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N. S. Abugaliyeva^{1*}, M. K. Iztleuov², Y. M. Iztleuov³, S. A. Ryzhkin⁴, G. A. Smagulova⁵, S. S. Saparbaev⁶

PROTECTIVE EFFECTS OF URTICA DIOICA L. OIL ON OXIDATIVE STRESS AND INFLAMMATION IN THE RAT BRAIN FOLLOWING GAMMA IRRADIATION AND HEXAVALENT CHROMIUM EXPOSURE

¹Aktobe Regional Multidisciplinary Hospital (030017, Republic of Kazakhstan, Aktobe c., Zhanakonys str., 8E; e-mail: aktobeob@mail.ru)

²Department of Natural sciences, NC JSC «Marat Ospanov West Kazakhstan Medical University» (030000, Republic of Kazakhstan, Aktobe c., Mareseva str., 68; e-mail: info@zkmk.kz)

³Department of Radiation diagnostics, NC JSC «Marat Ospanov West Kazakhstan Medical University» (030000, Republic of Kazakhstan, Aktobe c., Mareseva str., 68; e-mail: info@zkmk.kz)

⁴Department of Radiology, Radiotherapy, Radiation Hygiene and Radiation Safety, Russian Medical Academy of Continuous Professional Education (125993, Russian Federation, Moscow c., Barrikadnaya str., 2/1; e-mail: rsa777@inbox.ru)

⁵Department of Pharmacology, NC JSC «Marat Ospanov West Kazakhstan Medical University» (030000, Republic of Kazakhstan, Aktobe c., Mareseva str., 68; e-mail: info@zkmk.kz)

⁶Medical Center Al-Jhami (020000, Republic of Kazakhstan, Astana c., Beibit Mailin str., 31; e-mail: al-zhami@mail.ru)

***Nazerke Serikkyzy Abugaliyeva** – Aktobe Regional Multidisciplinary Hospital; 030017, Republic of Kazakhstan, Aktobe c., Zhanakonys str., 8E; e-mail: nazerkeabugaliyevaaa@gmail.com

Aim. To evaluate the neuroprotective effects of *Urtica dioica* L. oil on oxidative stress and inflammatory responses in the brains of rats exposed to ionizing radiation alone or in combination with hexavalent chromium.

Materials and methods. Sixty-five white adult male rats were randomly assigned to five groups (n=13/group): control, irradiation, irradiation + *Urtica dioica* L. oil, irradiation + Cr(VI), and irradiation + Cr(VI) + *Urtica dioica* L. oil. Seven days after irradiation, brain tissue was collected for biochemical analysis. Levels of malondialdehyde (MDA), reduced glutathione (GSH), superoxide dismutase (SOD), catalase (CAT), tumor necrosis factor- α (TNF- α), and interleukin-6 (IL-6) were determined.

Results and discussion. Exposure to ionizing radiation, particularly in combination with Cr(VI), significantly impaired antioxidant defenses and increased lipid peroxidation and inflammatory cytokine levels in brain tissue. Pretreatment with *Urtica dioica* L. oil significantly increased SOD, CAT, and GSH levels while reducing MDA, TNF- α , and IL-6 compared with the corresponding untreated exposed groups (p<0.05).

Conclusions. *Urtica dioica* L. oil attenuated oxidative stress and neuroinflammation induced by ionizing radiation alone or combined with hexavalent chromium. These findings suggest that nettle oil has promising neuroprotective potential through enhancement of endogenous antioxidant defenses and suppression of inflammatory responses.

Key words: ionizing radiation; brain; oxidative stress; inflammation; nettle oil; *Urtica dioica* L.

INTRODUCTION

Medicinal plants have historically served as a fundamental component of healthcare systems worldwide. Beyond their traditional use as remedies, many plant species are also consumed as food ingredients and spices, providing a rich source of bioactive compounds for pharmaceutical research. In recent decades, plant-based nutraceuticals and functional foods have attracted considerable scientific attention due to their potential protective effects against diseases associated with modern lifestyles and environmental factors, including inflammation, hypercholesterolemia, atherosclerosis, endothelial dysfunction, and cancer progression.

Among medicinal plants, *Urtica dioica* L., commonly known as stinging nettle, has attracted considerable scientific interest due to its wide range of biological activities. *Urtica dioica* L. is a perennial herbaceous plant belonging to the genus *Urtica*, characterized by serrated leaves covered with stinging hairs. Its leaves contain a rich composition of nutrients and bioactive compounds, including dietary fiber, essential fatty acids (linoleic, linolenic, palmitic, stearic, and oleic acids), essential amino acids, and pigments such as β -carotene, lutein, and other carotenoids. In addition, nettle is abundant in antioxidant compounds, including polyphenols (kaempferol, quercetin, caffeic acid, coumarins, and other flavo-

noids). It also contains numerous minerals such as calcium, zinc, magnesium, sodium, iron, phosphorus, cobalt, potassium, nickel, and molybdenum, as well as vitamins A, C, K, and B-complex vitamins. Due to this balanced nutritional composition and high content of bioactive compounds, stinging nettle has gained increasing recognition as a valuable medicinal and functional plant [1].

