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Effect of carnitine, methionine, vitamins E and B_{12}, selenium, and zinc as components of a complex preparation on the immune status of rats under conditions of toxic liver injury

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Toxic liver injury is accompanied by the development of oxidative stress and disturbances in the functional state of the immune system, particularly in the parameters of nonspecific resistance. The use of complex preparations with antioxidant and immunomodulatory properties is considered a promising approach for correcting such disorders. The aim of this study was to investigate the effect of a complex preparation containing carnitine, vitamins E and B_{12}, methionine, selenium, and zinc on the antioxidant and immune status of rats under conditions of toxic liver injury induced by carbon tetrachloride. The experiment was carried out on adult male Wistar rats weighing 180–200 g, which were divided into three groups: control, experimental (carbon tetrachloride-induced injury), and experimental with correction using the preparation "Devivit Carnitine". Toxic liver injury was induced by intramuscular administration of a 50% oil solution of carbon tetrachloride at a dose of 0.25 mL/100 g body weight on days 1 and 3. The preparation was administered at a dose of 0.1 mL/kg body weight for 5 days. Blood samples were collected on days 2, 5, 10, and 14 of the experiment. Lysozyme and bactericidal activity of blood serum, the level of circulating immune complexes, and phagocytic activity of neutrophils were determined. It was found that administration of carbon tetrachloride caused pronounced changes in the immune status of rats, manifested by increased lysozyme and bactericidal activity of blood serum and elevated levels of circulating immune complexes at early stages of the experiment, followed by suppression of both humoral and cellular components of nonspecific resistance. The use of the preparation "Devivit Carnitine" contributed to normalization of immune parameters, which was expressed by increased antimicrobial activity of blood serum, reduced levels of circulating immune complexes, and restoration of phagocytic activity of neutrophils. Carbon tetrachloride-induced liver injury is accompanied by the development of oxidative stress and immune imbalance. The complex preparation "Devivit Carnitine" exhibits pronounced antioxidant and immunomodulatory properties, contributing to the restoration of nonspecific resistance in rats. Further studies are warranted to elucidate the molecular mechanisms of action of the preparation components, particularly their effects on the antioxidant defense system. It is also advisable to investigate the efficacy of the preparation under different models of hepatotoxicity, as well as in productive animals to substantiate its practical application in veterinary medicine.

Keywords: carbon tetrachloride; Devivit Carnitine; oxidative stress; resistance; intoxication.

Introduction

Toxic liver injury remains one of the most pressing issues in modern veterinary and medical science, as it is accompanied by profound disturbances in metabolic processes, reduced adaptive capacity of the organism, and the development of systemic pathological changes. The liver plays a central role in maintaining homeostasis by ensuring detoxification of xenobiotics, biotransformation of endogenous and exogenous compounds, and regulation of lipid, protein, and carbohydrate metabolism. Damage to hepatic tissue leads not only to impairment of its functions but also to the development of secondary alterations in other organs and systems, particularly the immune system.

One of the most widely used experimental models of toxic liver injury is carbon tetrachloride (CCl_4), which is characterized by pronounced hepatotoxic effects (Gutyj et al., 2017; Cohen et al., 2023; Zhang et al., 2023). Biotransformation of carbon tetrachloride in the liver with the participation of the microsomal cytochrome P_{450} system leads to the formation of highly reactive free radical metabolites, including the trichloromethyl radical, which initiates lipid peroxidation processes (Ivankiv et al., 2019; Xue et al., 2022). As a result, hepatocyte membranes are damaged, membrane permeability is altered, organelles become destabilized, and necrotic and dystrophic changes develop in the liver (Que et al., 2022; Zhang et al., 2022; Fareed et al., 2024). A key pathogenetic mechanism of toxic liver injury is the development of oxidative stress, characterized by an imbalance between free radical oxidation processes and the antioxidant defense system of the organism (Vus et al., 2025). Excessive production of reactive oxygen species promotes lipid peroxidation, accumulation of toxic products such as malondialdehyde, and suppression of antioxidant enzymes including superoxide dismutase, catalase, and glutathione peroxidase. Disturbances in antioxidant status represent an important link in the development of both local and systemic pathological processes (Ivankiv et al., 2019; Unsal et al., 2020).

