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PROOXIDANT-ANTIOXIDANT PROFILE IN TISSUES OF RATS UNDER THE ACTION OF THIOSULFONATE ESTERS

N. M. LIUBAS[1]✉, R. Ya. ISKRA[2], B. I. KOTYK[1], N. Ya. MONKA[3], V. I. LUBENETS[3]

[1]Institute of Animal Biology, NAAS of Ukraine, Lviv, Ukraine;
[2]Ivan Franko Lviv National University, Lviv, Ukraine;
[3]Lviv Polytechnic National University, Lviv, Ukraine;
✉e-mail: n_lubas@ukr.net

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Thiosulfonates are characterized by a wide spectrum of biological activity and have effective antimicrobial, antithrombotic, antitumor and antiparasitic effects. However, the use of synthetic sulfur-containing compounds for therapeutic and preventive purposes requires the study of their effect on the protective mechanisms of maintaining homeostasis, the antioxidant status of the body in particular. The aim of the study was to estimate lipid peroxidation process and the state of the antioxidant system in the kidneys, spleen, brain, and muscles of rats under the influence of newly synthesized sulfur-containing compounds of S-alkyl esters of thiosulfonic acids S-ethyl-4-aminobenzenethiosulfonate (ETS), S-allyl-4-aminobenzenethiosulfonate (ATS) and S-allyl-4-acetylaminobenzenethiosulfonate (AATS). Male Wistar rats kept on a standard diet were divided into four groups of 5 animals each: I (control), II, III, IV (experimental). The animals of the control group received additional 0.5 ml of oil and the animals of the experimental groups 0.5 ml of oil solution of thiosulfonate esters once a day. The animals of II, III and IV groups were given ETS, ATS, AATS at the rate of 100 mg per kg of body weight. The lipid hydroperoxides (LPH), TBA-active products, GSH content and activity of SOD, catalase, glutathione peroxidase, glutathione reductase in tissue homogenates were determined. The multidirectional changes of the studied indicators after consumption of S-alkyl esters of thiosulfonic acids for 21 days have been identified and characterized indicating on different degree of inhibition or activation of LPO processes depending on the type of tissue and the structure of thiosulfonate ester.

K e y w o r d s: S-ethyl-4-aminobenzenethiosulfonate, S-allyl-4-aminobenzenethiosulfonate, S-allyl-4-acetylaminobenzenethiosulfonate, rat tissues, antioxidant system.

The health, productivity, and reproductive capacity of animals largely depend on the quality and balance of their feed. Storing feed with minimal losses for a long time depends on humidity, temperature, and chemical composition [1]. During long-term feed storage, complex biochemical processes can occur, resulting in their quality changes significantly. Fat is often destroyed due to oxidative processes, while the final products of oxidation (aldehydes, ketones, low-molecular fatty acids) can be toxic to animals. Antioxidants, both natural (tocopherols (vitamin E), ascorbic acid (vitamin C), flavones, etc.) and synthetic (butyloxytoluene (BOT) - ionol, santonin , diludin, dibut, phenozankislota, etc.) can be added to feeds to increase the stability of biologically active substances [2-4]. One can find functional sulfur-containing groups in many pharmaceuticals and natural products. Sulfur-containing compounds are natural antioxidants contained in garlic and onion extracts, including allicin, alliin, and others. They show antioxidant activity in *in vitro* [5-7] and *in vivo* [8-10] experiments. Researchers observed a positive effect after adding onion (*Allium cepa*), and garlic (*Allium sativum*) extracts to the diet of cows [11, 14], chickens [12], and pigs [13].

Compounds with -S-S-bonds (disulfide), which are widely used in many industries, deserve special attention. An example of this type of connection is disulfide bridges formed by cysteine residues during the modification of proteins *in vivo*, which play a significant role in forming and stabilizing the tertiary structure of proteins with peptides. Thiol-disulfide balance is maintained in the human body, thanks to

which the activity of hormones, enzymes, membrane permeability, and the blood coagulation process can be regulated [15].

Thiosulfinates (S-esters of thiosulfinic acids) and thiosulfonates (sulfonothioates or S-esters of thiosulfonic acids) are essential classes of disulfides. These are separate groups of disulfides in which one of the sulfur atoms is bonded to an oxygen atom. The sulfur atom in thiosulfinates is in an intermediate oxidation state (+4), and they are less stable biologically active compounds. An example is allicin, one of the main active substances of garlic phytoncides [16].

The first reports on thiosulfonates appeared as early as 1840, and publications on the comparison of the antimicrobial activity of thiosulfinates with thiosulfonates appeared in 1949. They are of particular interest as biologically active substances in pharmaceutical and agrochemistry, as well as reagents in organic synthesis [17]. It is known that synthetic esters of thiosulfonic acids exhibit a wide range of biological activity [18-23]. In particular, their antimicrobial activity often exceeds the effectiveness of their natural counterparts [18].

Thiosulfonates are highly reactive compounds that interact with nucleophiles, electrophiles, and radicals. Nucleophilic substitution reactions occur with the breaking of the -S-S- bond due to the redistribution of electron density in the thiosulfo group, which determines the direction of the nucleophilic attack [24-26].