Numerous studies have demonstrated that *Urtica dioica* L. exhibits a broad spectrum of pharmacological properties, including antioxidant, anti-inflammatory, antiproliferative, analgesic, immunomodulatory, antihypertensive, anti-infective, and anti-ulcer activities. Moreover, nettle has been suggested to contribute to the prevention of cardiovascular and neurodegenerative diseases [2].

Oxidative stress plays a central role in the pathogenesis of many neurological disorders. During incomplete reduction of molecular oxygen (O_2), reactive oxygen species (ROS) such as superoxide anion ($O_2^{\bullet-}$), hydroperoxyl radical ($HO_2^{\bullet}$), and hydroxyl radical ($HO^{\bullet}$) are generated [3]. These highly reactive molecules can damage lipids, proteins, and DNA, thereby disrupting cellular homeostasis. ROS-mediated oxidative stress can activate multiple intracellular signaling pathways, including the nuclear factor kappa-B (NF- κ B) pathway. Activation of NF- κ B promotes neuroinflammation, microglial activation, neuronal apoptosis and necrosis, and secondary neuronal damage. Furthermore, it stimulates the transcription of genes encoding pro-inflammatory cytokines such as interleukin-1 β (IL-1 β), interleukin-6 (IL-6), and tumor necrosis factor- α (TNF- α) [4].

Reactive oxygen species particularly affect polyunsaturated fatty acids in cellular membranes, initiating lipid peroxidation chain reactions that ultimately lead to the formation of malondialdehyde (MDA), a widely recognized marker of oxidative damage [5]. To counteract oxidative stress, the body relies on endogenous antioxidant defense systems, including enzymatic antioxidants such as superoxide dismutase (SOD), glutathione peroxidase (GPx), catalase (CAT), and glutathione reductase (GR), as well as non-enzymatic antioxidants such as reduced glutathione (GSH), cysteine, coenzyme Q, and vitamins A, C, and E, metals (Se, Zn) [6].

Plant-derived compounds have attracted significant attention for their ability to modulate oxidative stress and inflammatory responses. Herbal extracts may exert anti-inflammatory effects by targeting various cellular signaling pathways or endogenous enzymes involved in inflammatory processes. In particular, extracts of *Urtica dioica* L. have been reported to modulate the inflammatory cascade by inhibiting cyclooxygenase enzymes (COX-1 and COX-2), thereby reducing the synthesis of inflammatory prostaglandins, and by suppressing mast cell tryptase activity to prevent degranulation [7].

In addition to these mechanisms, bioactive compounds present in nettle, such as rutin, kaempferol, and vitamin A, have been shown to possess strong antioxidant and anti-inflammatory properties. The phenolic and flavonoid constituents of *Urtica dioica* L. contribute to the scavenging of reactive oxygen species and the inhibition of lipid peroxidation, thereby protecting cells from oxidative damage [8].

Despite the growing body of evidence supporting the biological activities of *Urtica dioica* L., further research is needed to identify its active phytochemicals, clarify their mechanisms of action, and evaluate their therapeutic potential in conditions associated with oxidative stress and inflammation.

Therefore, the study aimed to investigate the effects of *Urtica dioica* L. oil on oxidative stress and inflammatory responses in the brain following combined exposure to ionizing radiation and hexavalent chromium, two environmental factors known to induce severe oxidative and inflammatory damage in neural tissues.

MATERIALS AND METHODS

White adult male rats (170-190 g) were obtained from the vivarium of the Scientific and Practical Center of NC JSC «Marat Ospanov West Kazakhstan Medical University» (Aktobe c., Republic of Kazakhstan). Prior to the experiment, the animals underwent a 14-day acclimatization period.

All experimental procedures were approved by the Institutional Animal Ethics Committee of NC JSC «Marat Ospanov West Kazakhstan Medical University» and were conducted in accordance with the European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes (Strasbourg, 1986).

A total of sixty-five rats were randomly assigned to five experimental groups ($n=13/\text{group}$): group I – control group; group II – rats exposed to a single total-body γ -irradiation dose of 4 Gy; group III – rats treated daily with *Urtica dioica* L. oil at a dose of 2.5 mL/kg body weight for 14 days, followed by total-body γ -irradiation (4 Gy); group IV – rats administered potassium dichromate ($K_2Cr_2O_7$) in drinking water at a concentration equivalent to 180 mg/L Cr(VI) for 14 days, followed by total-body γ -irradiation (4 Gy); group V – rats administered potassium dichromate ($K_2Cr_2O_7$) in drinking water at a concentration equivalent to 180 mg/L Cr(VI) and treated with *Urtica dioica* L. (2.5 mL/kg body weight) for 14 days, followed by total-body γ -irradiation (4 Gy).

Seven days after irradiation, animals were euthanized under light anesthesia by cervical decapitation.

The brain was rapidly excised and placed in ice-cold buffer containing 10 mM Tris-HCl (pH 7.4). Brain tissue samples were centrifuged, and the supernatants were stored at -20°C until biochemical analysis.

Lipid peroxidation was evaluated by measuring MDA levels using the spectrophotometric method described by H. H. Draper and M. Hadley [9]. Under acidic conditions and high temperature, MDA reacts with 2-thiobarbituric acid to form a colored complex with maximum absorbance at 532 nm. The molar extinction coefficient was $1.56 \times 10^5 \text{ M}^{-1} \cdot \text{cm}^{-1}$. MDA concentrations were expressed as nmol/g tissue for brain samples.