Oxidative stress and toxic liver injury are closely associated with the functional state of the immune system (Sadasivam et al., 2022). The liver is an immunocompetent organ in which innate immune cells, particularly Kupffer cells, are activated and produce pro-inflammatory cytokines and mediators. Under hepatotoxic conditions, impaired immune reactivity is observed, including alterations in phagocytic activity, imbalance of humoral factors of nonspecific resistance, and decreased bactericidal and lysozyme activity of blood serum. At the same time, excessive activation of the immune response may further aggravate tissue damage due to inflammatory reactions and oxidative stress.

In this regard, considerable scientific interest is focused on the search for effective agents capable of correcting disturbances in antioxidant and immune status under conditions of toxic liver injury (Vlizlo et al., 2023). Particular attention is paid to complex preparations containing biologically active substances with antioxidant and metabolic properties (Gutyj et al., 2022; Vlizlo et al., 2024). Carnitine is invol-

ved in the transport of fatty acids into mitochondria, contributing to optimization of energy metabolism and stabilization of hepatocyte function. Vitamin E is a potent lipid-soluble antioxidant that protects cell membranes against peroxidative damage (Usenko et al., 2020; Galli et al., 2022). Methionine acts as a donor of methyl groups and a precursor of glutathione, one of the major intracellular antioxidants (Tassinari et al., 2024; Vus et al., 2025). Selenium and zinc are components of antioxidant enzymes, including glutathione peroxidase and superoxide dismutase, and play an important role in maintaining antioxidant and immune homeostasis. Vitamin B_{12} is involved in metabolic processes and hematopoiesis and indirectly influences the immune response (Green & Miller, 2022).

Despite the considerable number of studies devoted to individual components, their combined use in a complex preparation may provide a synergistic effect, enhancing the efficiency of correcting oxidative stress and immune disorders. However, the effects of such multicomponent agents on antioxidant status and parameters of nonspecific resistance under conditions of toxic liver injury require further investigation.

The aim of this study was to investigate the effect of carnitine, vitamins E and B_{12}, methionine, selenium, and zinc as components of the complex preparation "Devivit Carnitine" on the immune status of rats under conditions of carbon tetrachloride-induced toxic liver injury.

Materials and methods

During the study, all procedures were conducted in accordance with bioethical standards and current legislation governing the use of laboratory animals, in compliance with the provisions of the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986) and the General Ethical Principles of Animal Experiments, approved by the First National Congress on Bioethics (Kyiv, 2001).

The experiment was performed on adult male Wistar rats weighing 180–200 g. The animals were kept under standard conditions in the vivarium of the State Scientific-Research Control Institute of Veterinary Medicinal Products and Feed Additives. Throughout the experimental period, the rats were provided with a complete balanced diet and had free access to drinking water supplied via glass drinkers (0.2 L).

The animals were divided into three groups (n = 10 per group): a control group (intact animals) and two experimental groups in which toxic liver injury was induced by carbon tetrachloride. Rats of the second experimental group additionally received the preparation "Devivit Carnitine". Toxic liver injury was induced by intramuscular injection of a 50% oil solution of carbon tetrachloride at a dose of 0.25 mL/100 g body weight on days 1 and 3 of the experiment. Rats of the second experimental group were additionally administered "Devivit Carnitine" at a dose of 0.1 mL/kg body weight for 5 days. The preparation contained carnitine hydrochloride, vitamin E, vitamin B_{12}, methionine, selenium, and zinc.

Blood samples for biochemical and hematological analyses were collected under ether anesthesia from the jugular vein on days 2, 5, 10, and 14 of the experiment.

Lysozyme activity of blood serum was determined by a nephelometric method using a 24-hour culture of *Micrococcus lysodeicticus* strain VKM-109 as a test microorganism. Optical density was measured at a wavelength of 540 nm. Bactericidal activity of blood serum was assessed according to the method of Markov (1968) using a 24-hour culture of *Escherichia coli* strain VKM-125; photocolorimetric measurements were performed before and after 3-hour incubation (Vlizlo et al., 2012).

The level of circulating immune complexes in blood serum was determined using borate buffer. Antigen–antibody complexes were precipitated with polyethylene glycol (PEG) with a molecular weight of 6000 Da. The results were evaluated by photocolorimetric measurement of the optical density of the precipitate at 450 nm (Vlizlo et al., 2012).

Phagocytic activity of blood neutrophils was determined based on phagocytic activity (PA), phagocytic index (PI), and phagocytic number (PN) according to the method of Gostev (1950). Stabilized blood was incubated with a 24-hour culture of the *E. coli* strain VKM-125. Smears were examined under a microscope using an immersion system. PA was calculated as the percentage of active neutrophils among 100 counted cells; PI as the number of phagocytosed microbial cells per active neutrophil; and PN as the total number of phagocytosed microbial cells per 100 neutrophils (Vlizlo et al., 2012).