Among the derivatives of thiosulfonic acids, which have a pronounced antimicrobial activity with relatively low toxicity, S-alkyl esters of 4-amino- and 4-acetylaminobenzenethiosulfonic acids are distinguished (LD50 = 2000 - 2500 mg/kg). Their high antimicrobial activity can be explained by the ability of these thiosulfonates not only to block SH- and NH- groups of enzymes and proteins, but also, similarly to sulfonamide drugs, they can exhibit antagonistic properties of n-aminobenzoic acid [26].

There is an assumption that the mechanism of antifungal activity of thiosulfonic acid esters may be associated with disruption of the cytoplasmic membrane, which leads to significant defects in the delivery of nutritional components to cells and the removal of vital metabolites from them. [6]. The interaction of S-ethyl-4-aminobenzenethiosulfonate (ETS) with the surface structures cell of the *Candida tropicalis* initiates deep structural rearrangements of the membranes, which leads to increased permeability and, possibly, suppression of its physiological functions [18].

The activation of LPO processes causes significant changes in the cell's metabolic processes and the structural and functional integrity of cell membranes. It is also accompanied by an imbalance of enzymatic and non-enzymatic components of the antioxidant defense system, the release of lysosomal enzymes, and changes in the transport of Ca^{2+} ions [27]. Oxidative stress can lead to the inactivation of membrane receptors, as well as enzymes such as glucose-6-phosphatases and Na/K-ATPases, which take a direct part in maintaining ion homeostasis of the cell. As a result of free radical reactions in mitochondria, both matrix enzymes and components of the respiratory chain can be damaged. Consequently, membranes damaged by LPO processes lose their energy potential, electroexcitatory function, control over ion flows, and mediator systems. There are pathological (inflammatory, neurodegenerative, malignant) changes in tissues, ultimately leading to cell death. [28].

However, esters of thiosulfonic acids, exhibiting antimicrobial [19], antiparasitic [23] and antitumor [22] effects, can also affect normal cells. When using antioxidants in feed, it is necessary to know whether they react with free radicals and neutralize them and what effect they have on the antioxidant system in various animal organs. The possible use of synthetic esters of thiosulfonic acids (thiosulfonates) for preventive or therapeutic purposes requires a thorough preliminary study of their effects on the animal body. One of the main criteria for assessing the possible use of new effective drugs to protect feed from oxidative processes, and damage by bacterial and fungal infections, is the study of their effect on the pro-oxidant-antioxidant profile in various tissues of healthy animals. Therefore, our research aimed to determine the effect of newly synthesized sulfur-containing compounds: S-ethyl-4-aminobenzenethiosulfonate (ETS), S-allyl-4-aminobenzenethiosulfonate (ATS), S-allyl-4-acetylaminobenzenethiosulfonate (AATS) introduced by the *per os* diet method on the condition pro/antioxidant system in tissues of healthy rats.

Materials and Methods

The object of the study was S-ethyl-4-aminobenzothiosulfonate (ETS), S-allyl-4-aminobenzothiosulfonate (ATS), and S-allyl-4-acetylaminobenzothiosulfonate (AATS). All compounds were

synthesized at the Department of Technology of Biologically Active Substances, Pharmacy and Biotechnology, Lviv Polytechnic National University, as per the protocol described in detail in [19, 29]. These thiosulfonates demonstrated the highest antioxidant activity in experiments *in vitro* [4]. These compounds may be potential substances to protect fodder from pathogens during its production and storage, so they were used for *in vivo* studies in the form of oil solutions added to animal fodder. Taking into account the results of our previous studies [4, 24] and literature data on the use of natural sulfur-containing compounds in experiments *in vivo* [8, 9], the daily dose of thiosulfonates was chosen 100 mg/kg body weight of rats for feeding animals with per os diet during the 21 days.

The research was conducted on male Wistar white laboratory rats, weighing 190–200 g, in compliance with the General Ethical Principles of Animal Experiments adopted by the First National Congress on Bioethics, used for research and other scientific purposes and consistent with the provisions of the European Convention for the Protection of Vertebrate Animals used for Experimental and other Scientific Purposes (Strasbourg, 1986). The animals were housed in a vivarium under the appropriate lighting conditions, temperature regime, and standard diet, which was balanced in proteins (not less than 8% crude protein), fats (not less than 2% crude fat), carbohydrates (not more than 30% crude fiber), vitamins, minerals. Rats were divided into four groups of 5 animals each: I (control), II, III, IV (experimental). All rats were clinically healthy. Control and experimental groups of animals were fed standard granulated food for laboratory rats. The animals of the control group were additionally given 0.5 ml of oil once a day. The animals of the experimental groups were given 0.5 ml of oil solution of thiosulfonate esters, at the rate of 100 mg per kg of body weight. In particular, the II group had ETS in their food (20.0 mg ETS/day per rat in the daily amount of feed, the average weight of rats in the group - 200 g); III – ATS (19.5 mg ATS/day per rat in the daily amount of feed, the average weight of animals in the group – 195.4 g); IV – AATS (19.3 mg AATS/day per rat in the daily amount of feed, the average weight of animals in the group – 193 g). For the preparation of oil solutions of synthesized compounds, oil of the "Oleina" brand was used (traditionally refined, deodorized, frozen; producer of PrJSC from II "DOEZ"; certified according to the DSTU 4492:2017 standard and according to the requirements of ISO 14024). Twice a day, the amount of food consumed was monitored in order to get the appropriate dose of thiosulfonates. Once every three days, the rats were weighed and the diet was adjusted to their weight (which increased as they grew).