GSH levels were determined according to G. L. Ellman method [10] with modifications by D. J. Jollow et al. [11], which is based on the formation of a yellow color upon the addition of DTNB (5,5-dithio-bis-2-nitrobenzoic acid) to a sample containing SH groups. Briefly, 3.0 mL of 4% sulfosalicylic acid was added to 0.5 mL of tissue homogenate, followed by centrifugation at $1600 \times g$ for 15 min. Ellman's reagent was added to 0.05 mL (50 μL) of the supernatant, and absorbance was measured at 412 nm after 10 min. Results were expressed as nmol/mg protein.

CAT activity was measured using the method of M. Koroliuk et al. [12]. The reaction was initiated by adding 2 mL of 0.03% H_2O_2 to 0.1 mL of supernatant and terminated after 10 min by the rapid addition of 1.0 mL of 4% ammonium molybdate dissolved in 12.5 mM H_2SO_4 and 1 mL of 125 mM H_2SO_4 . All samples were centrifuged at 3000 g for 10 min. The absorbance of the sample was measured at 410 nm. CAT activity was expressed as $\mu\text{mol H}_2\text{O}_2 \text{ min}^{-1} \text{ mg}^{-1} \text{ protein}$.

SOD activity was assessed according to C. Beauchamp and I. Fridovich [13]. This method is based on recording changes in the rate of nitroblue tetrazolium (NBT) reduction in the presence of reduced nicotinamide adenine dinucleotide and phenazine metasulfate. Optical density was measured at 560 nm. One unit of SOD activity was defined as the amount of enzyme required to inhibit NBT reduction by 50%. Results were expressed as U/mg protein for brain tissue.

Protein concentration in tissue fractions was determined by the method of O. H. Lowry [14].

Levels of inflammatory cytokines, including IL-6 and TNF- α , in brain homogenates were measured using rat-specific ELISA kits (Cloud Clone Corp., Katy, TX, USA) according to the manufacturer's instructions.

Statistical analyses were performed using R Studio (version 2024.12.1+563). Data distribution was evaluated using the Shapiro – Wilk test. Because the data were not normally distributed, intergroup differences were assessed using the nonparametric Kruskal – Wallis one-way analysis of variance (ANOVA). When significant differences were detected, pairwise comparisons were conducted using the Mann – Whitney test with Bonferroni correction. Effect sizes were calculated using Cliff's delta with 95% confidence intervals (cliff.delta() function, "effsize" package). According to J. Romano et al. [15], $|\delta|$ val-

ues were interpreted as follows: <0.147 – nonsignificant effect; $0.147\text{--}0.33$ – small effect; $0.33\text{--}0.474$ – medium effect; ≥ 0.474 – large effect. Relationships between variables were evaluated using Spearman's rank correlation coefficient. $P\text{-value} < 0.05$ was considered statistically significant.

