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Effect of Cadmium Accumulation on Renal Tissues in Broilers

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Cadmium is a toxic substance that is widely dispersed in the environment and has a long biological half-life in organs. Thus, cadmium exposure to both humans and animals can cause adverse health effects leading to itai-itai disease (Friberg et al. 1986), kidney tubular dysfunction (Friberg et al. 1984, 1986), and cancer (Kazantzis et al. 1988; Waalkers et al., 1999; Valverde et al., 2000). Among such characteristic features cadmium typically gives rise to renal dysfunction since the kidneys are main route of excretion. As a result, there has been increased public awareness and concern for cadmium exposure among the public.

The tolerance level for cadmium in poultry feed has not yet been well established in Korea however Korea has followed the tolerance level of cadmium established by WHO. Most of heavy metals tend to accumulate in organs of animals and fishes. Korean has different dietary habit from other countries. For example, Korean has usually consumed edible meat organs such as the liver, kidneys, and bone in the form of soup, frying or steamed. However, there are few studies on cadmium residues in meat organs like poultry.

This study was designed to investigate if the current allowance level for cadmium in Korean formula feed, 1 ppm, would cause any health side effects for animals and humans. Therefore, the accumulation of cadmium in broilers fed with formula feed containing 0.0, 0.5, 1.0, or 10.0 ppm of cadmium was determined. This data obtained may provide basal information about reevaluation and establishment of the level of cadmium residues for public health interest.

MATERIALS AND METHODS

Male Abaeiker broilers, 7 days of age, were obtained from Yong-In poultry LAB and carried to National Vertinary Hygiene Institute (Anyang, Korea) where they were placed into stainless steel cages in a temperature- and humidity-controlled room with 12-h light and dark cycle. They were allowed to acclimatize for 1 week and weighed every week. Upon 10 days, they were changed and maintained into bigger cages and fed with formula feed for adult broilers. They were randomly assigned one control group and four experimental groups by feeding conditions. Animals in experimental groups were given formula feed containing 0.5, 1.0, 5.0, or 10.0 ppm of cadmium ($CaCl_2.H_2O$, GR, Wako Co.) for 45 days. At 15-day intervals, 20 broilers picked randomly from each group were sacrificed. The kidney tissues were taken and stored at –25°C until analysis. At the same time, the tissues of the

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kidney were fixed in fixative solution for analysis of histology. The samples used for accumulation of cadmium were prepared by the dry ash method and were determined by Inductively Coupled Plasma Spectrophotometer (ICP: Labtan Co., Model 8440 Plasmalab, Australia). The operation conditions of ICP were: flush time: 35 sec.; integration: 10 sec.; floward power: 1200 watts; auxilliary flow: 2.5; reflected power: <5.0; pump speed: 800; nebulizer flow: 3.0; coolant flow: 4.0; wave length: 226.5 nm. Also, histological specimens of the kidney were prepared using H&E staining method. The cadmium residues were examined on the basis of the cadmium allowances, which are regulated by the Ministry of Agriculture and Forestry in Korea.

RESULTS AND DISCUSSION

This study was designed to determine if the various level of cadmium in formula feed including the current allowance level for cadmium in Korean formula feed (1 ppm) would be safe for animal and human health. Cadmium chloride was assayed five times with constant results. There was no difference in weight gain among groups ($p>0.05$). There was the increased accumulation of cadmium in accordance with the duration of the feeding. The kidney tissue was examined for cadmium accumulation and the finding is presented in Table 1.

Table 1. Cadmium accumulation in the kidneys of broilers fed cadmium.

Cd levels	Duration of Feeding (day)		
(ppm)	15	30	45
0.0	0.05 ± 0.01^{1a}	0.05 ± 0.01^{a}	0.06 ± 0.01^{a}
0.5	0.16 ± 0.77^{ap}	0.23 ± 0.04^{apq}	0.25 ± 0.09^{aq}
1.0	0.35 ± 0.19^{ap}	0.46 ± 0.28^{ap}	0.98 ± 0.37^{aq}
5.0	1.12 ± 0.68^{bp}	1.15 ± 0.78^{bp}	1.64 ± 0.71^{bq}
10.0	2.01 ± 0.78^{cp}	3.98 ± 1.32^{cp}	4.12 ± 1.27^{cq}

1) mean ± S.E , n=8
2) Values in row with different superscript (p,q,r) are signifycantly different at the 0.05 level by Scheffe-test.
3) Values in column with different superscript (a,b,c) are significantly different at the 0.05 level by Scheffe-test.