Statistical analysis of the obtained data was performed using Statistica 6.0 software (StatSoft Inc., USA). Data are presented as mean ± standard deviation ($x \pm SD$). Differences between control and experimental groups were assessed using analysis of variance (ANOVA), with significance set at $P < 0.05$ (Bonferroni correction applied).

Results

The results of the study of humoral immunity parameters in rats under conditions of oxidative stress and following administration of the preparation "Devivit Carnitine" are presented in Figures 1–3.

It was established that after the development of oxidative stress induced by carbon tetrachloride administration (first experimental group), the parameters of the humoral component of nonspecific resistance differed from those of the control group. In particular, on day 2 of the experiment, an increase in lysozyme activity of blood serum by 7.34% ($P < 0.001$) compared to the control group was observed (Fig. 1). Lysozyme is known to be one of the key indicators of natural resistance in animals, as it is capable of lysing microorganisms and neutralizing toxins entering the organism.

At this stage of the experiment, under carbon tetrachloride exposure, an increase in the bactericidal activity of blood serum by 6.7% ($P < 0.001$) was also recorded. Bactericidal activity of serum is an important indicator of humoral nonspecific resistance and is associated with the presence of specific proteins capable of destroying bacterial cells or neutralizing toxins of various origins.

An important indicator of the immune status of the organism is the level of circulating immune complexes (Fig. 2).

In rats of the first experimental group, on day 2 of the experiment under conditions of oxidative stress, the level of circulating immune complexes in the blood was nearly twofold higher ($P < 0.001$) compared to that of the control group.

Under carbon tetrachloride exposure and following administration of the preparation "Devivit Carnitine", rats of the second experimental group on day 2 showed a significant increase in both lysozyme and bactericidal activity of blood serum by 8.82% and 15.68%, respectively ($P < 0.001$). At the same time, the level of circulating immune complexes exceeded that of the control group by 57.7% ($P < 0.001$). Similar changes in the humoral component of nonspecific resistance were observed on day 5 of the experiment. In rats of the first experimental group, lysozyme activity of blood serum reached 42.20 ± 0.45% ($P < 0.001$), compared to 35.34 ± 0.28% in the control group. Bactericidal activity increased to 38.66 ± 0.66%, whereas in control animals it was 30.64 ± 0.38%. The level of circulating immune complexes remained elevated at 94.02 ± 0.59 mmol/L, significantly exceeding the value in the control group (42.40 ± 0.62 mmol/L).

In rats of the second experimental group on day 5, lysozyme and bactericidal activity of blood serum were even higher compared to the previous time point, reaching 48.06 ± 0.52% and 43.30 ± 0.53%, respectively, while in the control group these values were 35.34 ± 0.28% and 30.64 ± 0.38%. At the same time, the level of circulating immune complexes decreased compared to day 2 and amounted to 57.92 ± 0.82 mmol/L, although it remained higher than in control animals (42.40 ± 0.62 mmol/L).

On day 10 of the experiment, under conditions of oxidative stress, a decrease in humoral nonspecific resistance parameters was observed. In particular, in rats of the first experimental group, lysozyme activity decreased to 38.48 ± 0.66% ($P < 0.001$), while bactericidal activity was 28.62 ± 0.57% ($P < 0.05$). At the same time, a slight decrease in circulating immune complexes to 90.50 ± 0.61 mmol/L ($P < 0.001$) was noted, although this value remained significantly higher than in the control group (42.68 ± 0.67 mmol/L).