RESULTS AND DISCUSSION

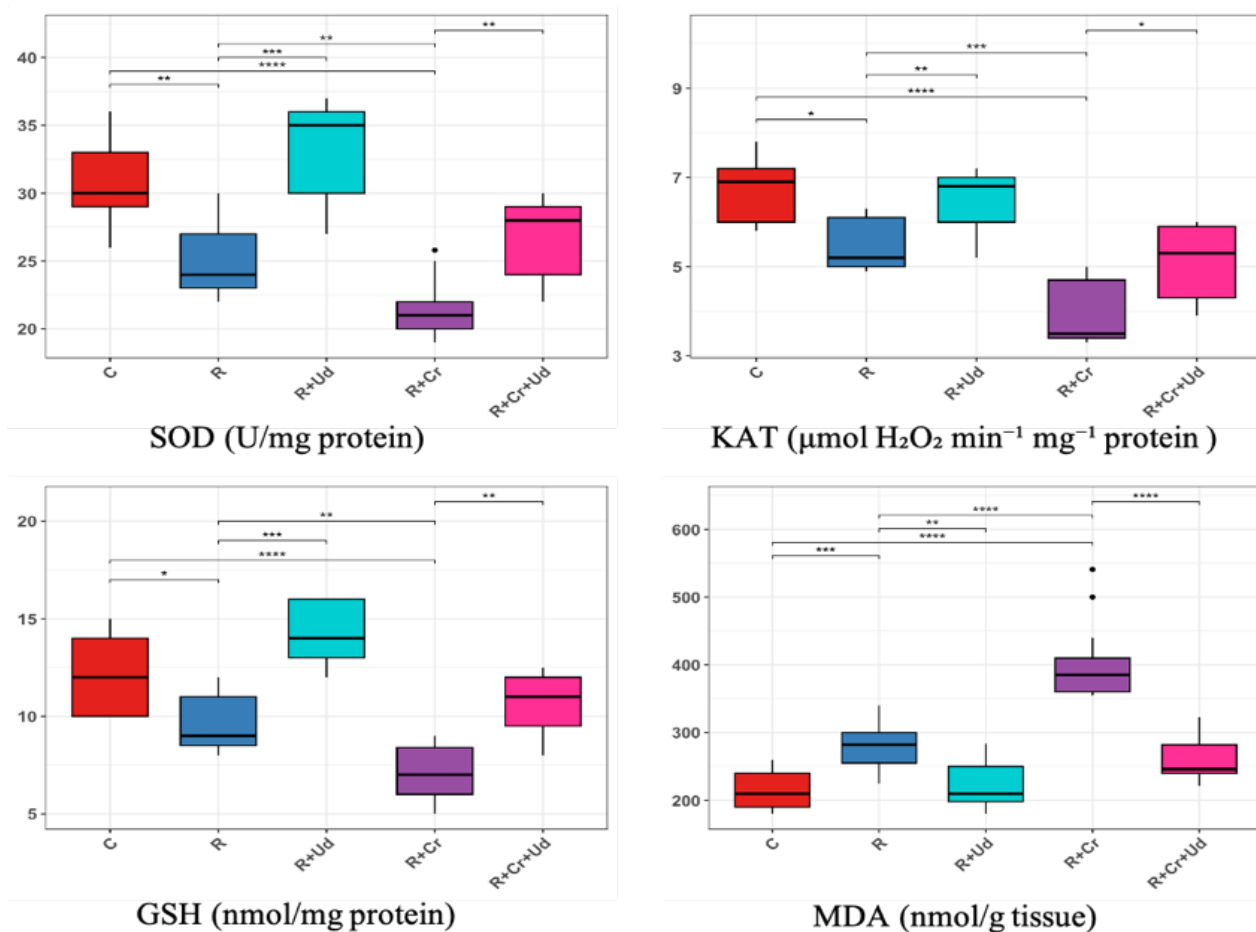
To assess the effects of nettle oil on antioxidant status and inflammatory responses, we analyzed biochemical parameters in rat brain tissue following combined exposure to ionizing radiation and hexavalent chromium. As shown in Figures 1 and 2, the Mann – Whitney test with Bonferroni correction was applied, and Table 1 presents the effect size estimates calculated using Cliff's delta. Administration of nettle oil exerted a pronounced protective effect on the brain's antioxidant system. Seven days after treatment, rats subjected to either isolated irradiation or combined exposure demonstrated a significant increase in SOD activity ($\delta = -0.899$, $p=0.0005$; $\delta = -0.840$, $p=0.0013$), CAT activity ($\delta = -0.734$, $p = 0.007$; $\delta = -0.651$, $p=0.024$), and GSH levels ($\delta = -0.964$, $p=0.0001$; $\delta = -0.846$; $p=0.0012$) compared with the corresponding intoxicated groups. Concurrently, reductions were observed in MDA levels ($\delta = 0.698$, $p=0.0029$; $\delta=1.0$; $p<0.0001$), TNF- α ($\delta=0.728$, $p=0.0078$; $\delta=1.0$, $p<0.0001$), and IL-6 ($\delta=0.852$, $p=0.0009$; $\delta=1.0$, $p<0.0001$), indicating attenuation of oxidative stress and inflammatory responses in the brain.

Overall, the Cliff's delta values confirm a strong protective influence of nettle oil under both isolated radiation exposure and combined radiation-chemical stress. Positive effect size values for antioxidant enzymes indicate restoration of antioxidant capacity, whereas negative values for MDA and pro-inflammatory cytokines reflect a decline in oxidative damage and inflammatory activity.

As illustrated in Figure 3, Spearman's correlation analysis was performed to examine relationships among key indicators of antioxidant function, lipid peroxidation, and inflammation. Strong and statistically significant associations ($p < 0.0001$) were identified between antioxidant parameters and markers of lipid oxidation and inflammatory responses, underscoring the close interplay between reduced antioxidant potential and the intensification of oxidative and inflammatory processes in brain tissue.

In summary, the findings demonstrate that nettle oil effectively restores antioxidant defenses and mitigates inflammatory reactions under radiation-chemical exposure, providing protection in both isolated ionizing irradiation and combined irradiation with hexavalent chromium.

The study provides new evidence that nettle oil exerts a pronounced protective effect on the brain under radiation-chemical stress, improving antioxidant defenses and attenuating inflammatory responses.