The experiment lasted 21 days. During this time, thiosulfonate esters can affect the body of animals and cause certain changes that we can see and record, but not cause adaptation or addiction. At the end of the experiment, animals of all groups were decapitated under thiopental anesthesia. All procedures were performed at 4°C. The research materials were brain, kidney, spleen and skeletal muscle homogenates of rats, which were prepared on 0.05 M Tris HCl buffer with pH 7.4 at the ratio of 1 g tissue and 9 ml buffer (1:9, weight/volume) and then centrifuged for 15 min at 1000 g.

The lipid hydroperoxides (LHP) content in tissue homogenates was determined by the method based on protein precipitation with a solution of trichloroacetic acid and extraction of lipids with ethanol, followed by the interaction of the studied extracts with ammonium thiocyanate. The absorption value was measured after adding 0.2 ml of 20% ammonium thiocyanate solution at λ 480 nm. The content of lipid hydroperoxides was determined by the difference between the experimental sample and the control, but instead of the homogenate, 0.2 ml of bidistilled water was added, expressed in conditional units per 1 g of tissue [30].

The content of TBARS (thiobarbituric acid reactive substances) in tissue homogenates was studied using the color reaction of malondialdehyde (MDA) with thiobarbituric acid (TBA) as described by Korobeinikova. The optical density was measured at λ 535 nm and λ 580 nm to exclude the absorption of stained complexes of TBA substances of a non-lipid nature, the values were expressed as nmol of MDA per 1 g of tissue [31].

The activity of superoxide dismutase (SOD, EC 1.15.1.1.) was determined by the method, the principle of which is the reduction of nitrotetrazolium by superoxide radicals and was expressed in conventional units per 1 mg of protein [32]. The extinction was measured at a wavelength of λ 540 nm against water in a cuvette with an optical path length of 1 cm. In the control sample, distilled water was added instead of the supernatant. The activity of the enzyme was determined by the percentage of blocking the formation of hydrazine tetrazolium.

Catalase activity (CAT, EC 1.11.16) was determined using the ability of hydrogen peroxide to form a stable colored complex with molybdenum salts [33]. The amount of the colored complex formed in blank and test samples was determined at a wavelength of λ 410 nm. The intensity of the color of molybdenum peroxide compounds depends on the amount of H_2O_2 in the solution, i. e., on the activity of catalase in the sample, the values were expressed in mmol/min×mg of protein.

The rate of GSH oxidation determined the activity of glutathione peroxidase (GP, EC 1.11.1.9) before and after incubation with tertiary butyl hydroperoxide. The concentration of reduced glutathione was determined by the formation of a colored product - thionitrophenyl anion, the amount of which is directly proportionate to the number of SH-groups that reacted with 5,5′-dithiobis-2-nitrobenzoic acid. The absorbance was measured at λ 412 nm. Enzyme activity was expressed in nmol GSH/min×mg of protein [34].

The activity of glutathione reductase (GR, EC 1.6.4.2) was determined in a reaction environment containing 2.5 ml of 0.15 M phosphate buffer (pH 7.4), 0.2 ml of oxidized glutathione (7.5 mM), 0.1 ml tissue homogenate, 0.1 ml NADPH (1.2 mM). Enzyme activity was determined by the decrease in NADPH content at 37°C for 1 min on a spectrophotometer at λ 340 nm. GR activity was expressed in μmole of oxidized NADPH/min×mg protein [31].

The content of reduced glutathione (GSH) was determined by the level of thionitrophenyl anion formation due to the interaction of SH-groups of glutathione with 5,5′-dithiobis-2-nitrobenzoic acid (DTNBA). The absorption was measured spectrophotometrically at λ 412 nm. The content of GSH was expressed in mmol of GSH per gram of tissue [35].

Protein concentration was determined by the generally accepted Lowry method [36]. The absorbance values were measured on a spectrophotometer “Unico”1205 (USA).

The obtained digital data were processed statistically with Microsoft EXCEL program, using one-way analysis of variance (ANOVA). For each of the parameters, the reliability level was determined using three gradations of reliability levels: $*P < 0.05$; $**P < 0.01$; $***P < 0.001$. The differences were considered significant if $P \leq 0.05$.

Results and Discussion

Biological oxidation processes are at the center of cell metabolism. Under normal physiological conditions, LPO is at a low level. It is maintained thanks to the balance of pro- and antioxidants, which, in turn, are important components of the body’s homeostasis [23]. LPO is normally a vital link in the regulation of many membrane-dependent processes: the regulation of the permeability and transport of substances through the membrane, the regulation of membrane-associated enzymes and the lipid composition of membranes, the synthesis of prostaglandins, leukotrienes, thromboxanes, steroid hormones, cholesterol, and catecholamine metabolism [37]. However, increased synthesis of reactive oxygen species (ROS) and the free radical processes initiated by them lead to the occurrence of oxidative stress and disruption of the pro/antioxidant system in the body [28, 38].

The results of our research indicate that the content of the products of the intermediate stage of lipid peroxidation or LHP under the influence of various thiosulfonates probably decreased in the kidneys of rats of groups II, III and IV by 30, 33 and 35%, respectively. In addition, a tendency towards a decrease in their content was observed in the brain of animals of group II and the muscles of animals of group IV, as compared to the control (Fig. 1), which may have been caused by a decrease in the formation of LPO products or their breakdown due to the activation of the antioxidant system.

