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Detoxification properties of pumpkin pectin and pectin-enriched foods via bioassay evaluation

Running Head: Pumpkin Pectin for Heavy Metal Detoxification

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ABSTRACT
Heavy metal pollution, particularly lead and cadmium, poses significant health risks due to bioaccumulation and multi-organ damage. This study investigates the detoxification potential of pumpkin pectin and pectin-rich products in laboratory rats, *Rattus norvegicus*. Male rats (230 ± 20 g in weight) were chronically intoxicated with lead nitrate (2.0 mg kg^{-1}) or cadmium chloride (2.08 mg kg^{-1}) over three months. Correctors, including pumpkin pectin (0.06 g day^{-1}), pectin-enriched bread (0.5%), and confiture (1.0%), were administered orally. Hematological and biochemical blood parameters were assessed using a Hitachi spectrophotometer and a Mindray BC-3000 analyzer. Heavy metal accumulation reduced total protein (91-95% of control) and hemoglobin, and increased urea. Pumpkin pectin correction restored these parameters, with better outcomes in lead-induced rats than in cadmium-induced rats. Pectin-rich products showed moderate improvements. These findings demonstrate that pumpkin pectin serves as an effective natural chelator, mitigating the toxic effects of heavy metals. Its use is recommended for therapeutic and preventive purposes in populations exposed to chronic heavy metal pollution in industrial regions.

Keywords: Cadmium, Detoxification, Heavy metals, Lead, Pectin, Pumpkin

Introduction
Human production activities entailed severe consequences - pollution of the planet's ecological system with toxic substances. It is known that one of them - lead and its compounds are very dangerous for humans. Lead poisoning ranks first in frequency among all metals. Among a wide variety of environmental factors affecting the human body, the leading place is occupied by heavy metals, which enter mainly into the environment as a result of technogenesis. Heavy metals include mercury, lead, cadmium, cobalt, copper, zinc, and iron. Among chemical

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pollutants, heavy metals are considered as a factor with severe environmental and biological consequences (Ali *et al.* 2019). Heavy metals due to their migratory ability, a tendency to bioaccumulate, specific toxic effects, getting into feed and food products, worsen their sanitary qualities, and if they are kept above acceptable levels, they pose a danger to animal and human health (Kaplan & Hays 2022). Compounds of heavy metals that are highly toxic to living organisms do not break down in soil, water, plants, and animals. They can persist for a long time in environmental objects, migrate, accumulate in the human and animal body, causing changes in organs and tissues and cause irreparable harm to health. Many heavy metals and their compounds, in addition to toxic effects, are carcinogenic and mutagenic and cause serious long-term effects. Among these compounds, lead is one of the first places (Ewert *et al.* 2001; Afzaal *et al.* 2022). Lead, as a potentially dangerous toxicant, refers to substances of the first hazard class and its content in food, drinking water, atmospheric air, etc. is strictly regulated. It is listed as a priority pollutant by a number of international organizations, including WHO and UNEP (2004). In many countries of the world (Russia, USA, Germany, Denmark, Australia, Mexico, Thailand, etc.), national programs have been developed to reduce environmental pollution by lead and to limit its negative impact on the health of children. Lead can even cause low levels of health impairment: immune, neuropsychiatric, hematological, etc. Due to the wide spread of lead pollution, almost the entire population is at risk of exposure regardless of socio-economic status, race or ethnicity or place of residence (rural locality, city or suburb). Chronic lead poisoning poses a threat, first of all, to the health and mental development of the younger generation and thereby to the future of all mankind. The increased attention to this problem is due to the fact that it has moved from a professional plane to an ecopathological one, due to the global distribution of lead (Ruebner *et al.* 2019; Xu *et al.* 2023).
