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ALTERATIONS OF LACTATE DEHYDROGENASE ACTIVITY IN THE SKELETAL MUSCLES AND CARDIAC TISSUE OF SALMONID AFTER DISINFECTING PROCEDURE WITH CHLORAMINE-T

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*Chloramine-T is a widely used disinfectant for the treatment of gill diseases of fish in freshwater and can be toxic to fish. Therefore, the current study aimed to examine the safety of this disinfecting product (as it has been attracting researchers' attention for applying in aquatic animals) for fish health using markers of aerobic and anaerobic capacity (i.e. lactate dehydrogenase activity) in the skeletal muscle and cardiac tissues of rainbow trout (*Oncorhynchus mykiss* Walbaum), grayling (*Thymallus thymallus* Linck), and brown trout (*Salmo trutta m. fario*). Twenty-two clinically healthy rainbow trout, twenty-one brown trout, and twenty graylings were exposed to Chloramine-T in a final concentration of 9 mg per L. The Control group of fish was handled in the same way as the exposed groups. Fish were bathed for 20 min and repeated three times every 3 days. Two days after the last bathing fish were sampled. In the skeletal muscle tissue, LDH activity was decreased in the rainbow trout and grayling after disinfection by Chloramine-T compared to the unhandled controls. On the other hand, LDH activity was increased in the skeletal muscle tissue of brown trout. In the cardiac tissue, disinfection by Chloramine-T caused the decrease of LDH activity in rainbow trout, brown trout, and grayling. Moreover, in unhandled controls, LDH activity in the cardiac tissue was higher by 107.5 % ($p = 0.000$) in brown trout and by 57.6 % ($p = 0.001$) in the grayling compared to the values obtained in skeletal muscles. The present investigation demonstrates the alterations in LDH activity in the skeletal muscles and cardiac tissue after the disinfecting procedure with Chloramine-T in dose 9 mg per L. Although, after disinfection, the rainbow trout, brown trout, and grayling showed decreased trends of aerobic responses in the cardiac tissue indicating adaptive response against the Chloramine-T toxicity. Similar trends were observed in the skeletal muscles of rainbow trout and grayling. On the other hand, LDH activity in the skeletal muscles of brown trout after the disinfecting procedure with Chloramine-T was increased. Therefore, these biochemical parameters can be considered as indicators for the assessment of disinfecting effects, although further studies are required for investigating the mechanism involved in this pattern.*

Keywords: rainbow trout (*Oncorhynchus mykiss* Walbaum), brown trout (*Salmo trutta m. fario*), grayling (*Thymallus thymallus* Linck), muscles, cardiac tissue, lactate dehydrogenase, disinfection

The active chlorine compounds are characterized by major differences in their chlorinating and/or oxidizing activity. The hypochlorous acid (HOCl) is the strongest

while organic chloramines are the weakest one [12]. Chloramine T and monochloramine (NH_2Cl) are active chlorine compounds and well-known biocides. Chloramine T has stronger oxidative activity than monochloramine, which is a smaller and more lipophilic molecule [1, 11]. The application of chloramines as anti-infectives is advisable because they can efficiently kill pathogens (bacteria, fungi, viruses, protozoa). On the other hand, they possess additional beneficial properties, i.e. destruction of toxins, degradation of biofilms, and anticoagulative and anti-inflammatory activities [12].

Chloramine-T is an organic N-chloramine with a slow-release mechanism that involves the production of aqueous free-chlorine ($\text{HOCl} + \text{OCl}^-$) species that are quite toxic to aquatic life [14, 17]. Organic chloramines in general are thought to be considerably less toxic to aquatic life than the inorganic chloramines monochloramine (NH_2Cl), dichloramine (NHCl_2), and trichloramine (NCl_3). Inorganic chloramines usually exist as monochloramine in aqueous solutions [17]. The kinetics of chloramine hydrolysis is slow and rate-limiting compared to those where free chlorine oxidizes another organic amine or some other organic-N or non-N compound. Usually, the reaction produces a compound much less toxic than free chlorine [13, 14]. Under many circumstances, chloramines also lose chlorine through a direct chlorination mechanism, i.e. no free-chlorine species is involved as an intermediate [17].