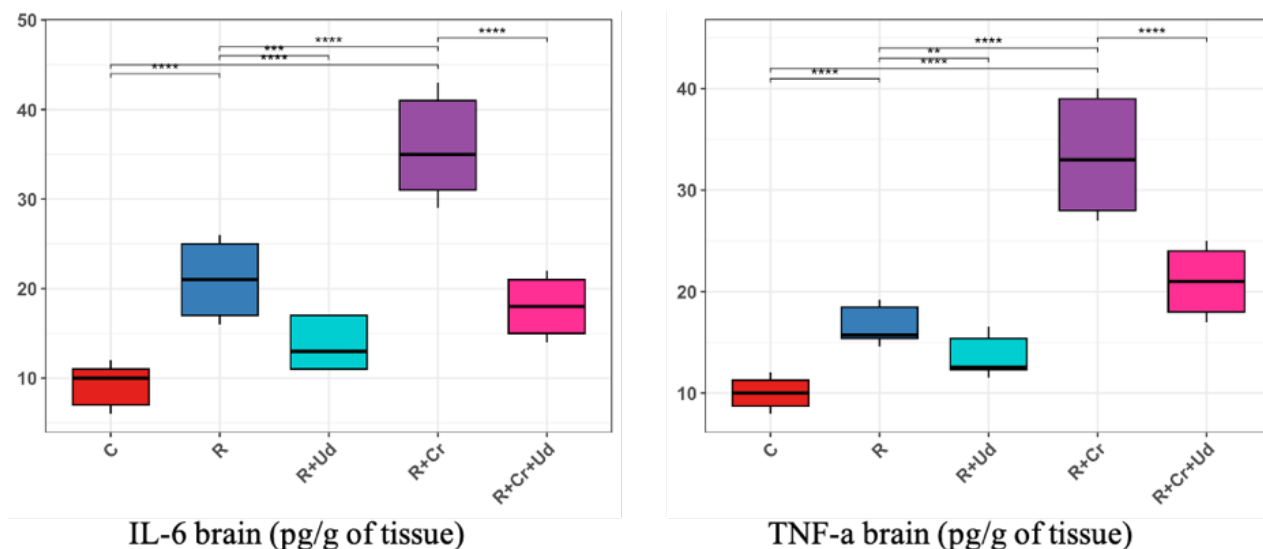
MDA – malondialdehyde; SOD – superoxide dismutase; CAT – catalase; GSH – glutathione; C – control; R – ionizing radiation; R + Ud – ionizing radiation + *Urtica dioica* L. oil; R + Cr – ionizing radiation + chromium; R + Cr + Ud – ionizing radiation + chromium + *Urtica dioica* L. oil; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$

Figure 1 – Comparative evaluation of antioxidant status and lipid peroxidation in the brain of rats subjected to ionizing radiation and chromium exposure and treated with *Urtica dioica* L. oil

Table 1 – Effect size analysis of antioxidant, lipid peroxidation and inflammatory parameters in the brains of rats exposed to ionizing radiation and chromium and corrected with *Urtica dioica* L. oil

Parameter	C - R	C - R+Cr	R - R+Ud	R - R+Cr	R+Cr - R+Cr+Ud
MDA	-0.864	-1.0	0.698	-1.0	1.0
SOD	0.775	1.0	-0.899	0.757	-0.840
CAT	0.698	1.0	-0.734	0.964	-0.651
GSH	0.692	1.0	-0.964	0.740	-0.846
TNF- α	-1.0	-1.0	0.728	-1.0	1.0
IL-6	-1.0	-1.0	0.852	-1.0	1.0

Note: C – control; R – ionizing radiation; R + Ud – ionizing radiation + *Urtica dioica* L. oil; R + Cr – ionizing radiation + chromium; R + Cr + Ud – ionizing radiation + chromium + *Urtica dioica* L. oil; SOD – superoxide dismutase, CAT – catalase, GSH – reduced glutathione, MDA – malondialdehyde, TNF- α – tumor necrosis factor- α , IL-6 – interleukin-6



TNF- α – tumor necrosis factor- α ; IL-6 – interleukin-6; C – control; R – ionizing radiation; R + Ud – ionizing radiation + *Urtica dioica* L. oil; R + Cr – ionizing radiation + chromium; R + Cr + Ud – ionizing radiation + chromium + *Urtica dioica* L. oil; * $p<0.05$; ** $p<0.01$; *** $p<0.001$; **** $p<0.0001$

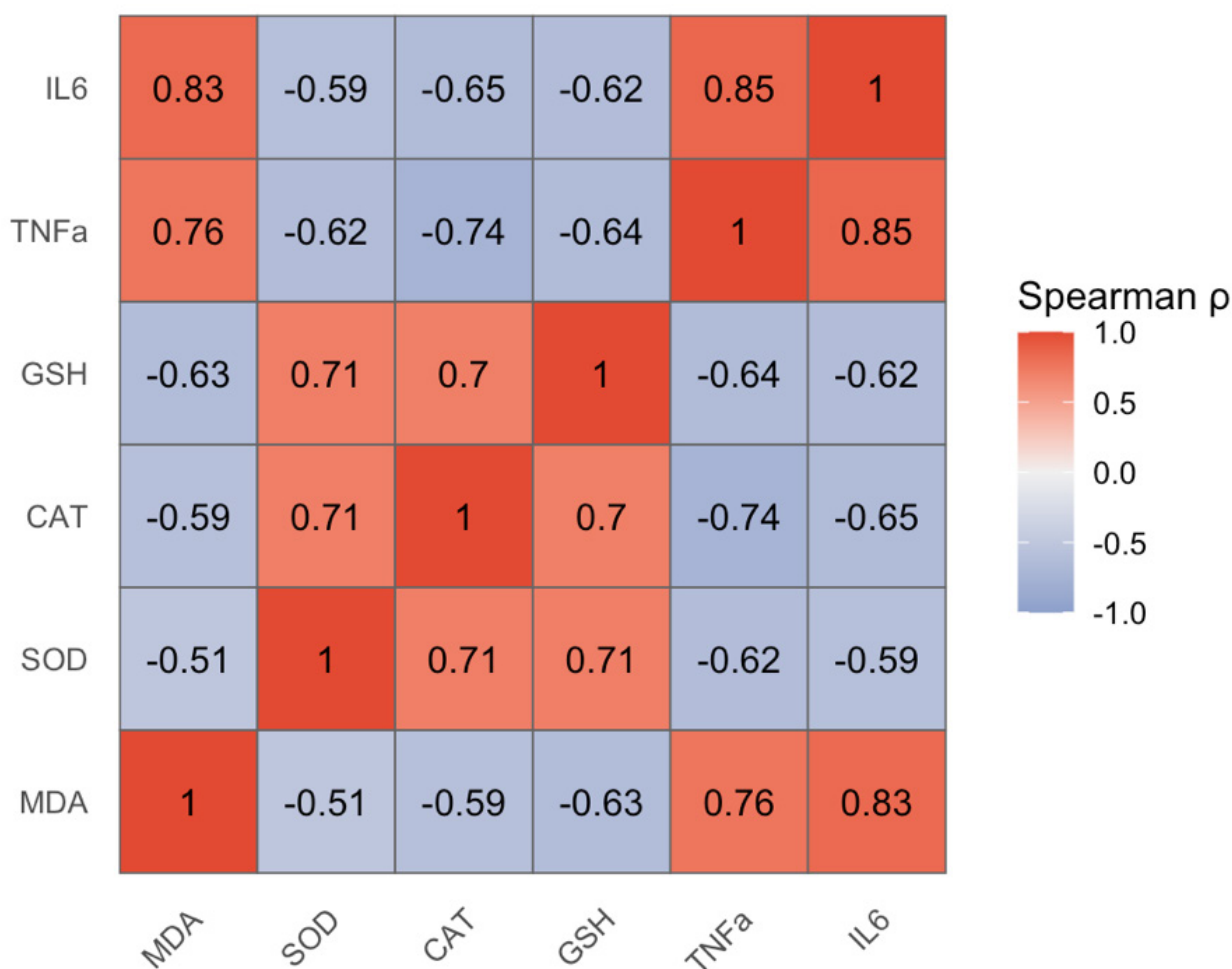
Figure 2 – Comparative evaluation of inflammatory markers in the brains of rats exposed to ionizing radiation and chromium and treated with *Urtica dioica* L. oil