The second, no less dangerous toxicant in its effect on the body of animals and humans is cadmium. One of the most dangerous environmental and toxicological phenomena is cadmium pollution of the soil. A large proportion of cadmium enters the human and animal organisms with plant food, which poses a great danger to both the animal organism and the human body, since it is a cumulative poison. For fodder plants, according to the results of various authors, the background level of cadmium is 0.07-0.27 mg kg^{-1} dry weight. Ingestion of 30-40 mg of cadmium in any form can be fatal. The half-life of cadmium is more than 10 years, with a systematic ingestion of it into the body, it is worth paying great attention to this. Chronic cadmium poisoning is caused by its slow removal from the body (0.1% per day; Nawab *et al.* 2015; Skipin *et al.* 2016). It has been established that Cd accumulates in almost all organs, mainly in the cortical part of the kidneys. High activity of Cd was discovered as early as 100 years ago. To date, animal experiments have established that cadmium in large doses causes damage to the renal tubules, necrosis of the placenta and testicles, impaired liver function, osteomalacia, testicular tumors, fetal malformations, anemia, hypertension, pulmonary edema, chronic pulmonary emphysema, iron deficiency, copper, zinc, i.e., we can talk about the multi-organ damaging effect of cadmium (Thompson & Bannigan 2008; El-Refaiy & Eissa 2013).
Summarizing the above, we can conclude that heavy metals with a wide range of biological effects are among the toxicants that are especially dangerous for human health. One of the ways to solve this problem, caused by environmental pollution and the ingestion of excessive amounts of heavy metals and radionuclides into the human body, is the creation of detoxifying action chelators. Studies by scientists have shown that chemical chelators such as ethylene diamine tetra acetic acid (EDTA), which are used to remove heavy metals and radionuclides from the body during acute poisoning, are not effective enough in chronic poisoning conditions and cause the body to become depleted with trace elements after prolonged administration. It was found that such a well-known chelator as EDTA had almost no effect on the state of the cardiovascular system in humans, while modified citrus pectin exhibited a significant effect on angiogenesis (Seely *et al.* 2005). Recent studies have established that it is more efficient to use substances contained in natural food products: they do not cause side effects and give a protective effect. These substances include pectin, which has a beneficial effect not only under the conditions of acute exposure to metals, but also when they are ingested for a long time, which is just characteristic of the environmental load of residents of industrial regions and the modern metropolis (Zhao *et al.* 2008; Wang *et al.* 2019; Zhexenbay *et al.* 2020). It has been established that modified citrus pectin significantly increased the excretion of lead in urine in adults and its use for children as a safe and harmless chelator is especially recommended (Eliaz *et al.* 2006; Eliaz *et al.* 2007; Sears 2013; Eliaz & Raz 2019; Emran *et al.* 2022). It should be emphasized that pectin's are natural products and do not have a toxic effect on the human body. The main effect of the therapeutic effect of pectin is associated with the peculiarities of its chemical structure. The polymer chain of polygalacturonic acid, the presence of chemically active free carboxyl groups and alcohol hydroxyls contribute to the formation of strong insoluble complexes with polyvalent metals, the so-called chelates, which remove heavy metals and nuclides from