The toxicity of chloramine-T has been tested in a variety of fish species by many authors, as well as in a variety of freshwater and marine life [2-5, 9, 16, 17]. Chloramine-T 96-h LC_{50} values were 1.8 mg/L for channel catfish, 1.9 mg/L for rainbow trout, and 2.8 mg/L for striped bass ($\text{pH} = 6.5$) [17]. The channel catfish, rainbow trout, and striped bass were similarly sensitive when tested in soft acidic water [3, 4]. The 96-h LC_{50} values in waters of $\text{pH} 7.5$ for channel catfish, rainbow trout, striped bass, and fat-head minnow, and in the water of $\text{pH} 7.7$ for harlequin fish were 3.8, 2.8, 6.3, 7.3, and 60 mg/L, respectively [17]. The 24-h LC_{50} for chloramine-T was determined under a variety of conditions ranging from the low of 2.8 mg/L for rainbow trout to a high of 120 mg/L for harlequin fish in soft alkaline water ($\text{pH} 8.0$) [17]. In spotted sea trout eggs and larvae, 48-hour medium tolerance limits were 14.14, 0.57, and 5.75 ppm [50.20, 2.0, and 20.4 μM] for two-hour- and ten-hour-old eggs, and one-hour post-hatch larvae, respectively. Exposure of larval lobsters to 1.0 mg/L [3.6 μM] chloramine-T resulted in a reduction in dry weight increase, standard respiration rate, growth, and metabolic activity [7].

In intermittent exposures of rainbow trout to chloramine-T at the therapeutic concentration (10 mg/L [36 μM]), the fish exhibited behaviors that were consistent with respiratory distress (i.e., fish crowing at the surface and appeared to hyperventilate) as described in the study of Powell and Perry (1996) [16]. Additional studies were performed to investigate the impact of a single exposure to chloramine-T. One-hour exposures of rainbow trout to chloramine-T (9 or 2 mg/L [30 or 7 μM]) or p-TSA (9 mg/L [50 μM]) through catheterized dorsal aorta resulted in a significant increase in both ventilation rates and PCO_2 levels. Both parameters returned to baseline levels within 90 minutes of removal from chloramine-T [7]. In our previous study [27], Chloramine-T disinfection markedly decreases the level of the aldehydic and ketonic derivatives of oxidatively modified proteins, and aminotransferase activity only in rainbow trout liver, and their elevation is a compensatory mechanism to impaired metabolism. No significant changes were found in oxidative stress biomarkers between untreated controls and Chloramine-treated brown trout. For grayling, Chloramine-T exposure caused a significant elevation in the levels of oxidative stress biomarkers in the liver. Increased levels of aldehydic and ketonic derivatives of oxidatively modified proteins could modify lactate and pyruvate levels, aminotransferase, and lactate dehydrogenase activities, princi-

pally causing increased enzyme activity due to oxidative stress in the liver of chloramine-exposed fish [27].

In this study, we have tested the use of Chloramine-T in dose 9 mg per L in disinfecting procedures in the rainbow trout (*Oncorhynchus mykiss*), brown trout (*Salmo trutta m. fario*), and grayling (*Thymallus thymallus* Linck). To observe the effects of Chloramine-T at the therapeutic concentration, rainbow trout, grayling, and brown trout, which are some of the most important salmonids in the human diet was studied. This study opens a new perspective on the investigation of toxic effects of Chloramine-T, mainly concerning the biochemical parameters in various tissues of salmonids. Thus, the purpose of the current study was to evaluate the safety of this disinfecting product (it has been attracting researchers' attention for application in aquatic animals) for fish health using markers of aerobic and anaerobic capacity (i.e. lactate dehydrogenase activity) in the skeletal muscle and cardiac tissues of rainbow trout, grayling, and brown trout.

