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EFFECT OF CADMIUM CHLORIDE POLLUTION AND USING PENICILLAMINE ON PHYSIOLOGICAL PERFORMANCE OF JAPANESE QUAIL

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Abstract

This experiment was carried out to investigate the effect of cadmium chloride ($CdCl_2$) pollution and using penicillamine (PA) as a mitigation of cadmium toxic effect on some physiological characteristics of Japanes Quail. One hundred and eighty birds 8 weeks old (156 females and 24 males) were used, the birds reared in 4 batteries with 3 floor dimension 60× 60× 50 cm of each floor, feed and water were provide ad-libdum and the diet contain 2892 Kcal/Kg feed and crude protein 20.1%, the bird were exposed to 16: 8 light: dark period, environmental temperature 21-24 °C and relative humidity 50% and the experiment lasted for 8 weeks. Four treatments were used T1 without any addition to drinking water,T2 addition 5mg of $CdCl_2$ /L drinking water, T3 as inT2 plus addition 5mg of PA / 3ml drinking water/day /bird (was given from 900-1000 hour only), T4 as in T2 plus addition 10 mg of PA / 3ml drinking water /day/bird (was given from 900-1000 hour only) all treatments water is withheld for 1 hour from 800-900 hour), birds allocated to 45 birds each treatment 15 birds each replicates (13 females, 2 males). Packed cell volume (PCV%), Hemoglobin (Hb), Total Protein (TP), Glucose, Creatinine, High Density Lipoprotein (HDL), Glutathione Peroxidase (GPX) Glutamic Pyruvic Transaminase (GPT), Glutamic Oxaloacetatic Transaminase (GOT), Alkaline Phosphatase (ALP) were calculated at 4, 8 weeks of experimental period, Cd in blood serum, Red blood cell (RBC), Cd in liver, kidney, testis, ovary, brain, feathers were estimate at the end of the experiment. Histological sections of liver and kidney were prepared, The result revealed that TP increased significantly ($p \leq 0.05$) at 8 week of experimental period in T4 compared with control T1 ,while glucose reduced significantly at 4 week in all treatments compared with T1 meanwhile at 8 week the significant reduction in T2,T3 compared with T1, T4, no significant difference in PCV, Hb , HDL creatinine , however at 4week GPX increased significantly ($P \leq 0.05$) in T2 compared with T1, Moreover GOT increase at 8 week in T3 compared with T1,T2 also ALP reduced at 8 week in T2 compared with other treatments, also GPT at 8 week was higher than other treatments, Cd in blood serum, RBC, liver, testis, brain, were higher in T2 compared with other treatments, changes in hepatic tissue sections in T2, degenerative, hemorrhagic foci, central venous congestion was observed, renal cortex showed several hemorrhagic, an average renal failure in (RT) and expansion of the bowman portfolio of(MT) Compared to liver and kidney tissue sections in T1. We can concluded that there were some improvement in about most physiological characters with PA addition to reduce the harm effect of $CdCl_2$.