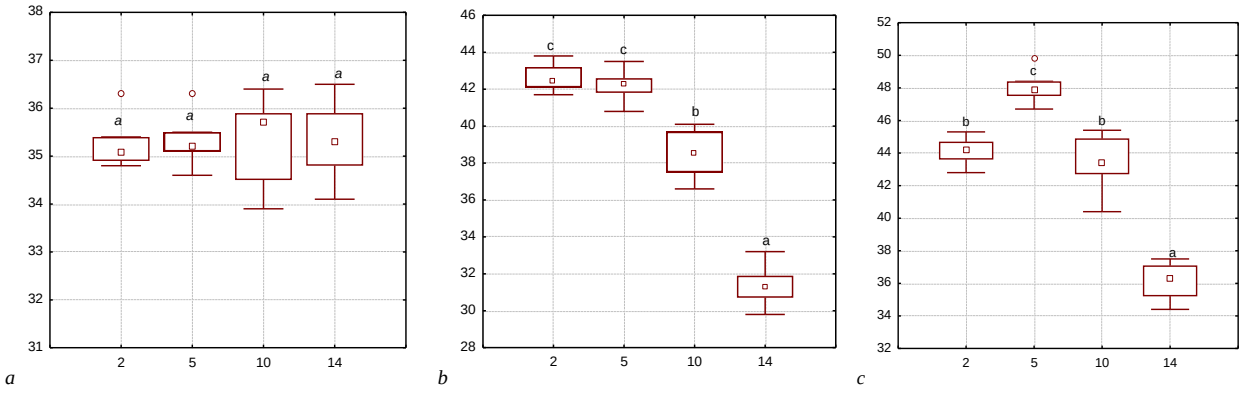

Fig. 1. Lysozyme activity of blood serum in rats under conditions of oxidative stress and after administration of the preparation "Devivit Carnitine": *a* – control group; *b* – first experimental group; *c* – second experimental group, %; small square – median, upper and lower edges of the rectangular square – 75% and 25% of quartile, vertical line – minimum and maximum values, circles – outliers; n = 5

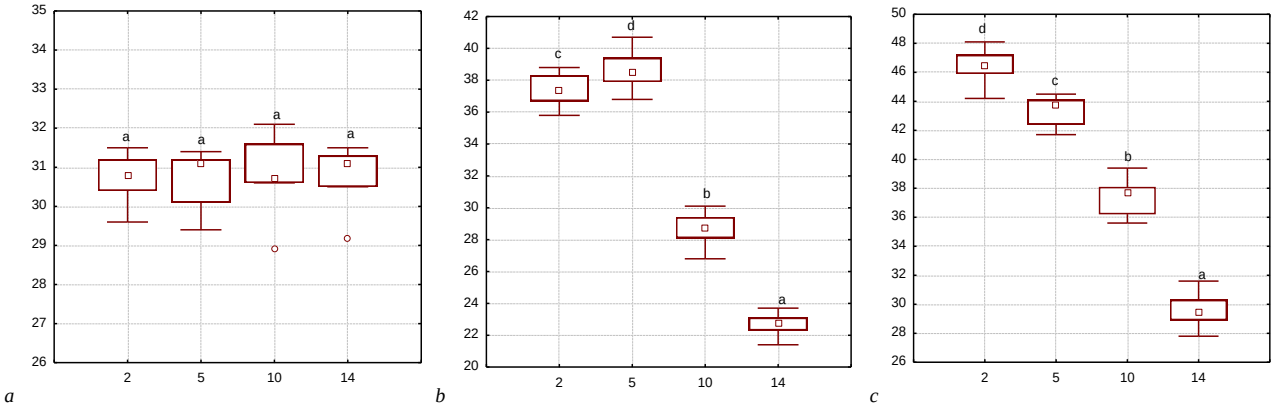

Fig. 2. Bactericidal activity of blood serum in rats under conditions of oxidative stress and after administration of the preparation "Devivit Carnitine": *a* – control group; *b* – first experimental group; *c* – second experimental group, %; small square – median, upper and lower edges of the rectangular square – 75% and 25% of quartile, vertical line – minimum and maximum values, circles – outliers; n = 5