Materials and methods. Fish. Twenty-two clinically healthy rainbow trout (*Oncorhynchus mykiss*), twenty-one brown trout (*Salmo trutta m. fario*), and twenty grayling (*Thymallus thymallus*) were used in the experiments. The study was carried out in the Department of Salmonid Research, Stanisław Sakowicz Inland Fisheries Institute (Rutki, Poland). Experiments were performed at a water temperature of $16 \pm 2^\circ\text{C}$ and the pH was 7.5. The dissolved oxygen level was about 12 ppm with an additional oxygen supply. All biochemical assays were carried out at the Department of Zoology and Animal Physiology, Institute of Biology and Earth Sciences, Pomeranian University in Słupsk (Poland).

The fish were divided into two groups and held in 250-L square tanks (70 fish per tank) supplied with the same water as during the acclimation period (2 days). In the disinfectant exposure, grayling ($n = 11$), rainbow trout ($n = 11$) and brown trout ($n = 10$) were exposed to Chloramine-T in final concentration 9 mg per L. Control untreated group of grayling ($n = 11$), rainbow trout ($n = 10$), and brown trout ($n = 10$) were handled in the same way as Chloramine-T exposed groups. Fish were bathed for 20 min and repeated three times every 3 days. Two days after the last bathing, fish were sampled. Fish were not anesthetized before tissue sampling.

Tissue isolation. Tissue samples (skeletal muscles and cardiac tissue) were removed from fish after decapitation. One fish was used for each homogenate preparation. Briefly, tissues were excised, weighed, and washed in the ice-cold buffer. The minced tissue was rinsed clear of blood with cold isolation buffer and homogenized in a homogenizator H500 with a motor-driven pestle (Pol-EkoAparatura, Poland) on ice. The isolation buffer contained 100 mM Tris-HCl; pH of 7.2 was adjusted with HCl.

Analytical methods. All enzymatic assays were carried out at $25 \pm 0.5^\circ\text{C}$ using a Specol 11 spectrophotometer (Carl Zeiss Jena, Germany). The enzymatic reactions were started by adding the homogenate suspension. The specific assay conditions are presented subsequently. Each sample was analyzed in triplicate. The protein concentration in each sample was determined according to Bradford (1976) using bovine serum albumin as a standard [6].

Assay of LDH (E.C. 1.1.1.27) activity. The colorimetric method of Sevela and Tovarek (1959) was used for the determination of LDH activity. LDH activity was expressed as $\mu\text{mol pyruvate per hour per mg of protein}$ [18].

Statistical analysis. The mean $\pm$ S.E.M. values were calculated for each group to determine the significance of the intergroup difference. All variables were tested for normal distribution using the Kolmogorov-Smirnov and Lilliefors test ($p > 0.05$). Significance of differences between biomarkers levels (significance level, $p < 0.05$) was exam-

ined using the Mann-Whitney *U* test. Correlations between parameters at the set significance level were evaluated using Spearman's correlation analysis [28]. All statistical calculation was performed on separate data from each individual with STATISTICA 13.3 (StatSoft, Poland).

Results. Lactate dehydrogenase activity in the skeletal muscle and cardiac tissues of the rainbow trout, grayling, and brown trout disinfected by Chloramine-T is presented in Fig. 1.

Fig. 1. Lactate dehydrogenase (LDH) activity in the skeletal muscle and cardiac tissues the rainbow trout (*Oncorhynchus mykiss* Walbaum), brown trout (*Salmo trutta m. fario*), and grayling (*Thymallus thymallus*) disinfected by Chloramine-T.

Data are represented as mean $\pm$ S.E.M.

* – the significant difference was shown as $p < 0.05$ when compared disinfected group ($n=10$) and unhandled group ($n=10$) values.