Keywords: Cadmium Chloride, Pollution, Penicillamine, Japanese quail

Introduction

Commercial poultry production is associated with various stresses include physical, psychological, physiological, chemical, biological, social, nutritional, climate and oxidative, nutritional stresses like heavy metals stresses lead to oxidative stress and decrease of production and reproductive performance (Grigorieva *et al*., 2017) Heavy metals contamination is a serious problem Considerable amount of heavy metal get to the environment by human activity (mining industry, steel, fossil fuel, fertilizer. etc) (Bersényi, 2003). Most of the poultry feed samples which they analyzed contained greater amount of cadmium (Cd) than the maximum tolerable levels for poultry (Maheser *et al*., 2010). Directly, when cadmium is absorbed by the human body or animal, it will remain for a long time if we knew that the cadmium half-life is up to 10 years (Darwish *et al*., 2002). complex Cadmium-protein (Metallothionin) is eliminated by the kidney and is re-absorbed by filtration of the proximal tubules and the renal cortex (By animal type) are most vulnerable to damage and erosion where the rate of disposal of the body is 0.009% through the kidney and 0.007% by liver (Klasing, 2005), The renal metallothionine leaves Cadmium free and unconnected and can cause damage to renal tubules Nordberg (1978). For the cadmium There is no clear mechanism for the process of cadmium buildup in the organs but there is a real possibility of the cadmium duo equivalence plays a disguised role in the body and accumulates in its organs by the same mechanism of transmission and accumulation of calcium and zinc in the human and animal body (Sutoo *et al*., 1990). Cadmium can replace iron and copper from a number of cytoplasmic and membrane proteins such as ferritin, which in turn will release and increase the concentration of non-bonded iron and copper ions. These free ions are involved in the induction of oxidative stress through the Fenton interactions (Casalino *et al*., 1997; Waisberg *et al*., 2003; Liu *et al*., 2009). Leach *et al*. (1979) found that cadmium in the diet significantly increased its concentration in the liver, kidneys and lesser in skeletal muscles. The kidney accumulates most cadmium and the liver accumulates a significant amount of cadmium. Muscle tissue showed limited cadmium deposition. Jakubbowski and Krakowska, (2010) observed that cadmium chloride increase malondialdehyde (MDA) in the brain tissue, as well as in Kidney and lungs, and a high level of glucose, Glutamic Pyruvic Transaminase (GPT) and Glutamic Oxaloacetatic Transaminase (GOT) in blood serum. The first use of chelating agent was during the War World 1 (WW1), toxic gases such as chlorine and mustard was used before it was banned under the 1925 Protocol (Aaseth, 2016) The effectiveness of treatment of heavy metal poisoning using Chelating agents compounds requires flexible, wide-ranging, producing less toxic compounds and disposed of by the urinary or digestive system. This depends on physical and chemical properties of metals and their compounds, such as ionic diameter, size of orbits, ability to give or accept electrons, availability, metabolic processes and ability to access body tissues and cells (Flora and Pachauri, 2010). Penicillamine (D-form) has been used to treatment Wilson's disease to produce copper from the body since 1956 and it was a dramatic change in chelating agents compounds of being the first oral chelating agent (Andersen, 2004). Also

Penicillamine is used to reduce the effects of low cadmium poisoning and is ineffective in acute poisoning (Jalilehvand *et al*., 2009; Mehta *et al*., 2001). And Because most compounds, vitamins and plant extracts used to mitigate the damage caused by chronic exposure to cadmium are limited to reducing the effect of oxidative stress and have no ability to extract cadmium from the cells and tissues of birds, this study aimed to evaluate penicillamin ability to Extraction cadmium as well as copper ion's and reduce the accumulated cadmium concentration in the vital organs and reduce the impact of oxidative stress on physiological performance of Japanese Quail as a model for poultry.

Material and Methods

180 birds of Japanese quail (156 females and 24 males) 8 weeks age were used and Distributed to 4 group, 3 replicates, each one with 15 quails (13 female and 2 male) The birds were placed in horizontal batteries with a base height of 50 cm, consisting of three cages with a distance of 60 x 60 x 50 cm. A plastic mesh was used to cover the metal clasp on the floor of the cage to provide maximum comfort to the bird. They were offered feed and water ad libitum throughout the experiment (8 to 16 weeks of age). Light was provided for 16 h/day from 0600 to 2200 during the experimental period .the bird were kept in an environmentally controlled room. For 8 weeks, the birds were exposure to 5 mg/l Cadmium chloride (Brown &Burk AF. London, UK) in drinking water to Cd and Cd+PA group (T2, T3 and T4). T3 as inT2 plus addition 5mg of PA / 3 ml drinking water/day /bird (was given from 900-1000 hour only), T4 as in T2 plus addition 10 mg of PA/3 ml drinking water /day/bird (was given from 900-1000 hour only) all treatments water is withheld for 1 hour from 800-900 hour). A total of 1.665 and 3.330 mg of penicillamine (D-form) (Panace Biotic - India) was added to 1 liter of drinking water and the resulting solution was introduced to birds in Cd+PA group T3 and T4 (5 and 10 mg PA /3ml/day/ bird) Respectively. At the 4 and 8 weeks of the experiment, the blood was withdrawn from the birds through the jugular vein. Liver and kidney was extracted and Treated with Formalin (10%). PCV and Hb was estimate, separate the blood samples and obtain serum by centrifuge to estimate TP, Glucose, Creatinine, HDL and liver enzymes (GOT, GPT, ALP and GPX) (Habig et al., 1974). At the end of the eighth week of the experiment, 9 birds (3 males and 6 females) Each treatment (3 birds of each duplicate) slaughtered and extract the liver, kidney, ovary, testis, brain and feathers of slaughtered birds to estimating the cadmium concentration in it as well as in serum and Red blood cell (RBC) by Atomic Absorption Spectrophotometer (SHIMADZU- AA 6300), The data were analyzed using statistical software SAS, (2004). The maximum acceptable error was considered less than 0.5. Duncan (1955) was used to compare differences between the averages.