Caspian J. Environ. Sci. Received:
DOI: Article type: Review

the body. There is evidence in the literature that when exposed to pectin's, an increase in the antioxidant activity of blood and liver tissues occurs.
Given the accumulation in the environment of radioactive elements, salts of heavy metals and pesticides that penetrate the human body, inexpensive melon products with a high content of pectin, carotene, and dietary fiber are of particular interest. The highest content of such substances is characterized by pumpkin, in which pectin polysaccharides interact with ions of radioactive substances and heavy metals, and a large number of free carboxyl groups in pectin molecules allows you to bind and remove heavy metal ions from the human and animal body. In connection with the foregoing, it becomes relevant to conduct preclinical studies in laboratory animals in order to establish the detoxification properties of pumpkin pectin as a potential natural, highly effective chelate that can remove heavy metals from the human body (Ptichkina *et al.* 2008; Yi *et al.* 2024; Kurdil *et al.* 2025).

MATERIALS AND METHODS

The experiments were conducted on white sexually mature laboratory rats, males weighing 230 ± 20 g, at the Institute of Human and Animal Physiology of the Ministry of Education and Science of the Republic of Kazakhstan in two stages.
At the first stage, experiments were carried out to determine the dose when seeding experimental rats with heavy metals: lead and cadmium is the lethal outcome of rats in 50% of experimental cases. To determine the lethal dose of toxicants, they were guided by the determination of the dose by statistical regression analysis. According to the linear regression equation: $Y = 500 X– 96.667$ ($R^2 = 0.99$).
where, X is the dose of the introduced toxicant, and Y is the number of dead animals in percent, and R^2 is the coefficient of determination, so we determined:
LD_{50} = 6-8 mg kg^{-1} for lead nitrate Pb $(NO_3)_2$ and
LD_{50} = 6.25 mg kg^{-1} for cadmium: cadmium chloride ($CdCl_2$; Satarug *et al.* 2020).
At the next stage, after determination of LD_{50} chronic experiments were carried out in two experimental groups, with four subgroups in each (72 rats in total). In the first experimental group, 32 rats were injected with cadmium chloride and in the second group 32 rats with lead nitrate. Separately, one subgroup of 8 rats (control) was monitored without the introduction of toxicants in the usual diet of vivarium. In the control group, the rats were injected once a week intraperitoneally throughout the entire period of the experiment (Facilities & Care 1968).
In order to establish the content of heavy metals in the blood plasma of laboratory rats, toxicants were administered weekly at a rate of 0.3, which corresponds to 2.0 mg kg^{-1} for lead nitrate and 2.08 mg kg^{-1} for cadmium chloride. Since the weight of rats averaged 250 g, 0.51 mg kg^{-1} cadmium chloride ($CdCl_2$) was taken for seeding animals; as well as 0.50 mg kg^{-1} lead nitrate [$Pb(NO_3)_2$], dissolved in 5-mL water, which were administered orally into the oral cavity with a special syringe. The experiments were carried out in compliance with the basic principles of the Helsinki Convention on the humane treatment of laboratory animals.
In experimental rats, under ether-thiopental anesthesia, blood was taken from the femoral vein, in which the content of heavy metals (lead and cadmium) was determined. In addition, the content of hemoglobin, total protein and urea was determined at the beginning, middle and end of the experiment.
All these rats were on the usual diet of vivarium. In order to detoxify heavy metals, experimental rats with chronic heavy metal intoxication were subsequently fed pumpkin pectin and pectin-containing products for 3 months.
The content of heavy metals was determined on a Hitachi atomic absorption spectrophotometer. For analysis, samples were prepared by dry ashing in a muffle furnace with a gradual increase in temperature to 450 °C and holding the ash at this temperature for 8 to 10 hours. The resulting ash was dissolved by heating in a 1 M unipolar nitric acid solution (GOST 30178 - 96). The analyzes were carried out in the Department of Mass Ecological Research; hereinafter, it will be conventionally named 0.1 μg mL^{-1} for lead and 0.005 μg mL^{-1} for cadmium. Blood biochemical parameters were determined on a BS200 Mindray biochemical analyzer, hemoglobin on a Sysmex KX-21 hematological analyzer.
Starting from the third day and the following days, within a month after the injection of heavy metals, the animals were taken for analysis. Under acute anesthesia in rats in acute experiments, blood was drawn from the abdominal vein, in which the content of heavy metals and a blood test for the content of hemoglobin were determined.
According to the generally accepted method using standard diagnostic reagent kits, the content of total protein, and urea in blood plasma was determined.
Biochemical blood tests in laboratory rats were performed on a BS200 Mindray instrument, and hemoglobin on a Sysmex KX-21 hematology analyzer (Elhussien & Adwok 2018; Ebrahimi *et al.* 2020).

Caspian J. Environ. Sci.
DOI:

Received:
Article type: Review

RESULTS

Reception of pectin for prevention (4-5 g), and in adverse environmental conditions, including intoxication with heavy metals and in conditions of radioactive contamination (15-16 g) per day is recommended. The average human weight is 70 kg, and experimental rats 0.250 kg, then the dose of pectin for the intoxication of one rat, calculated on its weight will be 0.06 g per day.

Biomonitoring results showed that the accumulation of lead and cadmium cations in the blood in intact animals and in the dynamics of their reproduction of lead and cadmium intoxication is characterized by certain features (Table 1). In intact (control) animals, under conditions of the natural intake of heavy metals from the environment (air, water, and food), the relative concentration of lead cations was twice as high as cadmium. These data coincide with data indicating a high cumulative ability of lead in the presence of stable sources of its entry into the animal organism.

In the dynamics of the experiment of modeling chronic intoxication with heavy metals with the addition of 1/3 LD_{50} of cadmium chloride and lead nitrate to rats, there was a progressive accumulation of these metals in the blood, for example, by the end of the month 12-12.5 times compared to the content in control animals (Fig. 1).