LDH is the terminal enzyme of anaerobic glycolysis and is used as an indicator of anaerobic capacity [19]. Changes in LDH activity may signal alterations in protein and carbohydrate metabolism in disinfected fish. LDH activity, likewise ALT and AST in the cardiac tissue, was significantly decreased after Chloramine-T exposure (Fig. 1). In the skeletal muscle tissue, LDH activity was decreased in the rainbow trout (28.61 ± 2.71 vs. 42.52 ± 4.07 $\mu\text{mol} \cdot \text{h}^{-1} \cdot \text{mg}^{-1}$ protein) and grayling (14.87 ± 1.81 vs. 16.53 ± 0.91 $\mu\text{mol} \cdot \text{h}^{-1} \cdot \text{mg}^{-1}$ protein) after disinfection by Chloramine-T compared to the unhandled controls. On the other hand, LDH activity was increased (24.08 ± 3.40 vs. 15.26 ± 1.51 $\mu\text{mol} \cdot \text{h}^{-1} \cdot \text{mg}^{-1}$ protein) in the skeletal muscle tissue of brown trout. In the cardiac tissue, disinfection by Chloramine-T caused the decrease of LDH activity in rainbow trout (30.87 ± 1.72 vs. 39.35 ± 1.99 $\mu\text{mol} \cdot \text{h}^{-1} \cdot \text{mg}^{-1}$ protein), brown trout (28.74 ± 1.46 vs. 31.67 ± 0.86 $\mu\text{mol} \cdot \text{h}^{-1} \cdot \text{mg}^{-1}$ protein), and grayling (19.27 ± 0.82 vs. 26.05 ± 1.11 $\mu\text{mol} \cdot \text{h}^{-1} \cdot \text{mg}^{-1}$ protein) (Fig. 1). Moreover, in unhandled controls, LDH activity in the cardiac tissue was higher by 107.5% ($p = 0.000$) in brown trout and by 57.6% ($p = 0.001$) in the grayling compared to the values obtained in skeletal muscles.

The statistically significant decreased LDH activity was recorded by 33% ($p = 0.001$) in the skeletal muscles of rainbow trout and by 26% ($p = 0.000$) in cardiac tissue of grayling, and a similar pattern was also observed in cardiac tissue of rainbow trout

and brown trout, but these changes were non-significant. In the cardiac tissue of grayling, disinfection by Chloramine-T caused the decrease of LDH activity by 26% ($p = 0.001$). The recovery pattern in case of LDH activity in the skeletal muscles after disinfection by Chloramine-T was in the following order: brown trout (58%) > rainbow trout (32%) > grayling (10%). In the case of cardiac tissue, the recovery pattern of LDH activity after disinfection by Chloramine-T was in the following order: grayling (10%) > rainbow trout (22%) > brown trout (9%).

Like transaminases, LDH activity was also reduced during disinfection as a compensatory response to overcome the stress. Reduced activity of LDH during disinfecting measurement by Chloramine-T may be due to lower synthesis rate of lactate and pyruvate and less energy demand as fishes are in the recovery period after disinfection. Moreover, the highest LDH activity was recorded in the skeletal muscle tissue of brown trout and rainbow trout. Indeed, the LDH activity in the white muscles of fish is related mainly to its involvement in anaerobic glycolysis [19]. This process is the main energy supply of the white muscle during intensive contractions [8]. With age and body mass gain, the rate of parr anaerobic metabolism increases. It was shown that the level of LDH activity reflects the degree of physical activity in fish and their swimming characteristics. Many fish species were found to have an age-related and size-related increase in the intensity of anaerobic energy metabolism, as well as in the activity of LDH and other glycolytic enzymes [19]. Atlantic salmon parr at age 1+, 2+, and 3+ are characterized by high physical activity due to increasing the energy supply for swimming activity as they inhabit areas with high current velocity and have to actively resist the current [8].