Results and Discussion

A significant difference ($P \leq 0.05$) was observed between value of total protein, Glucose and H/L ratio in, GHS (week 4), GOT and ALP (week 8), cadmium concentration serum, RBC, liver, kidney, testis, brain and feathers (week 8). while the result show no significant difference between value of PCV, Hb, creatinine, HDL, Cu, Ca, GPT and cadmium concentration in ovary Compared with control group. In table 1, total protein increase in the T4 in week 8 may indicate the effect of cadmium on liver function, which in turn has an effect on total protein increase in cadmium-group birds (Ottalwar, 2011). The decrease of Glucose in cadmium and cadmium + pencicllamine group at 4 and 8 week may due to the oxidative stress caused by cadmium, which leads to the consumption of larger amounts of Glucose to provide enough energy to body cell to resist the harmful of free radicals from oxidative agents , which is increase because of chronic cadmium exposure (Sant'Ana *et al*., 2005), the significant differences in H/L ratio (week 4 and 8) between additional treatments and control (Al-Maeini *et al*., 2006) treatment can be attributed to the rise in T3 (3.57) in week 4 to the immune response that the body produces to regenerate red blood cells and compensate the decomposer as a result of cadmium poisoning, which prevents iron absorption and by entering into the formation of iron-bearing protein complex containing an inorganic copper part, H/L ratio in T3 and T4 (0.33 and 0.02) may be due to the effect of PA on T-lymphocyte count, significantly reducing the number of T-cell, the PA is used to treat rheumatoid arthritis thought increases the number T-lymphocyte and swelling of the joint then obstruction the movement ,the penicillamine used to get rid of T-lymphocyte in the joint and reduce the swell and this causes a decrease in the number of lymphocytes in the blood (Netter *et al*., 1987) and exposure to cadmium leads to changes in antibody production. These changes mainly include lymphocyte production (Sant'Ana *et al*., 2005) in table 2, Clotathione peroxidase (GHS) significantly increased in Cd and Cd+PA group(T2) during the 4 week of experiment (table 2). This may be due to cadmium reducing the production of Clotathione reductase (liver GR) which is a key factor in reducing the harmful effects of oxidative agents such as Clotathione peroxidase but a significant differences in GHS was observe in the 8 week and This may be due to the fact that there are certain specific mechanisms that help the living organisms to mitigate the effect of oxidative stress caused by cadmium and thus reduce the levels of oxidation enzymes like the GHS (Bykove *et al*., 1996). There were also significant differences during the week 8 between liver GOT and ALP in Cd and Cd+ PA group Compared with control group (Zhang *et al*., 2004), Except ALP in Cd group (T2) which decreased significantly and that could be related to liver damage due to cadmium detention during chronic exposure (Mehmeti,2017), while no differences were observed on ALP, GPT and GOT during the week 4 of the experiment period. This indicates that the effect of chronic exposure to cadmium (even in low dose) have a Clear effect on birds liver function in the Cd and Cd+PA group (Carmen *et al*., 2002). High levels of liver enzymes in Cd + PA group (T3, T4) may be attributed to PA in the compounds entering the liver, which require Complex processing to remove it from the body and produce more Metallothionein to reduce the effect of free cadmium ion's. In table 3, Cadmium concentration in serum and red blood cells (RBC) birds of the T3 and T4 group decreased significantly compared with the serum and (RBC) of the birds in Cd and Cd+AP group, No significant differences in RBC cadmium concentration observe between T3 and T2. The decrease in cadmium in serum and RBC may be due to the effect of peak plasma concentration of PA occurs at 1 to 3 hours after ingestion, regardless of dose, the slow elimination phase lasting 4 to 6 days, More than 80% of plasma PA is bound to proteins, particularly albumin all that give the PA the opportunity to form more and faster complex with cadmium to remove it