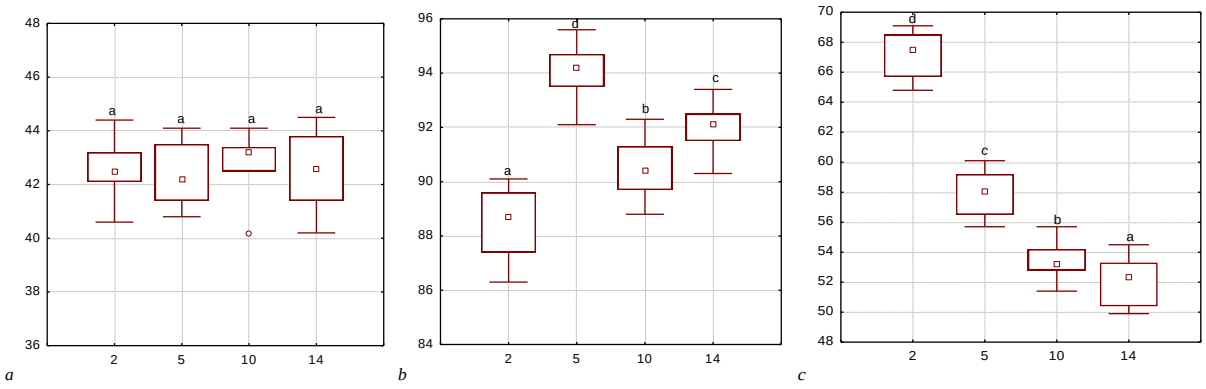

Fig. 3. Circulating immune complexes in the blood of rats under conditions of oxidative stress and following administration of the preparation "Devivit Carnitine": *a* – control group; *b* – first experimental group; *c* – second experimental group, mmol/L; small square – median, upper and lower edges of the rectangular square – 75% and 25% of quartile, vertical line – minimum and maximum values, circles – outliers; n = 5

In rats of the second experimental group, under conditions of intoxication and administration of "Devivit Carnitine", a tendency toward normalization of antimicrobial activity of blood serum was observed on day 10. Lysozyme and bactericidal activity were 43.36 ± 0.89% ($P < 0.001$) and 37.4 ± 0.68% ($P < 0.001$), respectively, exceeding control values by 8.08% and 6.62%. During this period, a decrease in circulating immune complexes to 53.46 ± 0.72 mmol/L was also recorded; however, this level remained significantly higher than in the control group by 25.3% ($P < 0.001$).

On day 14 of the experiment, under carbon tetrachloride exposure, suppression of the humoral component of immune defense was also observed in rats of the first experimental group. In particular, lysozyme activity of blood serum decreased by 3.94%, and bactericidal activity decreased by 8.06% compared to control values. At the same time, the level of circulating immune complexes remained elevated, reaching 91.96 ± 0.52 mmol/L, which significantly exceeded the value in the control group (42.50 ± 0.78 mmol/L).

In rats of the second experimental group treated with "Devivit Carnitine", normalization of the humoral immune parameters was observed on day 14 of the experiment. In particular, lysozyme and bactericidal activity of blood serum were within physiological ranges.

Thus, the obtained results indicate that administration of carbon tetrachloride induces antigenic load in rats, as evidenced by the increased level of circulating immune complexes. This is accompanied by activation (tension) of humoral factors of nonspecific resistance, including lysozyme and bactericidal activity of blood serum, which was most pronounced on days 2 and 5 of the experiment. At the same time, the results confirm the positive effect of the preparation "Devivit Carnitine" under experimental carbon tetrachloride exposure, manifested by enhancement of the humoral immune response and reduc-

tion of antigenic load. The results of the study of nonspecific resistance parameters in rats under carbon tetrachloride exposure and following administration of "Devivit Carnitine" are presented in Figures 4–6. It was established that in rats of the first experimental group, significant disturbances in the cellular component of innate immunity occurred. In particular, phagocytic activity of neutrophils decreased to 37.12 ± 0.44% compared to 49.12 ± 0.52% in the control group, the phagocytic index was 3.12 ± 0.13 units versus 5.78 ± 0.06 units, and the phagocytic number was 3.98 ± 0.09 units versus 5.08 ± 0.08 units in control animals. These changes indicate significant suppression of nonspecific immunity ($P < 0.001$). On days 5 and 10 of the experiment, under conditions of oxidative stress, the parameters of phagocytic activity, phagocytic index, and phagocytic number remained decreased. As shown in the figures, even on day 14 these parameters did not return to control values. Specifically, phagocytic activity of neutrophils in rats of the first experimental group reached 41.64 ± 0.69% ($P < 0.001$) compared to 48.90 ± 0.69% in the control group (7.26% lower). The phagocytic index was 27.1% lower ($P < 0.001$), and the phagocytic number was 14.7% lower ($P < 0.001$) than in control animals.