These findings are consistent with previously published data on the biological activity of *Urtica* species, which are known for their antioxidant, anti-inflammatory, and neuroprotective properties.

In earlier research, Wistar rats with streptozotocin-induced diabetes demonstrated a significant elevation of antioxidant enzymes (GPx, SOD, CAT) as well as GSH levels in hippocampal tissue following daily oral administration of *Urtica dioica* L. leaf extract at a dose of 50 mg/kg for six weeks, compared with untreated diabetic animals. Concurrently, marked reductions were reported in lipid peroxidation (MDA) and in the pro-inflammatory cytokine IL-1 β . These findings highlight the strong antioxidant and anti-inflammatory potential of *Urtica dioica* L. and support its relevance for mitigating neuroinflammatory alterations in the hippocampus [16]. It has also been shown that the ethanolic extract of *Urtica dioica* L. suppresses the secretion of the pro-inflammatory cytokines TNF- α and IL-1 β in LPS-stimulated human whole blood by 50.8% and 99.7%, respectively, demonstrating a pronounced dose-dependent anti-inflammatory effect [17]. In a scopolamine-induced memory impairment model, *Urtica dioica* L. extract reduced MDA levels and increased SOD activity in brain tissues, indicating a pronounced antioxidant effect [18].

Researchers recorded behavioral disturbances, as well as changes in redox homeostasis, in the cerebellum and liver of rats exposed to KBrO₃ at a concentration of 2 g/L in drinking water. The animals showed increased MDA levels and decreased activity of antioxidant enzymes, CAT and SOD, indicating the development of oxidative stress. Administration of

Urtica dioica L. had a significant therapeutic effect, reducing MDA levels and increasing SOD and CAT activity in the cerebellum and liver, indicating its antioxidant properties and ability to attenuate KBrO₃-induced redox imbalances [19]. The radioprotective properties of *Urtica dioica* L. were demonstrated in an experimental study on rats exposed to 5 Gy of ionizing radiation. Treatment with *Urtica dioica* L. resulted in significant increases in the activities of SOD, CAT, and glutathione peroxidase (GSH-Px), GSH levels, and a decrease in MDA concentrations. The obtained results indicate a pronounced antioxidant and radioprotective effect of *Urtica dioica* L., associated with the ability to enhance endogenous antioxidant protection and limit lipid peroxidation processes [20]. Our results are consistent with a clinical study in which the use of a hydroethanol extract of nettle leaves was associated with a significant increase in the activity of the antioxidant enzyme SOD ($p=0.002$) and an improvement in quality of life in patients with inflammatory bowel disease. The authors concluded that nettle extract has promising therapeutic potential as an adjuvant treatment, but further research is needed to confirm its clinical efficacy [21]. Treatment with *Urtica dioica* L. extracts demonstrated a significant antioxidant effect against scopolamine-induced neurotoxicity, with a significant reduction in MDA levels and an increase in GSH concentrations. These results indicate the ability of *Urtica dioica* L. to reduce oxidative stress and support the brain's endogenous antioxidant defenses [22]. The data obtained in the present study are confirmed by the results of other experimental works, in which the use of ethanol ex-



SOD – superoxide dismutase, CAT – catalase, GSH – reduced glutathione, MDA – malondialdehyde, TNF- α – tumor necrosis factor- α , IL-6 – interleukin-6

Figure 3 – Spearman's rank correlation analysis between antioxidant parameters, lipid peroxidation, and inflammatory markers in rat brain tissue

tract of *Urtica dioica* L. contributed to an increase in the activity of antioxidant enzymes SOD and CAT in the tissues of the brain and cerebellum of rats, which indicates a pronounced neuroprotective and antioxidant potential of the plant [23]. A number of studies have also shown that the use of *Urtica dioica* L. extract is accompanied by a decrease in MDA levels in hippocampal tissue, indicating a reduction in oxidative stress and may underlie its neuroprotective effects, including the protection of hippocampal neurons, slowing premature aging, and preventing cognitive impairment [24].