from the body through the kidney (Netter *et al*., 1987). Cadmium in the liver and kidney was significantly decreased in Cd + PA group (T3,T4) compared with the Cd in the kidney and liver of birds in the Cd group (T2) while there were no significant differences between the concentration of cadmium in bird`s liver in T2 and T4 that could refer to the high dose (10 mg/bird/day) which had a A pungent smell kept the birds in T4 with the lowest PA consumption. The significant cadmium reduction level in Cd + PA group liver and kidneys is attributed to the effect of PA which has reduced Cd concentration in bird`s body exposed to chronic Cd by kidney Excretion which associated with the high concentration of cadmium in bird's kidney compared with Cd concentration bird`s liver in the same group and that caused by the metallothionine - cadmium complex (Cd-MT) filtration by renal glomeruli which disintegrates after filtration to release cadmium ion and re - absorbed by the proximal tubules, which starts accumulating the Cd in kidney (Nordberg, 1978; Raddy and Hayes, 1989; Klasing, 2005).

Table 1 : Effect of adding cadmium chloride and PA on some blood Characteristics at 4 & 8 week of experiment mean ± standard error.

T4	T3	T2	T1[(2)]	Week	
42 ± 2.6	41.0 ± 2.9	43.8 + 1.9	2.4 ± 44.8	4	PCV
41 ± 1.7	47.2 ± 2.7	45.7 + 2.2	1.5 ± 45.8	**8**	%
14.0 ± 0.8	13.6 ± 0.9	14.6 + 0.7	0.8 ± 14.9	4	Hb
13.6 ± 0.6	15.7 ± 0.8	15.2 + 0.7	0.5 ± 15.2	**8**	g/dl
4.9 ± 0.2	5.0 ± 0.2	4.8 + 0.4	0.1 ± 5.1	4	Total Protein
6.5 ± 0.9[a]	5.0 ± 0.49[ab]	4.3 + 0.4[b]	0.4[ab(1)] ± 5.1	**8**	g/dl
255.2 ± 11.6[b]	254.0 ± 6.60[b]	247.7 + 28.7[b]	10.5[a] ± 308.7	4	Glucose
278.0 ± 18.0[a]	216.3 ± 28.2[b]	167.2 + 19.8[b]	17.2[a] ± 218.2	**8**	mg/dl
0.254 ± 0.5	0.36 ± 0.07	0.348 + 0.09	0.07 ± 0.27	4	Creatinine
0.124 ± 0.7	0.53 ± 0.2	0.072 + 0.04	0.07 ± 0.11	**8**	mg/dl
54.8 ± 11.4	70.6 ± 21.8	56.9 ± 14.8	20.5 ± 69	4	HDL
46.1 ± 9.8	63.7 ± 20.1	57.0 ± 14.8	20.5 ± 69	**8**	mg/dl
235.86 ± 20.65	244.62 ± 17.70	228.89 ± 17.46	216.84 ± 13.80	4	Cu
94.82 ± 20.58	80.03 ± 6.18	145.4 ± 41.97	120.8 ± 16.44	**8**	µg/dl
10.97 ± 0.29	10.46 ± 0.37	9.93 ± 1.49	11.42 ± 0.27	4	Ca
10.65 ± 0.10	10.53 ± 0.13	11.19 ± 0.56	10.88 ± 0.10	**8**	mg/dl
0.4 ± 0.14[b]	3.57 ± 1.19[a]	1.81 ± 0.05[b]	0.83 ± 0.02[b]	4	H/L ratio
0.02 ± 0.009[b]	0.33 ± 0.11[b]	1.02 ± 0.34[a]	1.09 ± 0.36[a]	**8**	

(1) The different letters in the seam row indicate significant differences between the averages at the probability of ($p \leq 0.05$).
(2) T1 Control , T2 Addition of cadmium chloride 5 mg/ l, T3 and T4 Add cadmium chloride 5 mg/l + 5, 10 mg PA/3 ml water /bird/day, respectively.