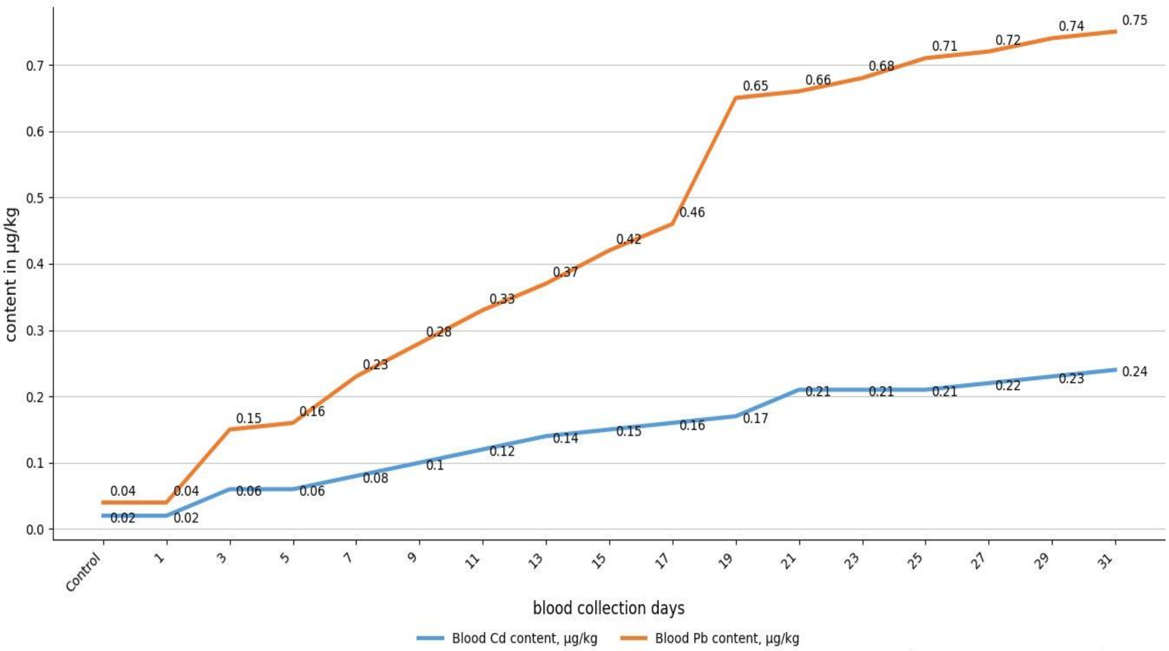

Fig. 1. The content of heavy metals in the blood of experimental rats every day for a month.

As can be seen from the obtained data (Fig. 1), the content of both cadmium and lead in the blood of experimental rats when they were seeded with heavy metals increased compared to those of intact rats from the control group, which were on vivarium nutrition. The most significant increase in both lead and cadmium was noted from the 21st day after rat poisoning with these pollutants, while lead intoxication (0.40 mg kg^{-1}) was more pronounced compared to cadmium (0.21 mg kg^{-1}).

After the introduction of toxicants in experiments in animals from each experimental group, a blood vein was taken from the femoral vein under ether-thiopental anesthesia, in which the content of hemoglobin, total protein and urea was determined (Monica *et al.* 2022). An increase in the concentration of lead and cadmium in the blood led to a change in some biochemical parameters of blood and hemoglobin in experimental rats.

In our studies of chronic intoxication of experimental rats, a significant decrease in the total protein in blood plasma was observed both when seeding with cadmium chloride and lead nitrate, the higher the concentration of metal in the blood increased, the more significantly the total protein content decreased (Tables 1-2).

The experiments were continued on laboratory rats, which for a month were susceptible to chronic intoxication in one experimental group with lead nitrate and in the other with cadmium chloride. In both groups, by the end of the seed, a progressive increase in the concentration of Cd and Pb and a negative change in the biochemical and hematological parameters of the blood were noted.

Caspian J. Environ. Sci.
DOI:

Received:
Article type: Review

Table 1 - The content of biochemical parameters of blood and hemoglobin in experimental (intoxication with Cd) and control rats.

Indicator	Control group	Intoxication with cd		
		Blood sampling days		
		11	21	31
The content of Cd in the blood (μg kg^{-1})	0.02 ± 0.0001	0.12 ± 0.000 5	0.21 ± 0.001	0.24 ± 0.001
Total protein (g L^{-1})	68.2 0 ± 0.34	54.99 ± 0.24	54.1 ± 0.27 *	52.3 ± 0.25 *
Urea in blood plasma (mmol L^{-1})	4.62 ± 0.02	6.05 ± 0.03	7.75 ± 0.03	8.02 ± 0.03
Hemoglobin (g L^{-1})	14.95 ± 0.06	12.26 ± 0.06	1 1.45 ± 0.05 *	11.03 ± 0.04 *
* - significantly compared with control ($p < 0.05$).				