CONCLUSION

The study demonstrates that nettle oil effectively attenuates oxidative stress and neuroinflammatory responses induced by ionizing radiation alone or in combination with hexavalent chromium exposure. Treatment with nettle oil restored antioxidant defenses by increasing SOD, CAT, and GSH levels

while reducing lipid peroxidation and pro-inflammatory cytokine production in rat brain tissue. These findings suggest that the neuroprotective effects of nettle oil are mediated through the enhancement of endogenous antioxidant capacity and suppression of inflammation. Therefore, nettle oil may represent a promising natural therapeutic agent for reducing radiation- and chromium-induced brain injury, although further mechanistic and clinical studies are required to confirm its translational potential.

Author contributions:

Y. M. Iztleuov, M. K. Iztleuov – concept and design of the study.

N. S. Abugaliyeva, S. S. Saparbaev – collection and processing of material.

N. S. Abugaliyeva, G. A. Smagulova – statistical processing.

N. S. Abugaliyeva, G. A. Smagulova – writing text.

M. K. Iztleuovm, S. A. Ryzhkin – editing.

Conflict of interest:

The authors declare no conflict of interest.

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Н. С. Аbugалиева^{1*}, М. К. Изтлеуов², Е. М. Изтлеуов³, С. А. Рыжкин⁴, Г. А. Смагулова⁵, С. С. Сапарбаев⁶

ЗАЩИТНОЕ ДЕЙСТВИЕ МАСЛА КРАПИВЫ НА ОКИСЛИТЕЛЬНЫЙ СТРЕСС И ВОСПАЛЕНИЕ В ГОЛОВНОМ МОЗГЕ КРЫС ПОСЛЕ ВОЗДЕЙСТВИЯ ГАММА-ИЗЛУЧЕНИЯ И ШЕСТИВАЛЕНТНОГО ХРОМА

¹Актюбинская областная многопрофильная больница (030017, Республика Казахстан, г Актюбе, ул. Жанаконьис, 8Е; e-mail: aktobeob@mail.ru)

²Кафедра естественных наук, НАО «Западно-Казахстанский медицинский университет им. Марата Оспанова» (030000, Республика Казахстан, г Актюбе, ул. Маресьева, 68; e-mail: info@zkmk.kz)

³Кафедра лучевой диагностики, НАО «Западно-Казахстанский медицинский университет им. Марата Оспанова» (030000, Республика Казахстан, г Актюбе, ул. Маресьева, 68; e-mail: info@zkmk.kz)

⁴Кафедра радиологии, радиотерапии, радиационной гигиены и радиационной безопасности, Российская медицинская академия непрерывного профессионального образования (125993, Россия, Москва, ул. Баррикадная, 2/1; e-mail: rsa777@inbox.ru)

⁵Кафедра фармакологии, НАО «Западно-Казахстанский медицинский университет им. Марата Оспанова» (030000, Республика Казахстан, г Актюбе, ул. Маресьева, 68; e-mail: info@zkmk.kz)

⁶Медицинский центр Аль-Жами (020000, Республика Казахстан, г. Астана, ул. Бейбит Майлин, 31; e-mail: al-zhami@mail.ru)

*Назерке Сериковна Аbugалиева – Актюбинская областная многопрофильная больница; 030017, Республика Казахстан, г Актюбе, улица Жанаконьис, 8Е; e-mail: aktobeob@mail.ru

Цель. Оценить нейропротекторное действие масла крапивы (*Urtica dioica* L.) на окислительный стресс и воспалительные реакции в головном мозге крыс, подвергшихся воздействию ионизирующего излучения отдельно или в сочетании с шестивалентным хромом.

Материалы и методы. Шестидесять пять белых взрослых самцов крыс были случайным образом распределены на пять групп (n=13/группа): контрольная, облучение, облучение + масло крапивы, облучение + Cr(VI) и облучение + Cr(VI) + масло крапивы. Через семь дней после облучения была собрана ткань головного мозга для биохимического анализа. Были определены уровни малонового диальдегида (МДА), восстановленного глутатиона (GSH), супероксиддисмутазы (СОД), каталазы (КАТ), фактора некроза опухоли-α (ФНО-α) и интерлейкина-6 (ИЛ-6).

Результаты и обсуждение. Воздействие ионизирующего излучения, особенно в сочетании с Cr(VI), значительно ослабило антиоксидантную защиту, усилило перекисное окисление липидов и обусловило повышение уровня воспалительных цитокинов в ткани головного мозга. Предварительная обработка маслом крапивы значительно стимулировала повышение уровней СОД, КАТ и GSH с одновременным снижением уровней МДА, ФНО-α и ИЛ-6 по сравнению с соответствующими группами, не подвергавшимися воздействию (p<0,05).