The initial decrease of LDH activity in the skeletal muscles and cardiac tissue observed in our experiment indicated aerobic condition at the cellular level induced by the disinfection by Chloramine-T. Since we measured LDH activity in other tissues such as skeletal muscles and cardiac tissue, we suggest their possible targets for induced aerobic metabolism by this particular chemical exposure. The effects of disinfection by Chloramine-T using oxidative stress biomarkers (levels of 2-thiobarbituric acid reactive substances and derivatives of oxidatively modified proteins) and biochemical enzymes' activity [alanine- and aspartate aminotransferases (ALT and AST), lactate dehydrogenase (LDH)] were assessed in the muscle tissue of rainbow trout [21]. Our results showed that Chloramine-T bathing caused a decrease in the lipid peroxidation as well as ALT and AST activity and a significant decrease in LDH activity compared to controls. Chloramine-T markedly affected lactate and pyruvate metabolism and resulted in to decrease in LDH activity. The correlative analysis revealed that the lipid peroxidation level is correlated with ALT and AST activity in the muscle tissue of the unhandled control group. In the muscle tissue of trout disinfected by Chloramine-T, LDH activity is correlated positively with ALT and AST activity. Thus, the skeletal muscles of fish play an important role in the processing of lactate through the gluconeogenic and glycogenic pathways including greater potential for biosynthesis [21, 22].

In our previous study [20-27], we have assessed the influence of chloramine-T on oxidative stress biomarkers and metabolic alterations in various tissues of some salmonids. Chloramine-T bathing markedly decreases aldehydic and ketonic derivatives of oxidative protein, and aminotransferases activity only in rainbow trout liver, and their elevation is a compensatory mechanism to impaired metabolism. No significant changes were found in oxidative stress biomarkers between control and chloramine-treated brown trout. For grayling, Chloramine-T exposure caused a significant elevation in the levels of severe oxidative stress biomarkers in the liver. Increased aldehydic and ketonic derivatives of oxidative protein could modify lactate and pyruvate levels, aminotrans-

ferases, and lactate dehydrogenase activities, principally causing increased enzyme activity due to oxidative stress in the liver of chloramine-exposed fish [27]. Our results also showed that chloramine-T bathing markedly increases aldehydic and ketonic derivatives of oxidative protein in hepatic tissue, while a significant decrease of carbonyl derivatives in cardiac tissue of grayling was observed [20, 23]. In the muscle tissue of grayling, chloramine-T bathing markedly decreases lipid peroxidation with a non-significant decrease of aldehydic and ketonic derivatives of oxidative proteins. However, reduced lipid peroxidation results in a decrease in total antioxidant capacity. Moreover, decreased lipid peroxidation level causes a decrease of aldehydic and ketonic derivatives of oxidatively modified proteins [24]. Our results also showed that Chloramine-T non-significantly decreases lipid peroxidation as well as aldehydic and ketonic derivatives of oxidative proteins in the gills of grayling. No statistically significant alterations in the activities of antioxidant defenses instead catalase and superoxide dismutase activity in the gill tissue of grayling disinfected by Chloramine-T were noted [22].

The effects of disinfection by Chloramine-T on the muscle tissue of grayling using oxidative stress biomarkers and antioxidant defense (superoxide dismutase, catalase, glutathione reductase, glutathione peroxidase, total antioxidant capacity) was studied in our previous study [26]. Our results showed that Chloramine-T bathing markedly decrease lipid peroxidation with a non-significant decrease of aldehydic and ketonic derivatives of oxidatively modified proteins. However, reduced lipid peroxidation results in a decrease in total antioxidant capacity. Moreover, decreased lipid peroxidation level causes a decrease of aldehydic and ketonic derivatives of oxidatively modified proteins. Fish developed tissue-specific enzyme responses, such as a decrease in superoxide dismutase and catalase activity as well as total antioxidant capacity in muscle tissue with a decrease of lipid peroxidation as a response to the Chloramine-T disinfection. Correlative analysis has revealed positive correlations between oxidative stress biomarkers (aldehydic and ketonic derivatives of oxidatively modified proteins, TBARS as a marker of lipid peroxidation) and antioxidant defenses [26].