However, a probable increase in the content of LHP was observed in the spleen of animals of group III by 59%, in the brain of animals of groups III and IV by 300 and 155%, and by 13% in the muscles of rats of group II, under the influence of various thiosulfonate esters. Such an increase in the level of LHP indicates the activation of peroxidation of lipids in these tissues under the action of sulfonic acid esters.

The content of TBARS under the action of ATS and AATS in rats of III and IV groups probably decreased in the spleen - by 30 and 77% and in skeletal muscles - by 13 and 24%, respectively, which indicates inhibition of the final link of LPO (Fig. 2). At the same time, under the influence of ETS, the content of TBARS practically did not differ from the level of the control group in all the investigated tissues.

The analysis of the obtained results shows significant organ tissue differences in the degree of inhibition and activation of LPO processes under the influence of thiosulfonates. Thus, in the kidneys, a decrease in the content of LHP was observed, with unchanged amount of TBARS. In the spleen, brain and muscles there was an increase in the content of LHP due to the effects of ETS, ATS and AATS, with a decrease in the level of TBARS.

Peroxide damage to cell structures is prevented by the antioxidant system, which regulates lipid peroxidation reactions in membranes and controls the content of active forms of oxygen, free radicals, and end products of metabolism. In our previous studies, it has been proven that some S-alkyl esters of thiosulfonic acids possess antioxidant properties in *in vitro* and *in vivo* experiments [4, 39].

As a result of our research, it was established that, under the influence of thiosulfonates in the kidneys of rats, superoxide dismutase activity decreased, and in groups III and IV, a probable decrease of 16 and 27% was observed, respectively, while in the skeletal muscles of rats of group II, an increase in SOD activity by 12% was observed. No probable changes in the activity of this enzyme were detected in the spleen and brain (Fig. 3).

Superoxide dismutase activity is related to the intensity of LPO and depends on the number of in-

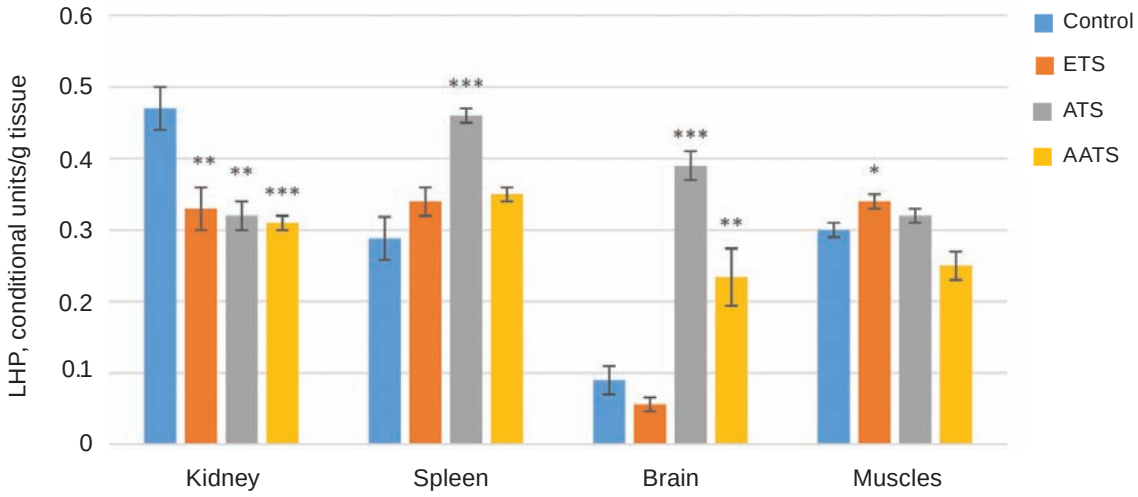

*Fig. 1. The content of LHP in tissues of rats under the influence of thiosulfonates, M ± m, n = 5; *P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001 (difference from control)*

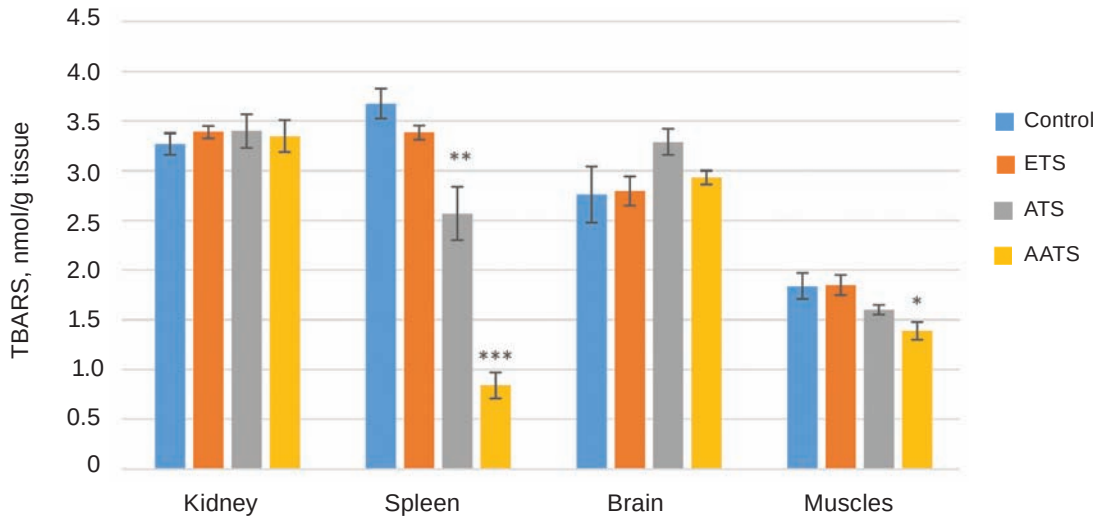

*Fig. 2. The content of TBARS in tissues of rats under the influence of thiosulfonates, M ± m, n = 5; *P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001 (difference from control)*