Выводы. Масло крапивы ослабило окислительный стресс и нейровоспаление, вызванные ионизирующим излучением как отдельно, так и в сочетании с шестивалентным хромом. Эти результаты свидетельствуют о том, что масло крапивы обладает многообещающим нейропротекторным потенциалом за счет усиления эндогенной антиоксидантной защиты и подавления воспалительных реакций.

Ключевые слова: ионизирующее излучение; мозг; окислительный стресс; воспаление; масло крапивы; *Urtica dioica* L.

Н. С. Әбуғалиева^{1*}, М. К. Ізмлеуов², Е. М. Ізмлеуов³, С. А. Рыжкин⁴, Г. А. Смагулова⁵, С. С. Сапарбаев⁶

ИОНДАУШЫ СӘУЛЕЛЕНУ МЕН АЛТЫ ВАЛЕНТТІ ХРОМ ӘСЕРІНЕН КЕЙІНГІ ЕГЕУҚҰЙРЫҚ МИЫНДАҒЫ ТОТЫҒУ КҮЙЗЕЛІСІ МЕН ҚАБЫНУҒА ҚАРСЫ ҚАЛАҚАЙ МАЙЫНЫҢ ҚОРҒАНЫШ ӘСЕРІ

¹Ақтөбе облыстық көпсалалы ауруханасы (030017, Қазақстан Республикасы, Ақтөбе қ., Жанақоныс к-сі, 8Е; e-mail: aktobeob@mail.ru)

²Марат Оспанов атындағы Батыс Қазақстан медициналық университеті, Жаратылыстану ғылымдары кафедрасы (030000, Қазақстан Республикасы, Ақтөбе қ., Маресьев к-сі, 68; e-mail: info@zkm.kz)

³Марат Оспанов атындағы Батыс Қазақстан медициналық университеті, Сәулелік диагностика кафедрасы (030000, Қазақстан Республикасы, Ақтөбе қ., Маресьев к-сі, 68; e-mail: info@zkm.kz)

⁴Ресей үздіксіз кәсіби білім беру медициналық академиясы, Радиология, радиотерапия, радиациялық гигиена және радиациялық қауіпсіздік кафедрасы. (125993, Ресей Федерациясы, Мәскеу қ., Баррикад к-сі, 2/1; e-mail: rsa777@inbox.ru)

⁵Марат Оспанов атындағы Батыс Қазақстан медициналық университеті, Фармакология кафедрасы (030000, Қазақстан Республикасы, Ақтөбе қ., Маресьев к-сі, 68; e-mail: info@zkm.kz)

⁶Аль-Жами медициналық орталығы (020000, Қазақстан Республикасы, Астана қ., Бейбіт Майлин к-сі, 31; e-mail: al-zhami@mail.ru)

***Назерке Серікқызы Әбуғалиева** – Ақтөбе облыстық көпсалалы ауруханасы; 030017, Қазақстан Республикасы, Ақтөбе қ., Жанақоныс к-сі, 8Е; e-mail: aktobeob@mail.ru

Зерттеудің мақсаты. Иондаушы сәулеленудің жеке әсері немесе алты валентті хроммен бірлескен әсер етуі жағдайында егеуқұйрық миындағы тотығу стрессі мен қабыну реакцияларына қарсы қалақай майының нейропротекторлық әсерін бағалау.

Материалдар және әдістер. Ересек ақ аталық тұқымды 65 егеуқұйрық кездейсоқ түрде бес топқа бөлінді (n=13/топ): бақылау, сәулелену, сәулелену + қалақай майы, сәулелену + Cr(VI), сәулелену + Cr(VI) + қалақай майы. Сәулеленуден кейін жеті тәулікте биохимиялық талдау жүргізу үшін ми тіндері алынды. Малонды диальдегид (МДА), глутатион (GSH), супероксиддисмутаза (СОД), каталаза (КАТ), ісік некрозының факторы-α (TNF-α) және интерлейкин-6 (IL-6) деңгейлері анықталды.

Нәтижелер және талқылау. Иондаушы сәулелену, әсіресе Cr(VI)-мен бірге әсер еткенде, антиоксиданттық қорғанысты айтарлықтай әлсіретіп, майлардың асқын тотығуын және ми тініндегі қабыну цитокиндерінің деңгейін жоғарылатты. Қалақай майымен алдын ала өңдеу СОД, КАТ және GSH деңгейлерін айтарлықтай арттырып, сәйкес ем қабылдамаған топтармен салыстырғанда МДА, TNF-α және IL-6 деңгейлерін едәуір төмендетті (p<0,05).

Қорытындылар. Қалақай майы иондаушы сәулеленудің жеке әсерінен де, алты валентті хроммен біріктірілген әсерінен де туындаған тотығу стрессі мен нейроқабынуды әлсіретті. Алынған нәтижелер қалақай майының эндогенді антиоксиданттық қорғанысты күшейту және қабыну реакцияларын тежеу арқылы нейропротекторлық қасиетке ие екенін көрсетеді.

Кілт сөздер: иондаушы сәулелену; ми; оксидативті стресс; қабыну; қалақай майы; *Urtica dioica* L.