The time-course stress responses in the liver of rainbow trout exposed to cuprous chloride (CuCl) and cupric chloride (CuCl_2) were examined by Elia and co-workers (2017). They noted that the decrease in LDH activity during the first days of post-treatment was relatively less marked at day 9, suggesting a decline in glycolytic activity. The marked increase after treatment with both copper species indicates that metal exposure induced a hypoxic condition, shifting from aerobic to anaerobic metabolism [10]. Also, Orrego and co-workers (2011) have used the anaerobic and aerobic metabolic capacities in rainbow trout livers for investigation whether pulse exposure to Chilean pulp and paper mill effluent solid-phase extracted (SPE) extracts *via* intraperitoneal injection (IP), would result in changes in the activities of the respiratory metabolic enzymes citrate synthase (CS) and LDH. It also investigated if an alteration in liver metabolic capacity influenced the liver detoxification processes and estrogenic effects. Their study showed that intraperitoneal injection of pulp and paper mill effluent extracts affected the anaerobic and aerobic metabolic capacities in rainbow trout livers, but this metabolic alteration did not affect detoxification capability or estrogenic effect. Besides, a comparison of those enzymatic activities with fish IP injected with SPE extracts of two model effluents coming from industries that process 100% different types of feed-stocks (softwood, SW, and hardwood, HW) was also evaluated. Initial induction of the anaerobic metabolism (increase in LDH enzymatic activity) was detected in all Chilean pulp mill effluent extracts evaluated, contrary to the initial unaltered aerobic metabolism (CS enzymatic activity) observed [15].

Conclusions. The present investigation demonstrates the alterations in LDH activity in the skeletal muscles and cardiac tissue after the disinfecting procedure with Chloramine-T in dose 9 mg per L. Although, after disinfection, the rainbow trout, brown trout, and grayling showed decreased trends of aerobic responses in the cardiac tissue indicating adaptive response against the Chloramine-T toxicity. Similar trends were observed in the skeletal muscles of rainbow trout and grayling. On the other hand, LDH activity in the skeletal muscles of brown trout after the disinfecting procedure with Chloramine-T increased. Therefore, these biochemical parameters can be considered as indicators for the assessment of disinfecting effects, although further studies are required for investigating the mechanism involved in this pattern.

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ИЗМЕНЕНИЕ АКТИВНОСТИ ЛАКТАТДЕГИДРОГЕНАЗЫ В СКЕЛЕТНЫХ МЫШЦАХ И СЕРДЕЧНОЙ ТКАНИ НЕКОТОРЫХ ЛОСОСЕВЫХ ПОСЛЕ ПРОЦЕДУРЫ ДЕЗИНФЕКЦИИ ХЛОРАМИНОМ-Т

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Хлорамин-Т, широко используемое дезинфицирующее средство для лечения заболеваний жабр пресноводных рыб, может быть также токсичным для них. Целью настоящего исследования было изучить безопасность этого дезинфицирующего агента (в последнее время привлекает внимание исследователей для использования на водных животных) для здоровья рыб с использованием маркеров аэробной и анаэробной способности (активность лактатдегидрогеназы, ЛДГ) в скелетных мышцах и сердечной ткани радужной форели (*Oncorhynchus mykiss* Walbaum), хариуса (*Thymallus thymallus* Linck) и кумжи (*Salmo trutta m. fario*). Двадцать две клинически здоровых радужной форели, двадцать одна кумжа и двадцать хариусов подвергались воздействию хлорамина-Т в конечной концентрации 9 мг/л. Рыб купали в растворе хлорамина-Т в течение 20 мин и эту процедуру повторяли трижды каждые 3 дня. Через два дня после последнего купания были взяты образцы рыб для биохимического анализа. Как показали результаты нашего исследования, активность ЛДГ была снижена в скелетных мышцах у радужной форели и хариуса после дезинфекции хлорамином-Т по сравнению с контрольной группой рыб. С другой стороны, активность ЛДГ была увеличена в скелетных мышцах кумжи. Дезинфекция хлорамином-Т вызвала снижение активности ЛДГ в сердечной ткани у радужной форели, кумжи и хариуса. Более того, активность ЛДГ в сердечной ткани контрольной группы рыб была выше на 107,5 % ($p = 0,000$) у кумжи и на 57,6 % ($p = 0,001$) у хариуса по сравнению со значениями, полученными для скелетных мышц. Настоящее исследование демонстрирует изменения активности ЛДГ в скелетных мышцах и сердечной ткани после процедуры дезинфекции хлорамином-Т в дозе 9 мг/л. Биохимические ответы в сердечной ткани указывают на адаптивные ответы организма рыб на влияние хлорамина-Т. Аналогичные тенденции наблюдались в скелетных мышцах радужной форели и хариуса. С другой стороны, увеличивалась активность ЛДГ в скелетных мышцах кумжи после процедуры дезинфекции хлорамином-Т. Следовательно, эти биохимические параметры можно рассматривать как индикаторы для оценки дезинфицирующих эффектов, хотя необходимы дальнейшие исследования