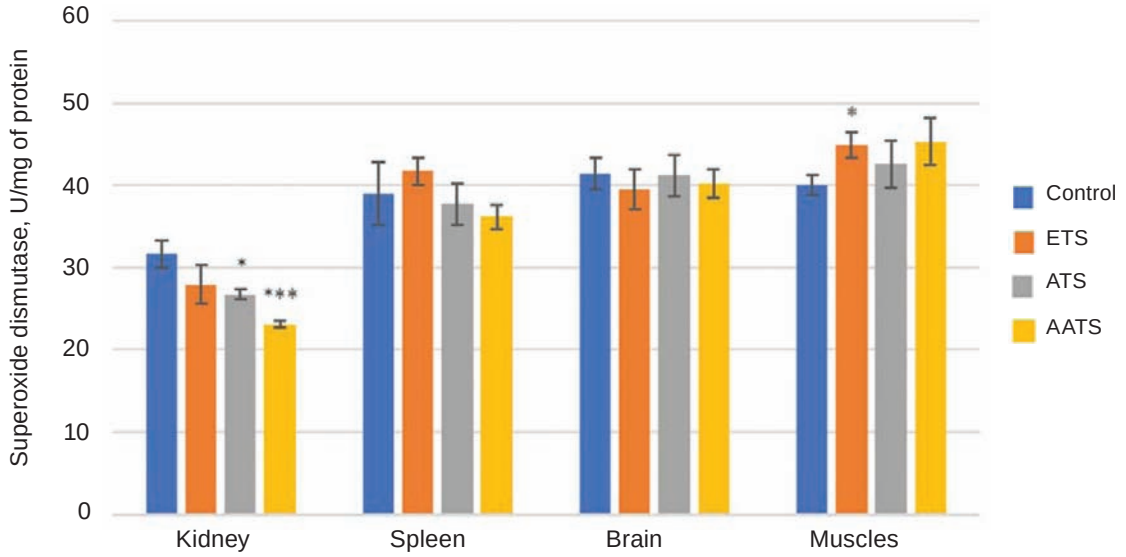

*Fig. 3. Activity of superoxide dismutase in tissues of rats under the influence of thiosulfonates, M ± m, n = 5; *P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001 (difference from control)*

termediates accumulated in the tissue. This confirms the results obtained by us of a decrease in SOD activity alongside a decrease in the content of LHP in the kidneys of rats of all experimental groups and an increase in enzyme activity in the muscles of animals of group II together with an increase in LHP.

$O_2^{\bullet-}$ formed because of the functioning of microsomal monooxygenases (cytochrome P-450 system), and xanthine oxidase is subject to dismutation under the action of SOD to hydrogen peroxide and molecular oxygen [40]. In turn, hydrogen peroxide degrades to molecular oxygen and water with the help of the heme-containing enzyme catalase [41]. However, the accumulation of hydrogen peroxide can lead to the reverse inhibition of SOD activity. This may cause a decrease in SOD activity in the kidneys while catalase activity remains unchanged.

A decrease in the overall dynamics of catalase activity in almost all experimental groups of rat tissues may be associated with a reduction in the generation of active forms of oxygen, particularly hydrogen peroxide, under the action of thiosulfonic acid esters (Fig. 4). Moreover, a probable decrease in catalase activity in the spleen and muscles of animals in groups III and IV correlates with a decrease in TBARS.

The formed $O_2^{\bullet-}$ and H_2O_2 induce peroxidation processes in tissue cells the main role in detoxification of which is played by glutathione peroxidase. The importance of this Se-containing enzyme lies in ensuring the inactivation of hydrogen peroxide and lipid hydroperoxides with the participation of reduced glutathione, for which the enzyme shows high specificity. Glutathione peroxidase protects tissue cells from the destructive effects of ROS. As a result of the conducted research, we can see that, under the influence of thiosulfonates, a probable decrease in the activity of GP was observed in the kidneys of groups II, III, and IV (by 23, 30, and 27%, respectively) and muscles of groups III and IV (by 23 and 25%, respectively), which may indicate inhibition of the activity of the glutathione link of antioxidant protection in these tissues under the influence of the studied substances (Fig. 5). Since glutathione peroxidase reduces organic hydroperoxides, a decrease in their content in the kidneys of rats of all experimental groups, as well as in the muscles of animals of group IV, is correlated with a decrease in GP activity. The results obtained may indicate a certain inhibition of the detoxification function of the kidneys under the action of thiosulfonates, since the glutathione system is known to take an active part in the processes of xenobiotic detoxification [42].

Since glutathione peroxidase reduces organic hydroperoxides, a decrease in their content in the kidneys of rats of all experimental groups and in the muscles of animals of group IV is correlated with a reduction of GP activity.

