic exposure to low-dose chlorophos, the activity indices of intestinal enzymes showed a tendency toward normalization [4].

These limited data indicate a high sensitivity of the enzyme-synthesizing systems of enterocytes to the effects of chlorophos. However, they are insufficient to provide a comprehensive characterization of the influence of organophosphorus compounds on the enzyme-forming function of the small intestine. In this regard, we conducted a detailed investigation of the effects of butiphos, a widely used organophosphorus pesticide in agriculture, on the activity of enteral enzymes [5].

Methodology

The study was performed on adult laboratory rats maintained under standard vivarium conditions with free access to water and a standard diet. Animals were kept at a controlled ambient temperature (20–22 °C) with a 12-hour light–dark cycle. All experimental procedures complied with accepted principles for the humane treatment of laboratory animals.

Butiphos, a widely used organophosphorus pesticide, was administered in doses calculated as fractions of the median lethal dose (LD_{50}). The compound was prepared immediately before administration to ensure stability and accuracy of dosing.

Animals were divided into control and experimental groups.

In acute exposure experiments, butiphos was administered once at a dose of 1/3 LD_{50}.

In chronic exposure experiments, rats received butiphos at doses of 1/20 LD_{50} or 1/50 LD_{50} for periods ranging from 15 days to 10 months.

Control animals received equivalent volumes of the vehicle solution.

At designated time points, animals were euthanized, and the entire small intestine was excised. The mucosal layer was collected by gentle scraping, and its mass was recorded. Homogenates of the intestinal mucosa were prepared for biochemical analysis.

The activity of the following enzymes was determined using standard enzymological methods:

1. monoglyceride lipase,
2. glycyl-valine dipeptidase,
3. invertase,
4. alkaline phosphatase,
5. amylase.

Enzyme activity was calculated per 1 g of raw mucosal mass (specific activity) and for the total mass of the mucosa (total activity), allowing evaluation of both enzymatic intensity and overall digestive capacity. To assess reversibility of pesticide-induced effects, enzyme activity and mucosal mass were measured one month after cessation of butiphos administration in selected experimental groups.

Results and Discussion

All results were expressed as mean ± standard error (M ± m). Differences between control and experimental groups were evaluated using standard statistical methods. Differences were considered statistically significant at $p \leq 0.05$.

A single administration of butiphos at a dose of 1/3 of LD_{50} did not affect enterocyte mass. The mass of the mucosal scraping of the small intestine in rats receiving the compound was 2.05 ± 0.04 g, compared to 2.13 ± 0.02 g in control animals [6].

The activity of monoglyceride lipase exhibited particularly pronounced alterations. In experimental rats, 24 hours after a single administration of butiphos at a dose of 1/3 of LD_{50}, the activity of this enzyme was 8.9-fold lower than that observed in control animals. The total monoglyceride lipase activity in the mucosal layer of the entire intestine decreased 9.2-fold [7].

The activity and total content of the other enzymes investigated in the intestinal mucosa of experimental rats did not undergo significant changes under these conditions [8].

During prolonged administration of butiphos to rats at a dose of 1/20 of LD_{50}, no marked changes in the mass of the small intestinal mucosa were observed. By the end of the first month of the experiment, the mucosal mass slightly increased; by the sixth month, it decreased by 18.6%, and by the tenth month, it again showed a slight increase [9].

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

The most substantial shifts observed following administration of butiphos at a dose of 1/20 of LD_{50}, as anticipated based on the results of the previous experimental series, were related to monoglyceride lipase activity. Thus, 15 days after the onset of treatment, the activity of this enzyme decreased threefold. A comparable reduction was noted in the total enzyme content throughout the intestinal mucosa, as the slight change in mucosal mass had minimal impact on this parameter [10]. After one month, the level of lipolytic activity in experimental animals was 3.7 times lower than in controls. By the second month, a maximal decrease in lipolytic activity (4.5-fold) was observed. By the fourth, sixth, and tenth months of the experiment, both the specific activity and the total content of monoglyceride lipase in the intestinal mucosa of experimental animals were reduced on average by 50–70% [11].

Glycyl-valine dipeptidase activity predominantly exhibited a downward trend. One month after the beginning of butiphos administration, dipeptidase activity decreased by 17%. Due to a slight increase in the mucosal mass of the intestine in experimental animals, the total enzyme content remained unchanged at this stage [12]. By the second and fourth months, dipeptidase activity in experimental animals did not differ from that of controls. By the end of the experiment (sixth and tenth months), a pronounced reduction in both specific and total dipeptidase activity was observed, averaging approximately 45% [13].