для изучения биохимических механизмов действия различных дезинфицирующих агентов в аквакультуре.

Ключевые слова: радужная форель (*Oncorhynchus mykiss Walbaum*), кумжа (*Salmo trutta m. fario*), хариус (*Thymallus thymallus Linck*), мышцы, сердце, лактатдегидрогеназа, дезинфекция.

ЗМІНИ АКТИВНОСТІ ЛАКТАТДЕГІДРОГЕНАЗИ В СКЕЛЕТНИХ М'ЯЗАХ І СЕРЦЕВІЙ ТКАНИНІ ДЕЯКИХ ЛОСОСЕВИХ РИБ ПІСЛЯ ПРОЦЕДУРИ ДЕЗИНФЕКЦІЇ ХЛОРАМІНОМ-Т

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Хлорамін-Т, який широко використовується як дезінфікуючий засіб для лікування захворювань зябер прісноводних риб, може бути також токсичним для них. Метою цього дослідження полягала в оцінці безпеки цього дезінфікуючого агента (останнім часом цей препарат привертає увагу дослідників для використання на водних тваринах) для здоров'я риб з використанням маркерів аеробного і анаеробного метаболізму (активність лактатдегідрогенази, ЛДГ) в скелетних м'язах і серцевій тканині райдужної форелі (*Oncorhynchus mykiss Walbaum*), хариуса (*Thymallus thymallus Linck*) і кумжі (*Salmo trutta m. fario*). Двадцять дві клінічно здорові райдужні форелі, двадцять одна кумжа і двадцять хариусов піддавали впливу хлораміну-Т в кінцевій концентрації 9 мг/л. Риб купали в розчині хлораміну-Т протягом 20 хв, і цю процедуру повторювали тричі кожні 3 дні. Через два дні після останнього купання були взяті зразки м'язової тканини риб для біохімічного аналізу. Як показали результати нашого дослідження, активність ЛДГ була знижена в скелетних м'язах у райдужної форелі і хариуса після дезінфекції хлораміном-Т в порівнянні з контрольною групою риб. Натомість, активність ЛДГ була підвищеною у скелетних м'язах кумжі. Дезінфекція хлораміном-Т викликала зниження активності ЛДГ в серцевій тканині райдужної форелі, кумжі і хариуса. Крім того, активність ЛДГ в серцевій тканині контрольної групи риб була вище на 107,5 % ($p = 0,000$) у кумжі і на 57,6 % ($p = 0,001$) у хариуса порівняно зі значеннями, отриманими для скелетних м'язів. Це дослідження демонструє зміни активності ЛДГ в скелетних м'язах і серцевій тканині після процедури дезінфекції хлораміном-Т в дозі 9 мг/л. Біохімічні відповіді в серцевій тканині вказують на адаптивні відповіді організму риб на вплив хлораміну-Т. Аналогічні тенденції спостерігали в скелетних м'язах райдужної форелі і хариуса. З іншого боку, збільшувалася активність ЛДГ в скелетних м'язах кумжі після процедури дезінфекції хлораміном-Т. Отже, ці біохімічні параметри можна розглядати як індикатори для оцінки ефектів дезінфектантів, хоча необхідні подальші дослідження для вивчення біохімічних механізмів їх дії в аквакультурі.

Ключові слова: райдужна форель (*Oncorhynchus mykiss Walbaum*), кумжа (*Salmo trutta m. fario*), хариус (*Thymallus thymallus Linck*), м'язи, серце, лактатдегідрогеназа, дезінфекція.