Table 2 : Levels of liver enzymes and Clotathionein peroxidase in blood serum at 4 & 8 week of experiment mean ± standard error.

T4	T3	T2	T1[(2)]	week	
51 ± 6.8[ab]	44.1 ± 5.1[ab]	59.4 ± 3.8[a]	4.2[b(1)] ± 42.7	4	GPX u/ml
46.3 ± 3.1	51.3 ± 4.7	48.7 ± 1.6	2.0 ± 50	**8**	
145.5 ± 32.9	268.4 ± 79.1	280 ± 65.9	172.6 ± 275.7	4	GOT u/ml
118.9 ± 41.9[ab]	154.9 ± 43.0[a]	38.8 ± 6.3[b]	16.6[b] ± 48.5	**8**	
382.4 ± 130.7	271.8 ± 98.9	350.1 ± 109.5	115.3 ± 392.1	4	ALP u/ml
246 ± 80.5[a]	121.5 ± 22.6[a]	233.4 ± 115.3[b]	132.1 ± 22.6[a]	**8**	
236 ± 38.3	314.9 ± 64.4	479.2 ± 113.7	74.7 ± 243	4	GPT u/ml
368.1 ± 89.7[ab]	541.3 ± 147.4[a]	186.9 ± 53.0[bc]	6.8[c] ± 44.6	**8**	

(1) The different letters in the seam row indicate significant differences between the averages at the probability of ($p \leq 0.05$).
(2) T1 Control, T2 Addition of cadmium chloride 5 mg / l, T3 and T4 Add cadmium chloride 5 mg/l + 5, 10 mg PA /3 ml water /bird/day, respectively.

Significant differences for cadmium concentration in the brain and feathers of birds in Cd and Cd+PA group compared to birds in control confirm the accumulation of cadmium in the brain and feathers birds exposed to low levels of cadmium. While there was no significant difference in the cadmium concentration in the brains of birds Cd+Pa group (T3) compared to birds in the T1 may match this result with (Seelig *et al*., 1994) conclusion about pharmaceutical compounds may cross the brain blood barrier in the case of high concentration in the blood which corresponds to the full dose consumption of PA in T3 .The PA Inactivity in reducing the concentration of cadmium in bird brain may be due to low consumption of PA in T4 and the fact that PA is lipophilic (Acar *et al*., 2007). Significant differences were observed on Feathers Cadmium in T2, T3 and T4 compared to T1 While PA did not play a role in reducing the cadmium concentration which reaches the keratinocytes through blood accumulates producing keratin protein, which in turn into a dead part retention the cadmium with no chance to eliminate by PA.

For testis cadmium ,there was no Significant differences for the Cd in Cd+PA group (T4) compared to T1 and that may refers to the effect of PA (10 mg/day) was enough to concentration And this is not observed on the testicle birds in

the (T3) (5 mg/bird/day), where the level of cadmium is closer to the level of the Cd group (T2),which indicates that some birds respond to a certain level of PA may not respond to the rest of the organs of the same bird.

No significant differences were observed for the Hb, Creatinine and HDL (table 1) these result could be due to the level and exposure duration of cadmium which have a deferent effect on physiological value (Cain *et al*., 1983; Huo *et al*., 2007). The absence of significant differences between additional treatments and the Control treatment in calcium and copper values in serum (table 1) is consistent with what it has been reported by (Fox, 1974) that high levels of cadmium (20 mg/kg diet) can interfere with calcium and copper by inhibiting absorption in the intestine which confirms the explanations in previous studies in this field about the camouflage of cadmium to enter the body through the protein transport of calcium, copper and iron when entering the gastrointestinal tract at high concentrations. The results also agree with Shehata, (1999) conclusion which include that the cadmium enters the calcium representation cycle in the animal's body if its concentration is deficient in birds' lipids and that the presence of calcium by-pass prevents absorption of larger quantities of cadmium that can cause calcium to be misrepresented, stored, and absorbed amount during the formation of the egg shell. the arithmetic differences between T2 and T1 of the copper levels during the 4 and 8 weeks of the experiment could attributable to that Cd can replace other mineral elements, such as copper, as it prevents it from connecting with the protein compounds it needs in its work, which gives it a free image in blood. The low level of copper in the blood of birds in addition T3 and T4 to the role of PA as a chelating agent with high selective characteristic to copper (Ye *et al*., 2003)

Table 3 : Cadmium concentration in the blood and some vital organs of Japanese quail mean ± standard error.