At the same time, an increase in the activity of GP in the brain and muscles of rats of group II (by 90 and 17%, respectively) under the influence of ETS, and in the spleen of rats of group IV (by 48%)

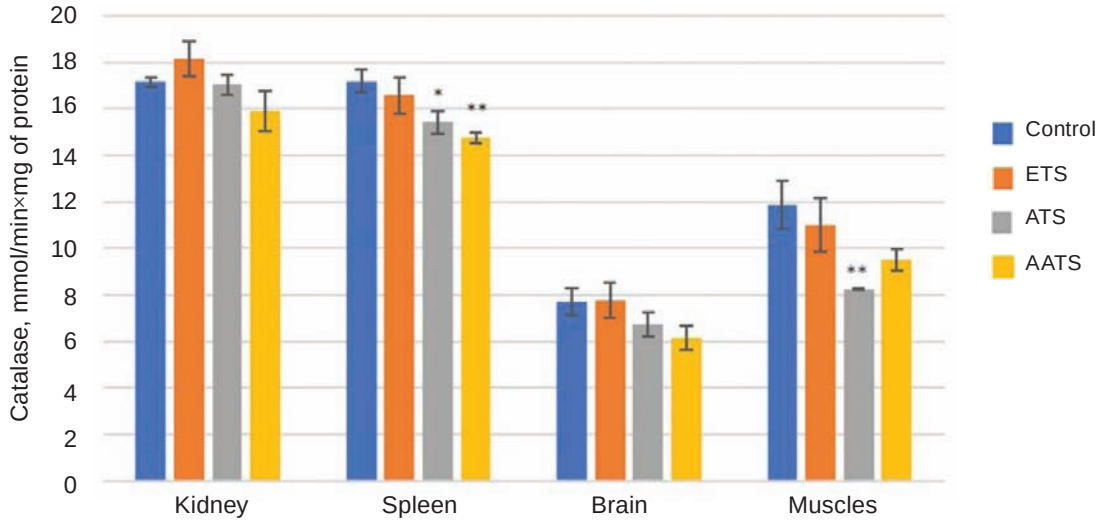

*Fig. 4. Catalase activity in tissues of rats under the influence of thiosulfonates, M ± m, n = 5; *P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001 (difference from control)*

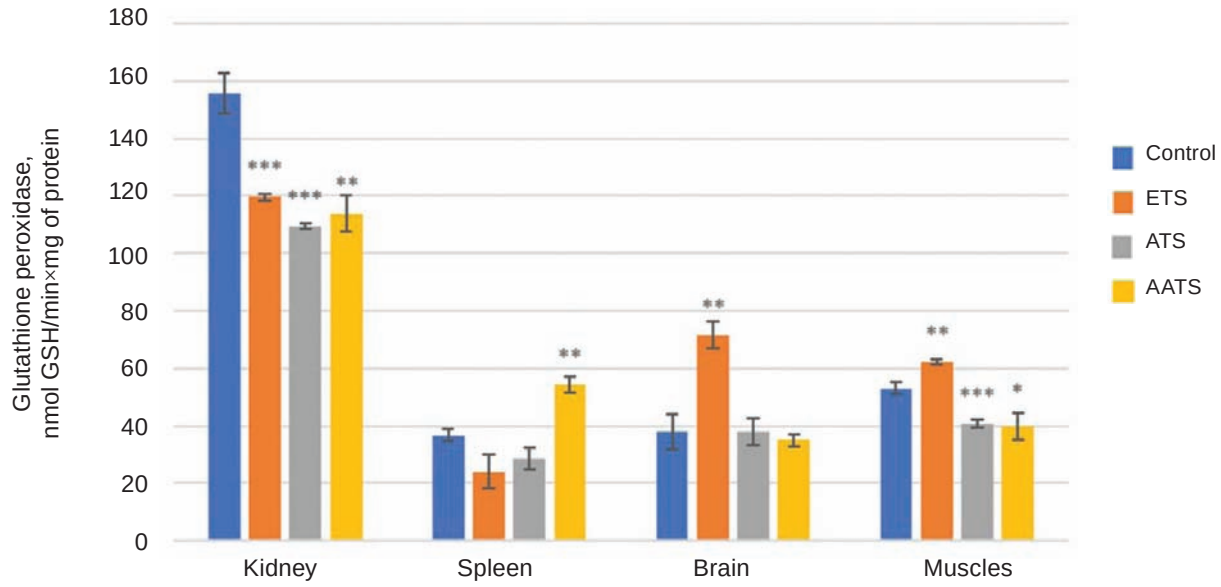

*Fig. 5. Glutathione peroxidase activity in tissues of rats under the influence of thiosulfonates, M ± m, n = 5;*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001 (difference from control)*

under the influence of AATS, was established, compared to the activity of the enzyme in the tissues of animals of the control group (Fig. 5). GP activation is possible only under the condition of maintaining a sufficiently high level of intracellular GSH, which is not only a substrate for reactions, but also plays the role of a factor necessary for the constant restoration of selenol groups located in the catalytic center of the enzyme, which are oxidized in the process of the glutathione peroxidase reaction [42].

Reduced glutathione is the most important component of the antioxidant system, which is rapidly mobilized in case of increased peroxide content and reduces it in a reaction accompanied by the formation of oxidized glutathione, which is toxic to cells [43]. In our research, we observed an increase in the content of reduced glutathione in the kidneys of rats in experimental groups II, III, IV (by 19, 44, and 19%, respectively), compared to its content in the tissues of rats of the control group (Fig. 6).