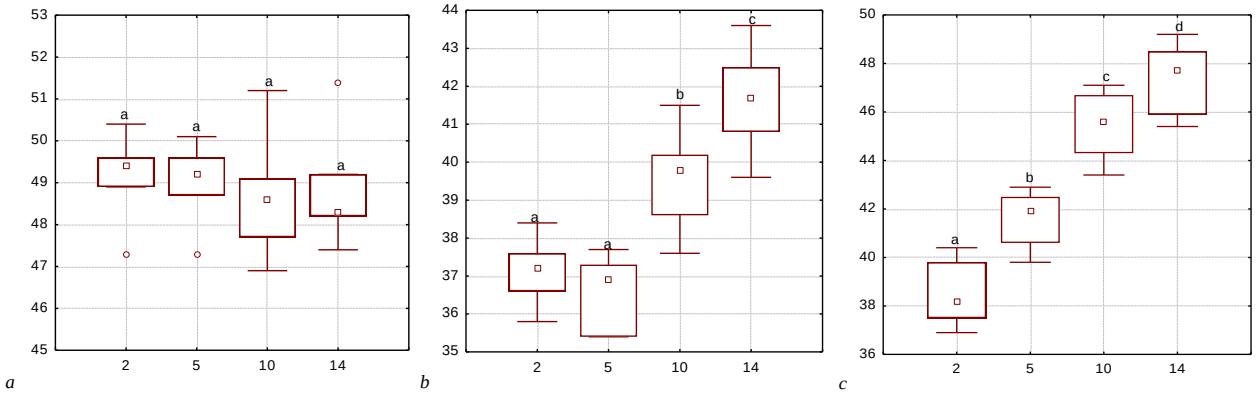

Fig. 4. Phagocytic activity of blood neutrophils in rats under conditions of oxidative stress and following administration of the preparation "Devivit Carnitine": *a* – control group; *b* – first experimental group; *c* – second experimental group, %; small square – median, upper and lower edges of the rectangular square – 75% and 25% of quartile, vertical line – minimum and maximum values, circles – outliers; n = 5

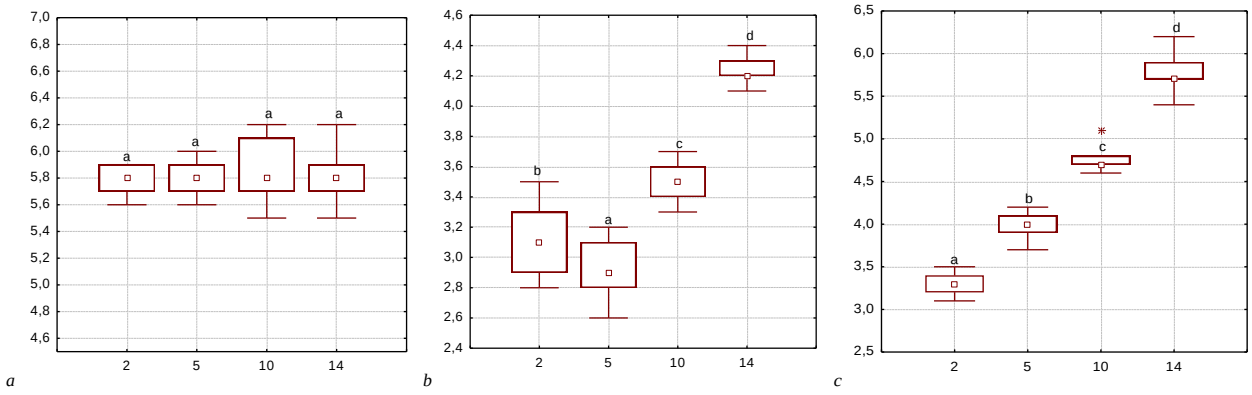

Fig. 5. Phagocytic index of blood in rats under conditions of oxidative stress and following administration of the preparation "Devivit Carnitine": *a* – control group; *b* – first experimental group; *c* – second experimental group, units; small square – median, upper and lower edges of the rectangular square – 75% and 25% of quartile, vertical line – minimum and maximum values, circles – outliers; n = 5

Under conditions of carbon tetrachloride exposure, administration of the preparation "Devivit Carnitine" in rats of the second experimental group resulted in an increase in phagocytic activity of neutrophils, phagocytic index, and phagocytic number in blood as early as day 2 of the experiment compared to control animals. A further tendency toward normalization of the parameters of the nonspecific immune response in this group was observed on days 5 and 10 of the study. In particular, phagocytic activity of neutrophils in rats of the second experimental group reached 41.54 ± 0.58% ($P < 0.001$) and 45.42 ± 0.70% ($P < 0.05$), respectively, compared to 48.98 ± 0.48% ($P < 0.001$) and 48.70 ± 0.73% ($P < 0.001$) in the control group. The phagocytic index was 3.98 ± 0.09 and 4.78 ± 0.09 units, respectively, compared to 5.80 ± 0.07 and 5.86 ± 0.13 units in the control group, while the phagocytic number was 4.52 ± 0.07 ($P < 0.001$) and 4.76 ± 0.05 units ($P < 0.01$), respectively, versus 5.06 ± 0.07 and 5.10 ± 0.07 units in control animals.