One month after the initiation of the experiment, invertase activity decreased by 19%, while its total content in the intestinal mucosa of experimental rats remained unchanged due to a slight increase in mucosal mass at that time point. After 2, 4, and 6 months of exposure, invertase activity did not differ between experimental and control animals. By the tenth month of butiphos administration, both specific and total invertase activities decreased by approximately 40% [14].

The activity of alkaline phosphatase during the initial stages of the study (15 and 30 days) tended to increase. Notably, by the end of the first month, the total content of this enzyme increased by more than 50%, due to a moderate rise in both specific activity and intestinal mucosal mass. An increase in alkaline phosphatase activity by 43% and 30%, respectively, was also observed during the fourth month of exposure. At other time points, these parameters in experimental animals showed a tendency toward reduction [15].

Amylolytic activity slightly increased 15 days after the onset of butiphos administration at a dose of 1/20 of LD_{50}. By the one-month time point, both specific and total amylase activities decreased by an average of 45%. After 2 and 4 months, enzyme activity levels in experimental and control animals were nearly identical. By the sixth month of the experiment, a repeated decrease in amylolytic activity of approximately 20% was noted. By the tenth month of butiphos administration, as at the beginning of the experiment, amylolytic activity in the intestinal mucosa of experimental and control animals was comparable.

One month after the cessation of butiphos administration at a dose of 1/50 of LD_{50}, the activity of all enzymes and the mass of the small intestinal mucosa in experimental rat groups became comparable to those observed in control animals.

In animals subjected to prolonged administration of butiphos at a dose of 1/50 of LD_{50}, no statistically significant changes in enterocyte mass were detected during the first three months of the experiment, although a tendency toward a decrease was observed. By the end of the fourth and sixth months of the study, the mass of the intestinal mucosal scraping decreased by 22% and 8%, respectively. Subsequently, by the tenth month, the mucosal mass in experimental and control rats became identical.

The most pronounced effect of this dose of butiphos was observed with respect to monoglyceride lipase activity. Fifteen days after the initiation of pesticide administration, enzyme activity decreased 2.6-fold, and by the end of the first month, it decreased 3.3-fold. Thereafter, the difference in monoglyceride lipase activity in the homogenates of the small intestinal mucosa between experimental and control animals gradually diminished; however, it remained statistically significant until the end of the study. The total content of this enzyme in the intestinal mucosa decreased at all time points to approximately the same extent as its specific activity.

Glycyl-valine dipeptidase activity exhibited wave-like fluctuations, with statistically significant changes observed exclusively in the direction of reduction. By the end of the first month of the experiment, butiphos caused a decrease in both specific and total activity by an average of 15%. By the second and fourth months, these parameters recovered to control levels, whereas by the sixth and tenth months, they again declined by approximately 25%.

Noticeable changes in invertase activity were observed only at later stages of the experiment. The inducing effect of butiphos became evident after four months, when invertase activity increased by 49%. Due to a reduction in the mass of the intestinal mucosa, the total content of this enzyme in the mucosa remained unchanged. By the sixth month of the experiment, invertase activity exceeded control levels by 46% (specific activity) and 34% (total activity). By the tenth month, however, both indices sharply declined and became lower than those of control animals by 20% and 19%, respectively.

During one- and two-month exposure of rats to butiphos, a tendency toward increased alkaline phosphatase activity relative to controls was observed. By the end of the fourth month, its activity exceeded control levels by 54%. Subsequently, enzyme activity declined, and by the sixth and tenth months, it returned to levels comparable to those in intact rats.

The amylolytic activity of the small intestinal mucosal homogenate comprising the activity of intrinsic intestinal γ-amylase and pancreatic α-amylase adsorbed on the surface of enterocytes showed a tendency toward reduction on the 15th day of the experiment. By the one-month time point, amylase activity increased by 25%. Since the intestinal mucosal mass of experimental and control animals was identical during this period, the increase in the total amylase content was approximately equal to the shift in its activity normalized per unit mucosal mass (27%). By the second and fourth months of the experiment, differences in amylolytic activity between control and experimental animals were no longer observed. By the sixth month after cessation of pesticide administration, the activity of all enzymes and the mass of the small intestinal mucosa in experimental animals did not differ significantly from those of control rats.