The amount of cadmium accumulation in the kidney shows significantly high at broilers fed 0.5 and 1.0 ppm $CdCl_2$, compared to that at broilers fed 5.0 and 10.0 ppm $CdCl_2$. Especially, the kidneys of broilers in 1.0 ppm cadmium group show

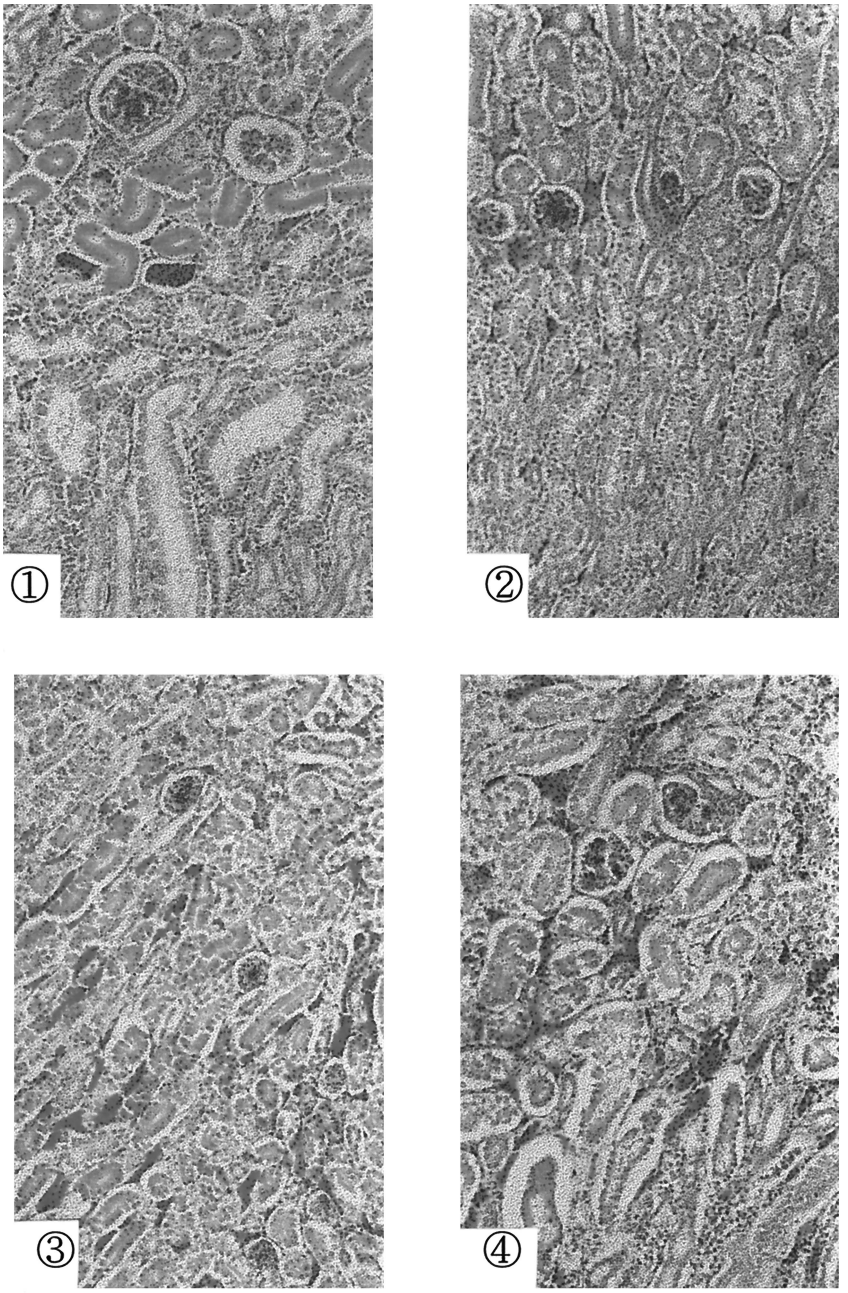

Figure 1. Histology of renal tissues (H&E stain, x100)
①: control ②: 0.05 ppm of Cd ③: 1.0 ppm of Cd ④: 5 ppm of Cd

almost 1ppm that is current allowance level at 45 days. In general, cadmium accumulation is influenced by the level of cadmium and feeding period.

Current allowance level, 1ppm of cadmium, in formula feed is established by World Health Organization (1992). Koreans consume edible meat organs such as the liver, kidney, and bone in the form of soup or fried, steamed or raw. Watanabe et al (1986) reported that cadmium intake of Koreans via food in the capital city of Seoul was about 25 μg per day. However, the exposure of people and animals to cadmium via food chain has been sharply worst concerning environmental pollution. Cadmium uptake was almost exclusively via dietary route with little contribution of the respiratory route (Ikeda et al. 2000).

The morphology of the kidney was shown in Fig. 1-①, ②, ③, ④. All of the renal corpuscles consist of condensed glomeruli and severe congestions revealed in the medulla at the level of 1 ppm $CdCl_2$ (Fig. 1-②). At 5 ppm of $CdCl_2$, the several shrunken renal corpuscles are seen (Fig. 1-③). Glomeruli-condensed renal corpuscles, segmented renal tubules and congestions are observed at 10 ppm of $CdCl_2$ (Fig. 1-④). This nephrotoxicity is due to the fact that urinary elimination is a main route of excretion and proximal tubules are sensitive due to their high reabsorptive activity (Madden and Fowler 2000).

Residues of cadmium in food, raw agricultural commodities, humans, and environment, have not been studied extensively in most developing countries. Basic cadmium legislation and official control procedures at the national level are essential first steps in promoting the safe and effective use of cadmium. On the basis of this study, which detected cadmium residue in broilers, the Korean Ministry of Health & Social Affairs should determine and establish the allowance limit of cadmium residue for food safety and public health. Further research is to be assessed unique biological response patterns to aid in the risk assessment and environmental and occupational metal exposures.

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