On day 14 of the experiment, under conditions of oxidative stress and administration of the preparation "Devivit Carnitine", restoration of the parameters of the nonspecific component of the immune system was observed in rats of the second experimental group. In particular, the values of phagocytic activity of neutrophils, phagocytic index, and phagocytic number were within physiological ranges.

Thus, the obtained results indicate that administration of carbon tetrachloride induces a significant antigenic load in experimental rats, as evidenced by changes in immune parameters. This is accompanied by activation (tension) of the nonspecific immune response, manifested by increased phagocytic activity of neutrophils, phagocytic index, and phagocytic number, especially on days 2 and 5 of the experiment. At the same time, the obtained data confirm the positive effect of the preparation "Devivit Carnitine" under experimental carbon tetrachloride exposure on the immune system of rats, which is expressed by enhancement of the nonspecific immune response and reduction of antigenic load.

Discussion

The obtained results indicate that experimental administration of carbon tetrachloride leads to pronounced disturbances in immune homeostasis and activation of oxidative stress processes in rats. The use of carbon tetrachloride as a model of toxic liver injury is widely recognized in experimental biology and veterinary medicine, as this compound reproduces the typical pathogenetic mechanisms of hepatotoxicity characteristic of many xenobiotics (Unsal et al., 2020; Li et al., 2023; Lee et al., 2023).

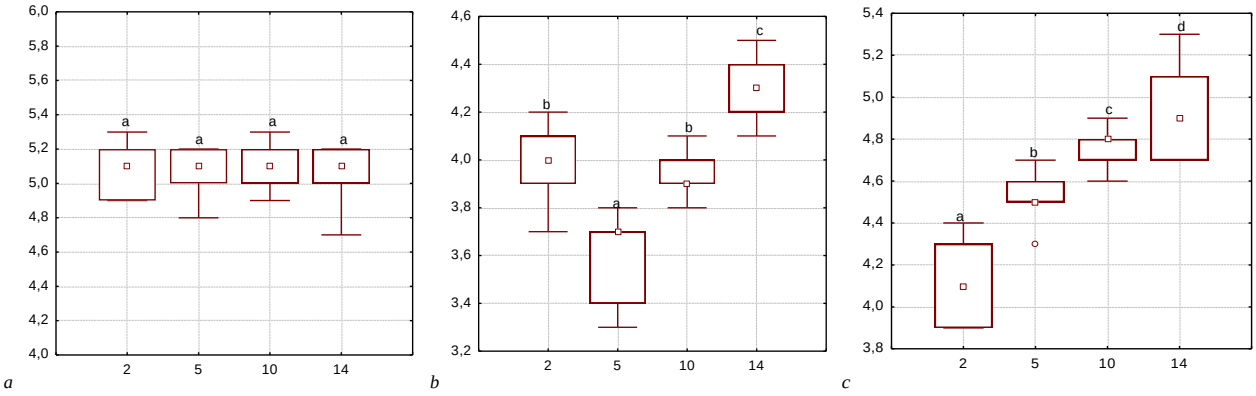

Fig. 6. Phagocytic number in the blood of rats under conditions of oxidative stress and following administration of the preparation "Devivit Carnitine": *a* – control group; *b* – first experimental group; *c* – second experimental group, units; small square – median, upper and lower edges of the rectangular square – 75% and 25% of quartile, vertical line – minimum and maximum values, circles – outliers; n = 5

It is known that after entering the organism, carbon tetrachloride is metabolized in the liver by the microsomal cytochrome P_{450} system with the formation of highly reactive trichloromethyl (•CCl_3) and trichloromethyl peroxyl (•$OOCCl_3$) radicals (Yildiz et al., 2022; Yang et al., 2023; Zein et al., 2023; Wang et al., 2024). These free radicals initiate intensive lipid peroxidation processes, leading to damage to cellular and subcellular membranes of hepatocytes, increased membrane permeability, enzyme inactivation, and the development of necrotic and dystrophic changes in the liver. In addition, lipid peroxidation products act as secondary toxic agents that further aggravate tissue damage and contribute to systemic intoxication.

The obtained results are consistent with findings of other researchers, who report that hepatotoxic agents, including carbon tetrachloride, cause marked suppression of the immune system through activation of lipid peroxidation processes (Baogui et al., 2022; El-Kashef & Zaghloul, 2022). At the same time, the use of antioxidants and metabolic modulators based on carnitine and vitamins contributes to normalization of immune status, reduction of cytotoxicity, and enhancement of nonspecific resistance in animals.