Table 2. The content of biochemical parameters of blood and hemoglobin in experimental (intoxication with Pb) and control rats

Indicator	Control group	Intoxication with Pb		
		Blood sampling days		
		11	21	31
The content of Pb in the blood (μg kg^{-1})	0.0 4 ± 0.0002	0.1 7 ± 0.0007	0.44 ± 0.002	0.50 ± 0.002
Total protein, (g L^{-1})	68.2 0 ± 0.33	5 5.20 ± 0.26	5 2.1 5 ± 0.25 *	5 0.80 ± 0.25 *
Urea in blood plasma (mmol L^{-1})	4.62 ± 0.02	6.73 ± 0.03	8.24 ± 0.04	8.80 ± 0.03
Hemoglobin, (g L^{-1})	14.95 ± 0.06	12.1 6 ± 0.05	11.25 ± *	11.00 ± 0.04 *
* - q reliably in comparison with the control ($p < 0.05$).				

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Thus, the scheme for conducting this stage of the experiments was as follows. Two series of experiments were carried out at this stage:
I series - experiments on rats poisoned with cadmium chloride;
Series II - experiments on rats poisoned with lead nitrate.
As correctors used: pumpkin pectin solution; pectin-containing food products: wheat bread with pumpkin pectin in an amount of 0.5%; confiture containing pumpkin pectin 1.0%. Calculation of the dose of correctors was carried out in accordance with the recommendations on the daily norms of pectin and minerals for rats (Mata *et al.* 2010). Reception of pectin for prevention is recommended (4-5 g). And in adverse environmental conditions, including intoxication with heavy metals and in conditions of radioactive infection (15-16 g) per day per person. Next, the daily amount of pectin and pectin-containing food products for one rat was calculated depending on its weight (250 g on average). As proofreaders used: 0.06 g of dry pectin dissolved in 5 mL of water, 12 g of bread, 6 g of confiture.
Proofreaders were administered daily once a day throughout the study period for 3 months to pre-seeded rats.
In each series of experiments, all animals were divided into 4 groups:
The first group of experimental animals received pumpkin pectin daily in an amount of 0.06 g dissolved in 5 mL water for each rat.
The second group of experimental animals received daily bread as a corrector with 0.5% pectin content at the rate of 12 g bread per rat weighing 250 g.
The third group of experimental animals received daily confiture with 1% pectin in a dose of 6 g confiture per rat weighing 250 g.
In each series of experiments, control was cadmium - and pig-induced animals that did not receive corrector, which were only on the usual food regimen. During the analysis, all the obtained results of the experimental and control groups of animals were compared with the results of intact animals, the studied parameters of which were taken as indicators of normal values for 100%. Daily monitoring was carried out on the state of animals in all experimental and control groups: feed intake, water intake, and behavioral status. In addition, on the 30th, 60th and 90th day of the experiment, blood was collected from animals according to the above method for determining heavy metals, total protein, urea and hemoglobin. The results of the experiment in the first series of experiments on cadmium-induced rats are shown in Fig. 2.

Caspian J. Environ. Sci. Received:
DOI: Article type: Review

The change in the content of total protein, urea and hemoglobin in the blood of experimental and control rats in% ratio

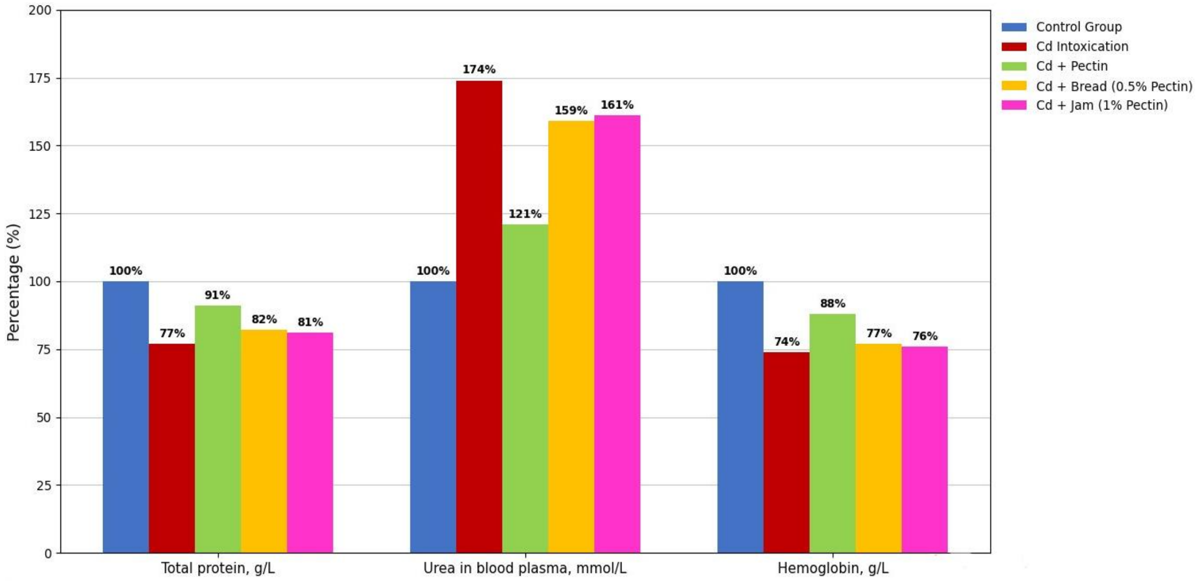

Fig. 2. The change in plasma ratios of experimental rats in a% ratio against the background of intoxication with cadmium chloride when feeding pectin and pectin-containing products.

The dynamics of changes in the biochemical parameters of blood and hemoglobin of cadmium-induced rats during the correction of their nutrition with pectin and pectin-containing products showed a stable and progressive change in the content of cadmium and biochemical blood parameters. Hemoglobin indices in the direction of improvement approached already 30 days after the start of correction to the indices of intact animals by the 3rd month of correction of their nutrition with pumpkin pectin. So, by the end of the 3rd month after the start of correction of Cd-induced experimental rats, the total protein content was 62.4 ± 3.80, which amounted to 91% of the intact rats, thereby being significantly close to the normal values (Fig. 2). Identical changes in urea and hemoglobin were observed in cadmium-induced rats when corrected by pumpkin pectin. A biochemical blood test in experimental rats from the 2nd and 3rd group, where the correction of cadmium-induced disorders was carried out with bread containing 0.5% pectin and confiture with 1% pectin, showed a tendency to improve the studied parameters. However, in comparison with the values from the control group of animals, they did not differ significantly and were close to each other. Comparison of the results of changes in the biochemical parameters of control rats (cadmium-induced rats under normal diet) and experimental rats receiving additional nutrition in the form of pure pectin and pectin-containing products showed that the studied blood parameters in control animals remained unchanged for almost 3 months, the general condition gradually worsened, objectively, the development of conjunctivitis was observed in animals, shortness of breath, impaired coordination of movements, hair loss, loss of appetite, weakness.

The dynamics of changes in the biochemical parameters of blood and hemoglobin of pig-induced rats during the correction of their nutrition with pectin and pectin-containing products showed a stable and progressive decrease in the content of lead and biochemical parameters of blood, as well as hemoglobin, in the direction of improvement. From day 30 from the beginning of correction to the end of the experiment, the biochemical blood parameters of the experimental rats approached those of intact animals by the 3rd month of their feeding with pure pectin. By the end of the 3rd month after the start of the correction of lead intoxication in experimental rats, the total protein content was 65.10 ± 3.20, which amounted to 95% of the intact rats, thereby being significantly close to the normal values (Fig. 3). Identical changes were noted in pig-induced rats with correction by their pectin in terms of urea and hemoglobin. However, when compared with parallel groups of rats induced by cadmium, lead intoxication is faster, heavy metals are more intense. Biochemical blood analysis in experimental rats from the 2nd and 3rd groups, where the correction of pig-induced disturbances was carried out with bread containing 0.5% pectin and confiture with 1% pectin showed a tendency to improve the studied parameters, compared to the control group of animals they differed slightly and were close to each other.

Caspian J. Environ. Sci. Received:
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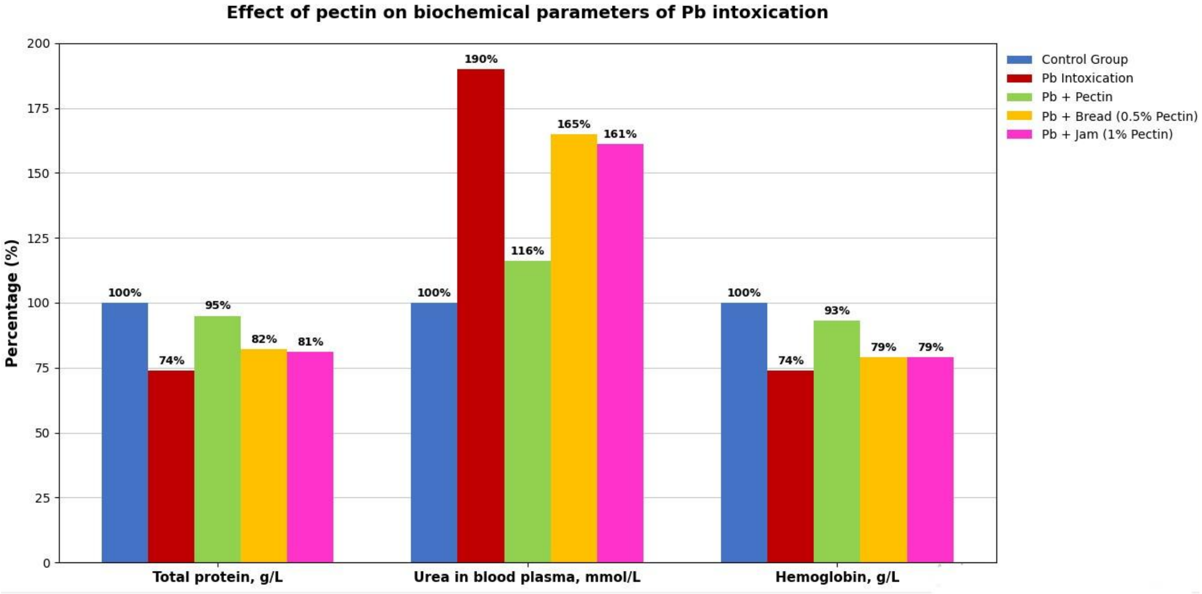

Fig. 3. Blood counts in% ratio on the background of lead nitrate intoxication when fed with pectin and pectin-containing products.

DISCUSSION

We took generally accepted biochemical blood parameters, such as total protein and urea, as well as hemoglobin for the following reasons. It is known that total blood protein characterizes metabolic processes in the body and liver function, since most of them are synthesized in this organ. A decrease in total protein in the blood leads to starvation, kidney disease, blood loss, diabetes, liver disease, poisoning with toxic substances. Overstatement of this indicator can cause dehydration and other serious disorders (Dhondup & Qian 2017). It is known that the final product of protein metabolism is urea, which is excreted by the kidneys and therefore the urea content in the blood is an indirect indicator of kidney function. The increase in urea in experimental rats with cadmium and lead intoxication indicates significant damage to the kidneys in experimental rats compared to intact rats.

Hemoglobin, an iron-containing pigment that plays an important role in the transfer of oxygen from the respiratory system to tissues. In our experiments, intoxication of rats with heavy metals, the hemoglobin index decreased significantly compared to the index of intact rats. This negatively affects not only the hematological parameters of the red blood of experimental rats and contributes to the development of anemia, but also the antioxidant system as a whole (Dallak, 2009; Mohammadi Soleimani *et al.* 2024). Thus, the results of studies that we obtained when setting up chronic experiments on rats with inoculation of heavy metals of both lead and cadmium salts revealed a significant increase in the concentration of these salts in their body over the duration of the inoculation, which in turn caused a drop in total protein and hemoglobin urea buildup in the blood. These changes in the biochemical composition of the blood allow us to judge the functional state of experimental rats: hypoproteinemia - a decrease in liver function; increase in urea - about the stress of kidney activity; decrease in hemoglobin - on the development of anemia and the formation of hemic hypoxia. It is known that the initial stage of development of hemic hypoxia is a serious stress factor for the life of any living organism.

All these factors dictate the need for timely treatment and preventive measures for various intoxications, including poisoning with heavy metals. The treatment and preventive measures aimed at detoxifying lead and cadmium in a living body are based on the use of different types of chemicals, which are noted for the ability to form real chelates, complexes or compounds with heavy metals, and are excreted in this form. It is known that chelation therapy is rarely directed to one system (target organ), therefore, therapeutic support of the target organ (for example, biologically active food additives enriched with macro- and microelements) is not less important than the use of antidotes only. Therefore, the search continues for new and most effective agents for the treatment of chronic lead and cadmium intoxication. A new enough direction is the use of natural sorbents, phytopreparations, dietary supplements and their complexes in combination with the foodstuffs necessary for humans to correct such disorders in order to increase the body's stability, remove toxic elements from the body that enter the body from

Caspian J. Environ. Sci. Received:
DOI: Article type: Review

the environment while filling up the deficit essential vital elements (Mata *et al.* 2010; Wong *et al.* 2014; Eliaz & Raz 2019; Yurak *et al.* 2021 ; Roushenas *et al.* 2022).
The next stage of experiments was carried out to study the possibility of correcting the multi-organ toxic effect of heavy metals in rats subjected to lead and cadmium intoxication using the pumpkin pectin. We obtained as a potential highly effective chelate capable of removing heavy metals and thereby possessing detoxifying properties. The main effect of the therapeutic effect of pectin is associated with the formation of strong insoluble chelate complexes with polyvalent metals and the removal of the latter from the body.
The pectin reacts with heavy metals most likely as follows: as a part of the complex, a bond forms between the donor and the acceptor. It is from the standpoint of the donor-acceptor mechanism that the formation of bonds in complex compounds is described. Oxygen atoms with non-separated electron pairs on small valence orbitals are donors: the bond is formed due to these pairs of oxygen electrons in the carboxyl, hydroxyl groups, glyosidic bond, and free orbital of the complexing atom. The role of the acceptor is played by the p-metal (for example, lead in the formation of the $Pb\ (OH)_2$- ion, which have unfilled energy cells in the valence electron layer, on which the undivided electron pair of the oxygen atom is located.
We associate the probability of such changes with an insignificant pectin content in these products and insufficient nutritional adjustment in time. Perhaps for a more positive use of pectin-containing products, we should increase the time of intake of these products. A comparison of the results of changes in the biochemical parameters of control rats (pig-fed rats under normal diet) and experimental rats receiving additional nutrition in the form of a solution of pectin and pectin-containing products showed that the studied blood parameters in control animals remained unchanged for almost 3 months, general condition gradually worsened.
By analogy, as in cadmium-induced animals, there was a violation of coordination of movements, loss of coat, loss of appetite, weakness. Thus, the results obtained indicate that even insignificant intake of pectin in pectin-containing products when used to correct cadmium and pig-induced animal disorders is positive in the direction of an improvement in blood parameters, thereby contributing to a decrease in the toxic effect of heavy metals and maintaining stability in life support of experimental animals.
Therefore, when comparing the results of cadmium correction of induced and pig-induced disturbances in experimental rats, pumpkin pectin solution and pectin-containing products revealed a general pattern. In both series of experiments, pectin has a positive effect on the reduction of detected stress-induced disorders. When comparing the results of the correction of pectin on the studied biochemical parameters, better indicators were revealed in pig-induced rats compared to cadmium-induced rats. The study allows us to recommend pumpkin pectin as an effective plant chelating biologically active substance not only for intoxication with heavy metals, but more as a prophylactic in a megalopolis, since pollutants entering the body even in minimal quantities can gradually accumulate and exert their harmful effects on the body and cause chronic diseases (Aldakhoul *et al.* 2024).

CONCLUSION

By analyzing the results of the studies, it can be concluded that heavy metals with a wide range of biological effects are among the toxicants that are especially dangerous for human health. One of the ways to solve this problem, caused by environmental pollution and the ingestion of excessive amounts of heavy metals and radionuclides into the human body, is to create chelators of a detoxifying effect.
1. It was found that pumpkin pectin, administered to experimental rats at a dose of 0.06 g per 250 g of animal weight, has a pronounced correction effect on the studied biochemical parameters, such as total protein, urea, as well as blood hemoglobin, which contributes to the improvement of the functional state of stress-induced animals.
2. The pronounced effect of the correction of pumpkin pectin on the content of heavy metals was detected to a greater extent in pig-induced rats, compared to cadmium-induced rats.
3. Pectin-containing products - bread and confiture with pumpkin pectin content of 0.5% and 1.0%, respectively, have a positive tendency to reduce the toxic effect, thereby performing the function of corrector of heavy metals.
4. Improving the biochemical parameters of blood and the general functional state of laboratory rats induced by heavy metals when using pumpkin pectin and pectin-containing food products allows us to recommend them as products with therapeutic and prophylactic, detoxifying properties in case of chronic heavy metal poisoning.
Thus, providing the population with ecologically clean food products with detoxifying properties, based on the use of pumpkin pectin, which helps to eliminate harmful substances from the body, is of great social importance.

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