8 week					Cd (µg/g)
T4	T3	T2	T1[(2)]	unit	
0.007 ± 0.000[b]	0.0083 ± 0.002[b]	0.0350 ± 0.003[a]	0.001[b(1)] ±0 0.006	ml	serum
0.026 ± 0.002[b]	0.0300 ± 0.003[ab]	0.0330 ± 0.000[a]	0.001[c] ± 0.0049	ml	RBC
0.069 ± 0.004[ab]	0.0450 ± 0.008[b]	0.0960 ± 0.010[a]	0.000[c] ± 0.0022	gm	liver
0.220 ± 0.040[b]	0.2200 ± 0.060[b]	0.4500 ± 0.070[a]	0.001[c] ± 0.0058	gm	kidney
0.001 ± 0.000[b]	0.0015 ± 0.000[ab]	0.0025 ± 0.003[a]	0.001[b] ± 0.0004	gm	testis
0.006 ± 0.001	0.0035 ± 0.001	0.0096 ± 0.003	0.001 ± 0.0042	gm	ovary
0.006 ± 0.000[a]	0.0045 ± 0.000[ab]	0.0068 ± 0.001[a]	0.000[b] ± 0.0028	gm	brain
0.064 ± 0.010[a]	0.0750 ± 0.006[a]	0.065 ± 0.020[a]	0.001[b] ±0 0.014	gm	Feathers

(1) The different letters in the seam row indicate significant differences between the averages at the probability of ($p \leq 0.05$).
(2) T1 Control, T2 Addition of cadmium chloride 5 mg / l, T3 and T4 Add cadmium chloride 5 mg /l + 5, 10 mg PA/3 ml water /bird/day, respectively.

Comparison of the histological sections for bird liver, kidney, ovary and testis in the experimental treatment:

In **Figure 1** the microscopic examination showed changes in hepatic tissue sections in T2, which included hepatitis, which is associated with degenerative changes in multiple hemorrhagic foci (H) changes with central venous congestion (CV) compared to the membrane capsule (C) of the liver tissue sections in T1. In the enlarged sections of the liver, it was observed that there was an average dissolution of liver cells (↑) and infiltration of the heterophilic cells. Most T3 liver tissue sections showed a small number of haemorrhagic foci, central venous congestion and acute cellular dissociation in liver cells associated with hepatic dislocation compared to T2 hepatic tissue sections. This reduction in the level of damage to the liver is due to the role of penicillamine in reducing the concentration of cadmium in its cells as shown in Table 4. While most of the liver sections in T4 were similar to those found in T2, while some hepatocellular sections showed similarity with the histological sections of the liver in T1 control. This discrepancy in the level of damage between histological sections of the T4 bird liver may be due to the PA consumption variation among the birds of this treatment T4 due to the odor of the solution used for the concentration used (10 mg / 3 ml water / bird / day) Which had a pungent odor with a bitter taste, which reduced its consumption in T4, which is not consistent with what (Nurhayati *et al*., 2019) reported about the quails have limited sense of taste and smell.

The microscopic examination for the histological sections of the renal cortex (T2) in Figure. 2 showed several hemorrhagic foci (H) with an accumulation of interstitial fluid and the expansion of the Bowman portfolio of MT glomeruli. The histological sections of the pulmonary tissue showed an average renal renal failure (Rt) and this corresponds to changes in tissue and renal tubules (Nordberg, 1978 ; Raddy and Hayes, 1989 ; Klasing, 2005). Most of the renal cortex in T3 showed some hemorrhagic foci (CV) and decreased bleeding and congestion (C), while other sections showed severe cellular swelling and necrosis of renal tubules. The difference in the level of Renal Damage T3 compared to T2 was due to the role of penicillamine in reducing cadmium concentration in glomeruli and renal tubules (Table 4). While most of the sections of the renal cortex T4 showed a little bleeding and congestion in the blood vessels between renal tubules.