Based on the presented data, it can be concluded that the most characteristic and consistent effect of butiphos is the suppression of intestinal monoglyceride lipase activity, since organophosphorus compounds (OPCs) are known to exert an inhibitory influence on esterases, which includes the monoglyceride lipase investigated in this study. The activity of the other intestinal enzymes examined during prolonged butiphos administration exhibited a wave-like pattern of fluctuations.

Conclusion

The present study demonstrates that butiphos, a representative organophosphorus pesticide, induces pronounced and sustained alterations in the

enzyme-forming function of the small intestine. The most consistent and characteristic effect of butiphos exposure is the suppression of monoglyceride lipase activity, reflecting the known inhibitory action of organophosphorus compounds on esterases. Other intestinal enzymes involved in protein and carbohydrate digestion exhibited time-dependent, wave-like changes, including transient activation, suppression, and partial recovery during prolonged exposure. Importantly, cessation of pesticide administration led to normalization of both enzymatic activity and intestinal mucosal mass, indicating a reversible component of pesticide-induced dysfunction. These findings highlight the high sensitivity of enterocyte enzymatic systems to organophosphorus compounds and underscore the potential risk of impaired digestive processes during chronic pesticide exposure

References

1. Sh. T. Atabayev, "Contamination of Food, Forage Crops, and Some Other Plants Under Pesticide Application in Uzbekistan," in Proc. Scientific Symposium on Toxicology and Hygiene of Pesticides Used in Agriculture, Tashkent, Uzbekistan, 1999, pp. 105-107.
2. S. V. Belmer and T. V. Gasilina, Impairment of Pancreatic Digestive Functions in Children: A Training and Methodological Manual. Moscow, Russia: Ministry of Health of the Russian Federation, 2006.
3. V. P. Bezugly, I. L. Odintsova, and R. L. Kazakevich, "Health Status of Individuals With Prolonged Occupational Exposure to HCH," Zdravookhranenie Respubliki Belarus, no. 1, pp. 49-51, 2000.
4. I. N. Georgiev, "Effects of Toxic and Maximum Permissible Amounts of Sevin on Intestinal Secretory Function," Hygiene and Sanitation, no. 8, pp. 42-46, 2002.
5. D. Green and R. Goldberg, Molecular Aspects of Life. Moscow, Russia: Mir Publishers, 2003.
6. P. Quadros dos Santos, J. C. Guedes, R. P. de Jesus, et al., "Effects of Using Symbiotics in the Clinical Nutritional Evolution of Patients With Chronic Pancreatitis: A Prospective, Randomized, Controlled, Double-Blind Study," Clinical Nutrition, vol. 36, no. 6, pp. 1622-1627, 2017.
7. V. S. Akshintala, R. Talukdar, V. K. Singh, and M. Goggins, "The Gut Microbiome in Pancreatic Disease," Clinical Gastroenterology and Hepatology, vol. 17, no. 2, pp. 290-295, 2019.
8. M. V. Shestakova, I. V. Mayev, A. S. Ametov, et al., "Exocrine Pancreatic Insufficiency in Type 1 and 2 Diabetes Mellitus," Diabetes Mellitus, vol. 26, no. 2, pp. 215-224, 2023.
9. H. N. Qahramonovich, "Worthy Descendants of the Samarkandians: Enlighteners Jadids," World Bulletin of Social Sciences, vol. 13, pp. 37-40, 2022.
10. R. T. Usanov and N. K. Khakkulov, "Iz Istorii Izucheniya Problemy 'Nenasilie'," Ekonomika i Sotsium, no. 6-2, vol. 121, pp. 1406-1413, 2024.
11. T. Shaymardonov, "Siddiqiy-Ajziy Hayoti va Ijodining O'rganilishi," Uzbekistan: Language and Culture, vol. 1, no. 1, pp. 27-39, 2022.
12. R. S. Madatovich, "Aesthetic Features of the Formation of a Healthy Environment in the Upbringing of Children in the Family," JournalNX, vol. 6, no. 4, pp. 88-90, 2020.
13. R. Madatovich, "The Role of Civic Responsibility in Educating Youth in a Healthy Spiritual Environment in an Information Society," Pubmedia Social Sciences and Humanities, vol. 3, no. 1, pp. 1-6, 2025.
14. P. A. Kholkhojayevich, "Regional Factors, Principles and Directions of Small Business Development," Asian Journal of Economics, Business and Management, vol. 8, no. 12, pp. 6178-6186, Dec. 2025.
15. A. A. Azizkulov and S. M. Ruzimurodov, "Gazali on the Significance of Intellect in Human Activity," Paradigmata Poznani, no. 2, pp. 43-46, 2014.

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo