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Research Paper

Effect of Cadmium Chloride on the weight of body and some organs of Japanese quail and the protective role of Quercetin

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Abstract— The current study wanted to know the effects caused by cadmium chloride in the body weight and the weight of some organs of the Japanese quail *Coturnix coturnix japonica* , which are the liver, kidney, and brain and the protective role of quercetin against these changes. In this study, (75) quail birds were used, and the birds were randomly divided into five experimental groups. The first group: which is the control group, was given distilled water for 45 days. The second group: the acute treatment group, was dosed with cadmium chloride at a concentration of 50 mg/kg for four consecutive days. The third group: the chronic treatment group, was dosed with cadmium chloride at a concentration of 20 mg/kg for 30 days. The fourth group: the quercetin group, was dosed with quercetin at a concentration of 50 mg/kg for 30 days, while the fifth group: which is the interference group, was dosed with quercetin at a concentration of 50 mg/kg for 45 days and within this period it was dosed with cadmium chloride at a concentration of 20 mg/kg for 30 days. The birds were dissected 4, 15, 30, and 60 days after the start of the experiment, and the birds were weighed before the start of the experiment and before each dissection, and the studied organs were weighed immediately after the dissection. The statistical results showed that there was a significant increase in the weight of the birds in the interference group compared to the control group as well as the rest of the groups. While the weight of the liver and kidney was significantly higher in the acute treatment group than the rest of the groups. While the brain weight was significantly higher in the quercetin group than the rest of the groups.

Keywords— Cadmium chloride; Japanese quail; Quercetin; Heavy metal.

1. Introduction

Pollutants are one of the major challenge in the society of modern human. The existence of heavy metals in the environments constitutes a real threat to the quality and sustainability of environmental systems. Pollution of aquatic and terrestrial ecosystems with toxic heavy metals is an environmental problem of public health concern. The high accumulation of toxic heavy elements poses a great danger to the health and life of plants, animals and even humans [1]. Mineral accumulation in birds is affected by a variety of indicators such as: nutritional status, taxonomic group, genetic diversity, age, sex, bird size and plumage. This is because they are non-degradable environmental pollutants that accumulate at higher levels of food chains [2-3].

Cadmium (Cd) is one of the known worldwide environmental pollutants. Nowadays, it is an area of particular interest to researchers for its effects on the environment and health for its half-life, which ranges from 15-30 years, and it accumulates in organs and tissues, leading to adverse effects. [4]. The main anthropogenic sources of cadmium are fuel combustion, cement manufacturing, protective coatings on solid materials, power plants, PVC stabilizers, chemical fertilizers, plastics, electrode materials in nickel-cadmium batteries, mining activities, smelting of zinc in metal alloys, and cigarette smoke [5].

Humans and animals in general are exposed to cadmium through contaminated drinking water, food, and air. Cd pollution and poisoning of economic animals lead to great losses, so there is an increasing concern about environmental pollutants on animal production [6-7].

Chronic exposure to Cd in low doses alters the microstructure of cells and tissues in animals, particularly in the brain, kidneys, liver, reproductive organs, intestines, and pancreas. As Cd causes an increase in intracellular oxidative stress, as it leads to excessive production of reactive oxygen species, which in turn leads to the depletion of antioxidant defense mechanisms [8].

Quercetin shows many beneficial effects for human and animal health, as it has different types of physiological roles,

as it acts as an antioxidant as well as an anti-inflammatory and also contributes to the regulation of immune activities [9-11].

Quercetin also has an antitumor effect, by changing the progression of cancer cells, preventing their proliferation, promoting programmed cell death, inhibiting angiogenesis, and affecting cell autophagy [12]. Quercetin also prevents oxidative stress by regulating the expression of antioxidant enzyme genes, and it contributes to the prevention of hypertension, stroke, ischemic heart disease, and heart failure [13].

Based on the previous, this study came to know the acute and chronic effects of cadmium chloride ($CdCl_2$) on the body weight and the weight of vital organs in Japanese quail, which are liver, kidney and brain and the protective role of quercetin.

2. Materials and methods

I. Study birds

The current study was conducted on Japanese quail *C. c. japonica*. They were (3) weeks old and weighed between (143-143.5g). The birds were obtained from the College of Agriculture and Forestry, Department of the Animal Production, University of Mosul. They were raised in wooden cages with attention to cleanliness, sterilization, and continuous nutrition. The natural conditions of lighting, temperature and ventilation were adopted during the experiment [14-16].

II. Choose the dose used in the study

The dose of the study was chosen based on the experiment to determine the LD50 [17-18]. The dose used in this study was 50,20 mg/kg of body weight, as it was dissolved in 0.5ml of distilled water and dosed through the mouth with a Gavage needle.

III. Experimental design

In this study, 75 quail birds were used from both sexes, divided equally into five groups. The first group: which is the control group, it was dosed with distilled water for 45 days. The second group: the acute treatment group, was dosed with cadmium chloride at a concentration of 50 mg/kg for four consecutive days. The third group: the chronic treatment group, was dosed with cadmium chloride at a concentration of 20 mg/kg for 30 days. The fourth group: the quercetin group, was dosed with quercetin at a concentration of 50 mg/kg for 30 days, while the fifth group: which is the interference group ($CdCl_2$ + Qu), was dosed with quercetin at a concentration of 50 mg/kg for 45 days and within this period it was dosed with cadmium chloride at a concentration of 20 mg/kg for 30 days.

The birds were dissected 4, 15, 30, and 60 days after the start of the experiment, and the birds were weighed before the start of the experiment and before each dissection, and the studied organs were weighed immediately after the dissection.

IV. Statical Analysis

The data were analyzed using the simple and factorial experiment system Complete random design. Transactions have been tested Dunken's New Multiple Rang Test, where the significantly different coefficients were distinguished by different alphabets and under 1% probability level.

3. Results and Discussion

I. Effect of $CdCl_2$ and Quercetin concentrations on the weight of birds

Table (1) indicates that there are significant differences at the level of probability ($P \leq 0.01$) in the weights of birds between the birds of the groups of materials used and their concentrations, as well as the periods used, compared with the control group. The highest weight and a significant difference from the control group and the rest of the experimental groups appeared in the fifth group exposed to an interference between ($CdCl_2$ + Qu) two months after the start of the experiment, with a value of (226,000), followed by the weight in the second experimental group exposed to a concentration of 50 mg/kg of $CdCl_2$ for the same period, and its value was (211,666). As for the lowest weight and a significant difference at the level of probability ($P \leq 0.01$), it appeared in the fourth group exposed to quercetin four days after the start of the experiment, and its value was (160,666).
As for the comparison between the experimental groups and the control group during the experimental periods. It find in Table (1) that there is a significant increase in the second experimental group after four days, compared to the rest of the experimental groups, and it was higher than the control group, but with a non-significant difference, while No significant difference appeared between the third and fifth experimental groups, and the third group had less weight than the control group with a significant difference.

As for 15 days after the start of the experiment, it is noted from the table that the highest significant increase in the weight of the birds appeared in the birds of the fifth group compared to the birds of the third and fourth experimental groups, as well as with the control group, and it also appeared higher than the second experimental group, but it was not significant. Whereas, less weight appeared in birds of the third and fourth groups at the level of probability ($P \leq 0.01$).
A month after the start of the experiment, the second and fifth experimental groups also showed higher weight than the rest of the experimental groups and the control group with a significant difference, while there was no significant difference between them in weight at the level of probability ($P \leq 0.01$). It showed less weight and a significant difference from the rest of the groups in the birds of the fourth experimental group. After 60 days, the birds of the fifth group continued to be significantly superior in weight to the rest of the groups, until the second experimental group, which appeared to be less significant in weight, but higher than the rest of the groups, as well as the control group at the level of probability ($P \leq 0.01$).

When comparing the weight of the birds in the same group during the experimental periods, it is noted from Table (1) a significant increase in the weights of the birds of all groups, as well as the control group.

It has been found that quercetin reduces the adipose tissue in animal, production and plasma NOx concentration in rats and has anti-inflammatory effects, which leads to a decrease in body weight [19]. The results agree with what [20], that cadmium caused an increase in body weight in groups exposed to cadmium chloride at a concentration of 12 mg/kg and 24 mg/kg, but it was less than that of the control group, because cadmium is able to induce Oxidative stress and altered activities of antioxidant enzymes and increased lipid peroxidation in birds.

The results of this study do not agree with a study conducted on rats that were treated with 200ppm of cadmium chloride with drinking water for a period of 5 weeks, where no statistically significant differences were observed regarding body weight or the relative weight of organs (liver, kidney) [21]. A decrease in the body weight of mice treated with 200ppm cadmium chloride for a period of 30 days was also observed [22-23].

Table 1. The effect of treatment with cadmium chloride and quercetin on the body weights of quails (g).*

Group / Period	1	2	3	4	5
Before experiment	143.5000 n	143.1667 n	143.6667 n	143.3333 n	143.0000 n
After 4 days	170.0000 jk	172.3333 j	165.0000 l	160.6667m	167.0000 kl
After 15 day	179.3333 i	181.6667 hi	169.6667 jk	171.8333 j	184.0000 h
After 30 day	191.6667 fg	199.0000 de	191.0000 g	184.3333 h	202.3333 cd
After 60 day	203.5000 c	211.6667 b	204.6667 c	195.3333 ef	226.0000 a

*The numbers followed by different lowercase letters indicate that there is a significant difference between the experimental groups at the probability level ($p \leq 0.01$), and vice versa, according to the Duncan test.

II. Effect of $CdCl_2$ and Quercetin concentrations on the weight of Liver

Table (2) indicates the effect of $CdCl_2$ and quercetin concentrations and the interaction between them on liver weight in experimental group birds compared with the control group at the probability level ($P \leq 0.01$).

It appears from the table that the highest liver weight, with a significant difference, appeared in the birds of the second experimental group, two months after the start of the experiment, and its value was (8.0937), while the lowest weight of the liver, with a significant difference, appeared in the birds of the third experimental group, 4 days after the start of the experiment, and its value was (2.9367).

When comparing the groups in the same periods, Table (2) shows that after 4 days of the experiment, the weight of the liver was less and with a significant difference than the control group and the rest of the experimental groups in the birds of the third experimental group, as mentioned previously, while there were no significant differences among the rest of the experimental groups in What's in between. After 15 days from the start of the experiment, it appears from Table (2) that there are no significant differences between the third and fourth experimental groups on the one hand and the control group on the other hand, and the weight of the liver in these three groups was higher and with a significant difference from the rest of the experimental groups in which the second experimental group was higher And a significant difference from the fifth experimental group at the level of probability ($P \leq 0.01$).

A month after the start of the experiment, the weight of the liver in the birds of the second experimental group, followed by the third experimental group, appeared to be higher in weight and with a significant difference from the rest of the experimental groups on the one hand and from the control group on the other hand, with a value of (5.1300) and (4.640), respectively. While the weight of the liver in the fifth group was lower and with a significant difference from the rest of the groups. Two months after the start of the experiment, a less significant difference in liver weight appeared in the birds of the fifth experimental group than the rest of the experimental groups and the control group. And higher weight and a significant difference appeared in the weight of the liver in the birds of the second experimental group at the level of probability ($P \leq 0.01$).

As for the weight of the liver in the same group over the length of the experiment period, it is noted from Table (2) a direct increase in the weight of the liver throughout the experiment period for the experimental groups, and this increase was significant in all groups except for the control group as well as the fourth experimental group, as the increase was between a period of 15 days Months from the start of the experiment were not significant at the probability level ($P \leq 0.01$).

The results of this study agree with the results of another study, [23], an increase in liver weight in rats treated with 200PPM cadmium chloride for a period of 30 days. These findings are also consistent with the observation by [24] of increased liver volume in mice treated with cadmium chloride, which may be attributed to inflammation resulting from exposure to this metal, which leads to activation of Kupffer cells and their release of inflammatory cytokines. These results are also consistent with the results of the study [25], which indicated an increase in the weight of the liver due to its enlargement as a result of its absorption and transport from the blood to the liver.

Table 2. The effect of treatment with cadmium chloride and quercetin on the liver weight of quails (g)*.

Group / Period	1	2	3	4	5
After 4 days	3.7333 ij	3.5233 k	2.9367 l	3.5967 jk	3.5867 jk
After 15 day	4.0933 gh	4.5900 f	4.0667 gh	4.0867 gh	3.7667 i
After 30 day	4.1600 g	5.1300 e	4.6400 f	4.1600 g	3.9567 h

After 60 day	7.0500 b	8.0933 a	6.1233 c	6.2100 c	5.9667 d

*The numbers followed by different lowercase letters indicate that there is a significant difference between the experimental groups at the probability level ($p \leq 0.01$), and vice versa, according to the Duncan test.

III. Effect of $CdCl_2$ and Quercetin concentrations on the weight of Kidney

Table (3) shows the effect of $CdCl_2$ concentrations as well as quercetin and the interaction between them on kidney weight in birds of the experimental groups and the control group at the probability level ($P \leq 0.01$). It is noted from the table that the lowest weight of the kidney and with a significant difference appeared in the third and second experimental groups after 4 days of the experiment had passed, and its value was (0.9200) and (0.9433) respectively, while the highest weight of the kidney and with a significant difference from the rest of the experimental groups in the birds of the control group after two months. From the beginning of the experiment, the value was (3.0207).

When comparing the group in each time period, it is noted from Table (3) that 4 days after the start of the experiment, no significant difference appeared between the fourth and fifth groups compared to the control group, as well as between them, while the second and third groups showed less weight and a significant difference than the rest of the groups. The experimental group and the control group did not show any significant differences in kidney weight. After 15 days from the start of the experiment, significant differences appeared between the four experimental groups, and all of them showed significant differences compared to the control group, except for the fourth experimental group, which did not show a significant difference with the control group. The highest kidney weight appeared in the birds of the fifth experimental group, with a value of (1.5433). As for the lower weight, with a significant difference from the control group and the rest of the experimental groups, it appeared in the second experimental group, and its value was (1.084).

As for after one and two months from the start of the experiment, a higher kidney weight appeared in the birds of the control group, compared to all experimental groups, with a significant difference at the level of probability ($P \leq 0.01$). While the comparison between the experimental groups alone showed that the weight of the kidneys was higher in the second group, with a significant difference from the rest of the groups, followed by the third experimental group. As for the lowest weight and a significant difference for the kidneys, it appeared in the fourth experimental group, and its value was (1.5167) and (2.5667) after one and two months, respectively.

When comparing within the same group and during the experimental period, it is clear from the table that there is a direct significant increase with the passage of the experiment period for the control group as well as the experimental groups.

It is clear from these results a decrease in the weight of the kidneys in general in the experimental groups compared to the control group, this may be due to the effect of the materials used on the composition histological of the kidney as well as its effect on the kidney function, which may lead to a defect in absorption water, as well as other substances, which in turn may affect the weight of the kidney. These results are not consistent with In the study of [26], kidney weight was significantly increased in rats exposed to cadmium chloride compared to the control group. While I agreed with another study [27], which showed a decrease in kidney weight in groups of rats exposed to cadmium chloride 150-300 mg/kg.

Table 3. The effect of treatment with cadmium chloride and quercetin on the kidney weight of quails (g)*.

Group / Period	1	2	3	4	5
After 4 days	1.1500 n	.9433 o	.9200 o	1.1367 n	1.1400 n
After 15 day	1.4567 kl	1.0867 n	1.3033 m	1.4033 l	1.5433 j
After 30 day	2.1167 f	1.8433 g	1.7367 h	1.5167 jk	1.6133 i
After 60 day	3.0267 a	2.9167 b	2.7667 c	2.5667 e	2.6700 d

*The numbers followed by different lowercase letters indicate that there is a significant difference between the experimental groups at the probability level ($p \leq 0.01$), and vice versa, according to the Duncan test.

IV. Effect of $CdCl_2$ and Quercetin concentrations on the weight of Brain

Table (4) indicates the effect of $CdCl_2$ and quercetin on brain weight in the birds of the experimental groups compared with the control group as well as between them at the level of probability ($P \leq 0.01$). It appears from the table that the highest brain weight, with a significant difference from the rest of the experimental groups and the control group, appeared in the fourth and fifth experimental groups, and after two months had passed, and its value amounted to (1.0217) and (0.9890), respectively, and no significant difference appeared between them. As for the less weight of the brain, it appeared in the birds of the second experimental group, 4 days after the start of the experiment, and its value was (0.4690).

As for the comparison between groups according to the time period, it is noted from Table (4) that after 4 days the brain weight was higher and with a significant difference in the birds of the third experimental group than in the control group and the rest of the experimental groups, and that less weight and a significant difference appeared in the birds of the second experimental group As mentioned above. After 15 days, the brain weight was higher and with a significant difference in the birds of the third and fourth experimental groups, and no significant difference appeared between them, although it was higher in the fourth experimental group.

After a month, the brain weight was higher in the fourth experimental group, with a significant difference from the control group and the rest of the groups, with a value of (0.9933), and it was less weight and a significant difference in

the second group at the level of probability ($P \leq 0.01$). Two months after the start of the experiment, Table (4) shows a significant increase in brain weight in the fourth experimental group compared to the control group and the second and third experimental groups, while no significant difference appeared between the brain weight in this group and the fifth experimental group. It was also less brain weight in the birds of the second experimental group.

As for the weight of the brain within the same group, it is noted from the table a direct significant increase in the average time period as well as in the control group, while in the experimental groups there was an increase, but it is not significant between the second and third periods in the second experimental group and between the second, third and fourth periods in the third experimental group And between the third and fourth periods in the fourth and fifth experimental groups. It appears from the above results that there is a clear effect of $CdCl_2$ on the weight of the brain, which indicates the negative effect of this substance on the weight of the brain and then on its histological structure and function, while the group treated with quercetin was close to the control group, which is indicated by most studies in the fact that quercetin is an antioxidant Which in turn contribute to maintaining the tissue structure of the organs and their functions. Studies have found that exposure to cadmium significantly increased the accumulation of the metal and reduced the concentration of zinc in the brains of pups of rats whose mothers were treated with cadmium chloride as changes in the expression of transcription factors, in response to Cd exposure, may have a detrimental role and lead to impaired brain development [28].

Table 4. The effect of treatment with cadmium chloride and quercetin on the brain weight of quails (g)*.

Group / Period	1	2	3	4	5
After 4 days	.6047 g	.4690 h	.7013 f	.6033 g	.6037 g
After 15 day	.8133 e	.7133 f	.8900 d	.9300 cd	.8333 e
After 30 day	.9073 d	.7367 f	.9180 cd	.9933 ab	.9423 bcd
After 60 day	.9667 bc	.8333 e	.9433 bcd	1.0217 a	.9890 ab

*The numbers followed by different lowercase letters indicate that there is a significant difference between the experimental groups at the probability level ($p \leq 0.01$), and vice versa, according to the Duncan test.

4. Conclusion and Future Scope

Cadmium is one of the heavy elements that have negative effects on human life, animals and even plants. It is an element used frequently in industries, which makes exposure to it inevitable. Therefore, it must be recommended to safely dispose of industrial waste residues and not touch them with living organisms. The cadmium chloride is one of the forms of cadmium used in modern industries. Exposure to cadmium chloride by quail birds leads to serious complications on their life, and it also causes a decrease in the weight of their bodies and vital organs, which reduces their economic benefit. The quercetin has an important role to play in reducing these risks. Because of the importance of quercetin in being one of the important antioxidants and the ease of obtaining it. Therefore, this study recommends that it should be used in feeding quails that are raised in the fields in order to increase their resistance to various pollutants.

Conflict of Interest

Authors declare no competing interest in the publication of this article.

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Authors' Contributions

Taha AM conceived the idea, designed this research work and prepared the manuscript for publication. While Mohammed H A contributed to the practical part of the research

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