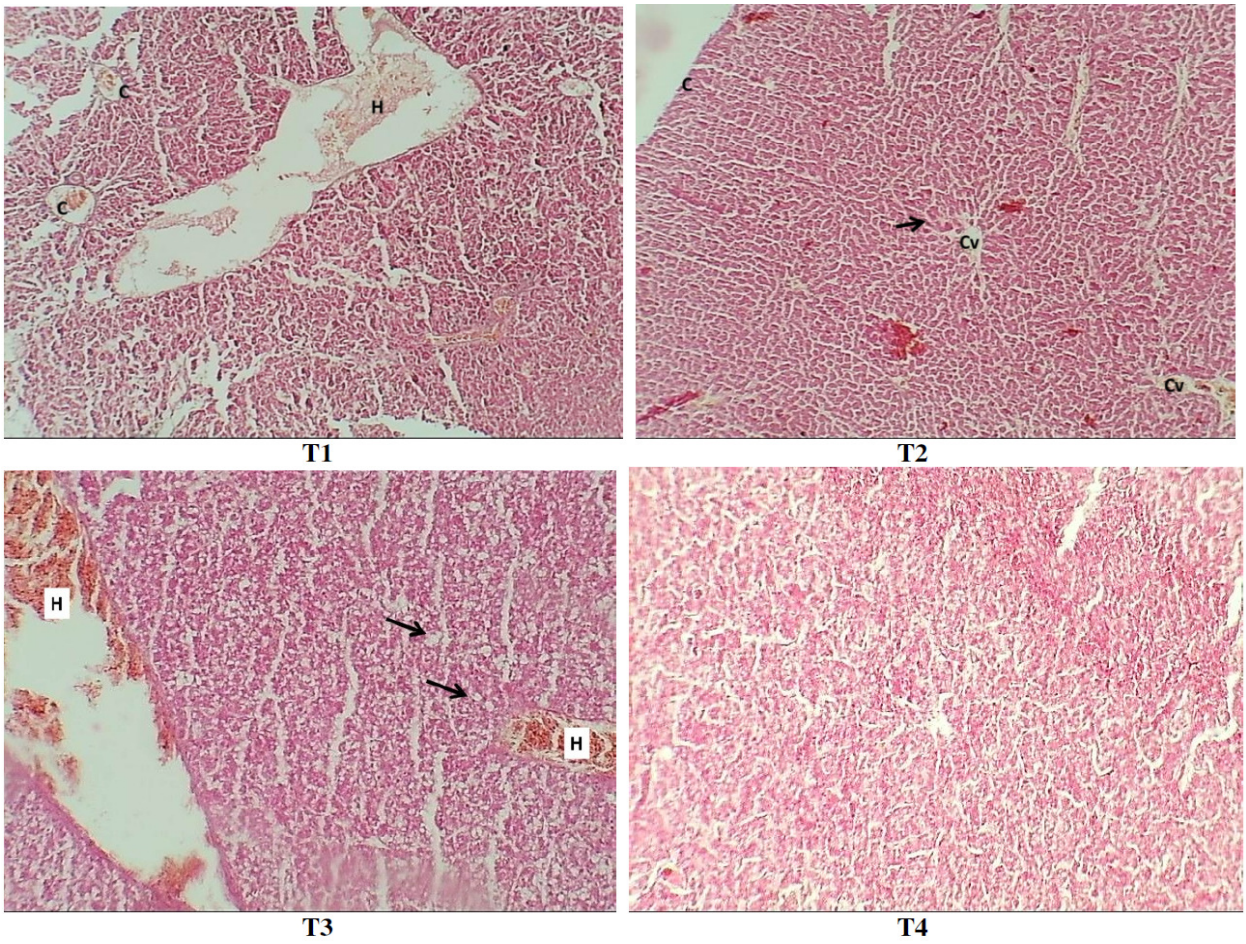

Fig. 1 : Comparison of hepatic hepatic tissue in the experimental treatments and as indicated for each C Cervical capsule (CV) Central vein (↑) Liver cell degeneration (H) Hemorrhage /H & E Pigment / 40 x