The development of oxidative stress under carbon tetrachloride exposure is closely associated with immune system function. Damage to hepatocytes and the release of endogenous antigens activate innate immune cells, resulting in increased levels of humoral factors of nonspecific resistance at early stages of the experiment. The observed increase in lysozyme and bactericidal activity of blood serum on days 2 and 5 confirms activation of protective mechanisms in response to toxic insult. At the same time, a significant increase in circulating immune complexes indicates pronounced antigenic load and the development of immunopathological processes.

A subsequent decrease in humoral immune parameters at later stages of the experiment (days 10 and 14) indicates exhaustion of the organism's defense mechanisms, which is characteristic of prolonged oxidative stress. The persistence of elevated circulating immune complexes suggests impaired clearance and maintenance of a chronic inflammatory state. In parallel, suppression of the cellular component of immunity was observed, manifested by decreased phagocytic activity of neutrophils, phagocytic index, and phagocytic number. These changes are likely associated with membrane damage, energy deficiency, and impaired functional activity of immunocompetent cells.

Administration of the complex preparation "Devivit Carnitine" resulted in significant correction of the detected disturbances. The observed increase in lysozyme and bactericidal activity of blood serum in rats of the second experimental group indicates stimulation of humoral nonspecific resistance, while the gradual decrease in circulating immune complexes during the experiment suggests reduced antigenic load and improved immune regulation. Restoration of phagocytic parameters at later stages confirms normalization of the cellular component of the immune system.

Carnitine facilitates the transport of long-chain fatty acids into mitochondria and supports energy metabolism, which is critically important under conditions of toxic liver injury. Vitamin E, as a potent lipid-soluble antioxidant, inhibits lipid peroxidation and stabilizes cellular membranes, reducing the extent of their damage (Ivankiv et al., 2019; Romanovych et al., 2019).

Methionine plays a key role as a methyl group donor and a precursor of glutathione, one of the major intracellular antioxidants involved in detoxification of free radicals and lipid peroxidation products. Selenium is a component of glutathione peroxidase, ensuring neutralization of peroxides, whereas zinc acts as a cofactor of superoxide dismutase and stabilizes cell membranes, preventing their damage (Sobolev et al., 2018; Mojadadi et al., 2021). Vitamin B_{12} participates in nucleic acid metabolism, hematopoiesis, and regulation of metabolic processes, thereby indirectly influencing immune function (Temova Rakuša et al., 2022).

Thus, the combined action of these components provides not only an antioxidant effect but also contributes to restoration of immune system function, which is particularly important under conditions of toxic liver injury. Reduction of oxidative stress intensity, stabilization of cellular membranes, and improvement of cellular energy supply create favorable conditions for normalization of both humoral and cellular mechanisms of nonspecific resistance.

Therefore, the obtained results confirm that the carbon tetrachloride model is adequate for studying the mechanisms of toxic liver injury and associated immune disorders. The use of the complex preparation "Devivit Carnitine" provides a pronounced corrective effect on immune status, manifested by normalization of humoral and cellular components of nonspecific resistance, reduction of antigenic load, and restoration of adaptive capacity of the organism.

Conclusions

It was established that experimental administration of carbon tetrachloride in rats induces pronounced oxidative stress and is accompanied by significant disturbances in immune homeostasis, manifested by alterations in both humoral and cellular components of nonspecific resistance. Under conditions of carbon tetrachloride exposure, activation of humoral immune defense factors was observed at early stages of the experiment (days 2–5), including increased lysozyme and bactericidal activity of blood serum, as well as a marked rise in circulating immune complexes, indicating substantial antigenic load. At later stages of the experiment (days 10–14), suppression of both humoral and cellular components of nonspecific resistance was detected, characterized by decreased lysozyme and bactericidal activity of blood serum, along with reduced phagocytic activity of neutrophils, phagocytic index, and phagocytic number. Administration of the complex preparation "Devivit Carnitine" under conditions of toxic liver injury contributed to correction of immune disturbances, as evidenced by enhancement of humoral nonspecific resistance, normalization of phagocytic parameters, and reduction in circulating immune complexes in rat blood.

It was demonstrated that "Devivit Carnitine" ensures restoration of immune system function at later stages of the experiment (day 14), as indicated by normalization of lysozyme and bactericidal activity of blood serum, as well as phagocytic activity parameters of neutrophils.

The obtained results confirm the feasibility of using complex preparations containing carnitine, vitamins E and B_{12}, methionine, selenium, and zinc for the correction of oxidative stress and immune disorders under conditions of toxic liver injury.

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The authors declare no conflict of interest.

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