The high content of GSH in the kidney tissue, as well as the increase in its level in the experimental groups compared to the control, can probably be associated with the intensification of

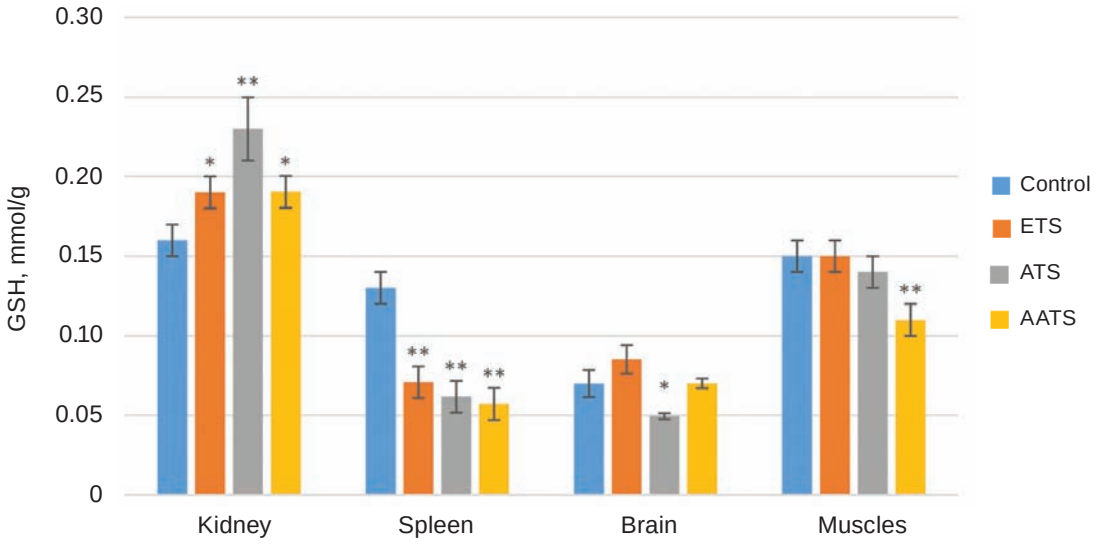

*Fig. 6. The content of GSH in tissues of rats fed with thiosulfonates, M ± m, n = 5; *P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001 (difference from control)*

its synthesis and the formation of an excess due to the reduced activity of GP. In general, the increase in GSH content in the kidneys depends on processes like de novo synthesis with the participation of γ-glutamylcysteinesynthetase and excretion into the extracellular space, as well as regeneration due to the reduction of oxidized glutathione and consumption to neutralize H_2O_2 and secondary peroxidation products. It should be noted that 80-90% of glutathione is taken up by the kidneys due to the extremely high activity of γ-glutamylcysteinesynthetase in them, while in other tissues the turnover of glutathione occurs at a low rate [43].

A probable decrease in the content of GSH was established in the spleen of rats of all experimental groups (by 46, 54 and 54%, respectively), in the brain of experimental group III (by 29%) and in the muscles of animals of experimental group IV (by 27%). A decrease in the content of GSH can be associated with both the intensification of LPO processes in tissues and its increased use, as well as the acceleration of glutathione catabolism [43]. It is of interest that the decrease in the level of intracellular GSH in the spleen under the influence of thiosulfonic acids occurs against the background of a decrease in HP activity in groups II and III, but an increase in group IV. Obviously, this is due to depletion of the GSH pool, to intensive use by glutathione peroxidase, and possibly glutathione transferase, while in the muscles of animals of group IV, the low content of GSH leads to lower activity of GP.

Glutathione reductase maintains physiological levels of reduced glutathione in cells. The decrease in GR activity in the kidneys (by 28 and 30%) and spleen (by 26%) of animals of group III, as well as the brain of group IV (by 32%) compared to the control (Fig. 7), can be explained by the depletion of the enzyme in the reactions of the reduction of the disulfide bond of oxidized glutathione GSSG to its sulfhydryl form GSH. It is known that glutathione reductase is a NADPH-dependent enzyme, the activity of which is inhibited in case of accumulation of the oxidized form of the nucleotide (NADP). Therefore, the reason for the decrease in glutathione reductase activity may be a decrease in the content of NADH and NADPH, caused by a violation of the functioning of mitochondria. Since the catalytic activity of GR is determined by the presence of NADPH, the obtained results may indicate the unequal influence of ETS, ATS, AATS on the intensity of the formation of reducing equivalents in the tissues of rats of the experimental groups.

To sum up, the research results indicate that the newly synthesized disulfide compounds S-ethyl-4-aminobenzenethiosulfonate, S-allyl-4-aminobenzenethiosulfonate and S-allyl-4-acetylaminobenzenethiosulfonate have different effects on the state of the pro/antioxidant system in the studied tissues of the rats. It was found that all the studied compounds reduced the content of ROS products in the kidneys and spleen. In particular, a decrease in the content of hydroperoxides in the kidneys was accompanied by a decrease in the activity of SOD, GP and GR, but