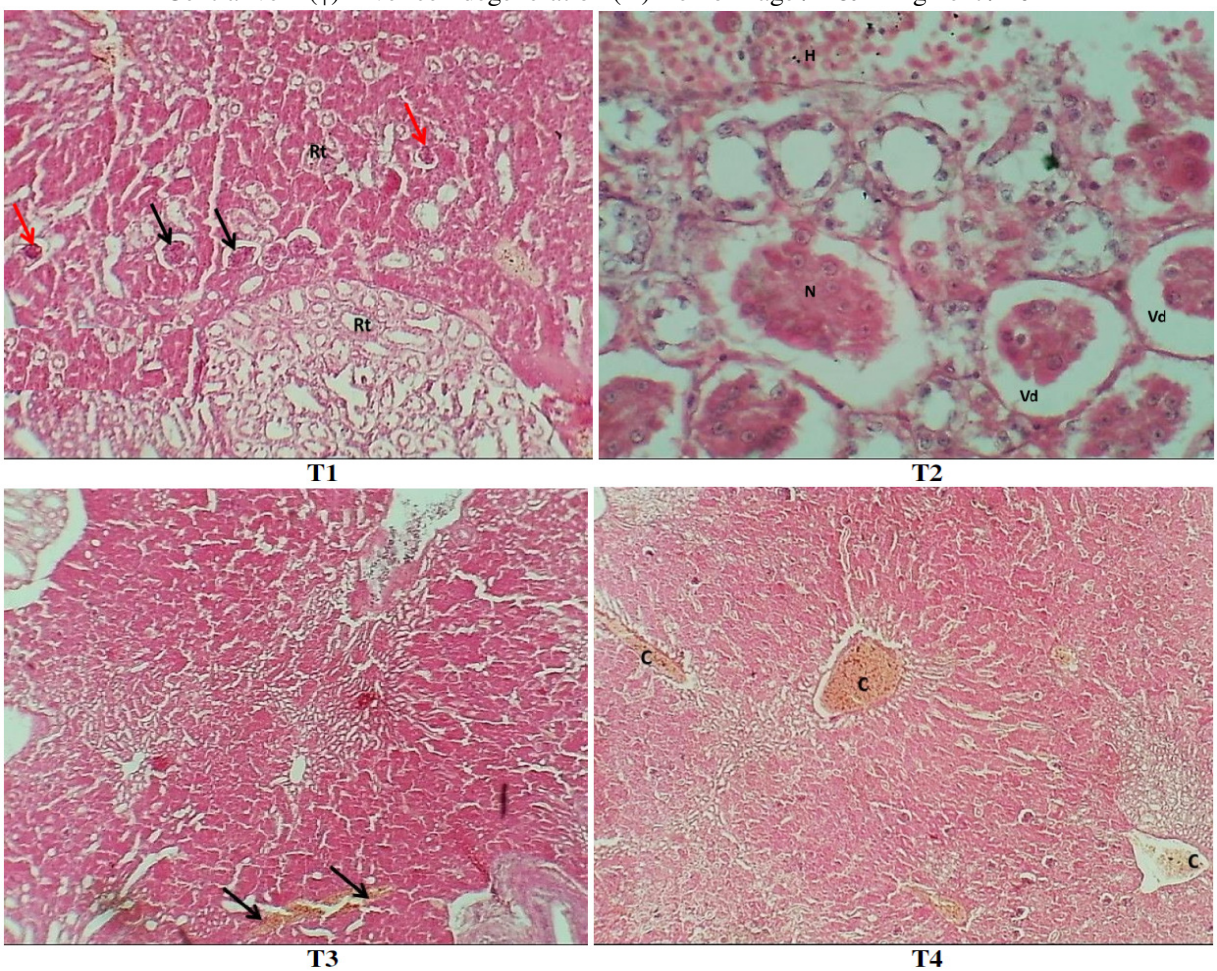

Fig. 2 : Comparison of renal tissue in the experimental treatment as indicated for each (Rt) renal tubules (↑) Glomerulosclerosis type MT (↑) Glomerulosclerosis Type RT (H) Hemorrhage (CV) Central vein (vd)) H & E Pigment (x100 : x400)

Conclusion

5 mg/l Cadmium chloride for 62 days has a high ability to accumulate in kidney and lesser in the liver as well as its effect on other physiological characteristics, while 5mg of penicillamine given through drinking water 3ml/day/bird has a good ability to extract cadmium from the tissues and cells of vital organs of the Japanese quail.

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