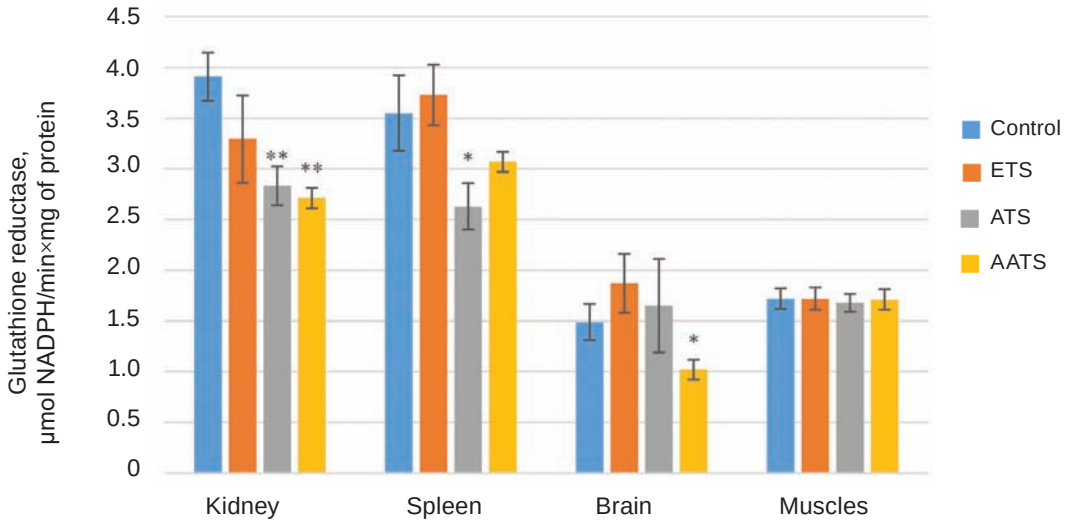

*Fig. 7. Glutathione reductase activity in tissues of rats fed with thiosulfonic acid esters at a concentration of 100 mg/kg of body weight, M ± m, n = 5; *P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001 (difference from control)*

an increase in the level of reduced glutathione. In the spleen, a decrease in the content of TBA-active products was accompanied by a decrease in catalase activity and the content of GSH. In the muscles, under the action of AATS, a decrease in the content of ROS products occurred against the background of a decrease in the activity of GSH and the content of GSH, under the action of ETS, ATS - at the control level. In the brain, a decrease in the content of ROS products was recorded only under the action of ETS. At the same time, the action of ATS caused an increase in the content of lipid hydroperoxides in the spleen and brain. This may be due to both the specificity and physiological characteristics of these tissues and the biochemical features of the studied compounds. Thiosulfonic acid esters at a concentration of 100 mg/kg can cause both inhibition of LPO processes in tissues and their activation. Based on the results obtained, it is impossible to clearly distinguish a group of esters with prooxidant or antioxidant properties. It is advisable in the future to conduct more extensive studies of these compounds in other concentrations in order to identify their optimal effect on body tissues. The revealed biological effects of the studied thiosulfonates can serve as a basis for the creation of antioxidant, antimicrobial, antifungal additives to feed.

Conflct of interest. Authors have completed the Unified Conflicts of Interest form at http://ukrbiochemjournal.org/wp-content/uploads/2018/12/coi_disclosure.pdf and declare no conflict of interest.

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ПРООКСИДАНТНО-АНТИОКСИДАНТНИЙ ПРОФІЛЬ У ТКАНИНАХ ЩУРІВ ЗА ДІЇ ЕСТЕРІВ ТІОСУЛЬФОНАТІВ

Н. М. Любас[1]✉, Р. Я. Іскра[2], Б. І. Котик[1], Н. Я. Монька[3], В. І. Лубенець[3]

[1]Інститут біології тварин НААН України, Львів;
[2]Львівський національний університет імені Івана Франка, Україна;
[3]Національний університет «Львівська політехніка», Україна;
✉e-mail: n_lubas@ukr.net

Тіосульфонати характеризуються широким спектром біологічної активності, мають ефективну антимікробну, антитромботичну, протипухлинну та протипаразитарну дію. Однак використання синтетичних сірковмісних сполук із лікувально-профілактичною метою потребує вивчення їх впливу на захисні механізми підтримання гомеостазу, зокрема, на антиоксидантний статус організму. Метою роботи була оцінка процесів пероксидного окислення ліпідів та стану антиоксидантної системи в нирках,

селезінці, головному мозку та м'язах щурів за дії нових, синтезованих сірковмісних сполук S-алкілових естерів тіосульфокислот: S-етил-4-амінобензентіосульфонату (ETS), S-аліл-4-амінобензентіосульфонату (ATS) та S-аліл-4-ацетиламінобензентіосульфонату (AATS). Щурів-самців лінії Вістар, які утримувалися на стандартному раціоні, було поділено на чотири групи по 5 тварин у кожній: I (контрольна), II, III, IV (дослідні). Тварини контрольної групи отримували додатково 0,5 мл олії, а тварини дослідних груп – по 0,5 мл олійних розчинів тіосульфонатів один раз на добу. Тваринам II, III та IV груп до добової кількості корму додавали ETS, ATS, AATS з розрахунку 100 мг/кг маси тіла відповідно. У гомогенатах тканин визначали вміст гідропероксидів ліпідів, ТБК-активних продуктів, відновленого глутатіону та активності СОД, каталази, глутатіонпероксидази, глутатіонредуктази. Виявлено різноспрямовані зміни досліджуваних показників після споживання S-алкілових естерів тіосульфокислот протягом 21 доби, що свідчило про різний ступінь інгібування та активації процесів ПОЛ, залежно від типу тканини та структури тіосульфонату.

Ключові слова: S-етил-4-амінобензентіосульфонат, S-аліл-4-амінобензентіосульфонат, S-аліл-4-ацетиламінобензентіосульфонат, тканини щурів, антиоксидантна система.

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