

Bioaccumulation of Pb and Cd on Broiler Chicken Fed in Difference Diets

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Abstract--The study was aimed to compute Pb and Cd bioaccumulation in different organs of broiler. Carcass, heart, liver, gizzard, intestine, and excreta. The data were obtained from broiler reared in the litter cage. Four treatments of feed were given to the broiler chicken, i.e. T₁ = X brand of commercial feed, T₂ = Y brand of commercial feed, T₃ = self-prepared feed without fish meal addition and T₄ = self prepared feed without fish meal but contaminated with cadmium chloride (Cd.Cl₂.4H₂O). For each treatment, five broiler chicken were grouped each week (from week I up to week VI). Results of the first stage of this study was analyzed descriptively. A polynomial regression equation was used as an empirical model to describe the heavy metal bioaccumulation phenomenon in broiler carcasses. The quadratic equation turned out to be the most suitable model for describing the bioaccumulation of heavy metal in broiler carcasses. From the simulation, it was found that quadratic model fit to 61.31% and 54.17% bioaccumulation data of Pb and Cd respectively. According to the model, initially metal concentrations declined since the first week and started to rebound at the fifth week, both in terms of chronological and physiological age. The patterns of Pb and Cd bioaccumulation in this study can be used as a reference to determine the proper slaughter period. It can be concluded that for reducing the risk of metal contamination the proper slaughter time of the broiler is before the fifth week.

Key words: broiler, feed, heavy metals, Pb, Cd, bioaccumulation

I. INTRODUCTION

Fish is an important source for broiler diets. Fish contain high protein concentration. In Indonesia, fish usually processed to be fish meal. Fish meal was processed from fish harvested from river or sea. In fact, some river and sea in Indonesia contaminated with heavy metals such as lead (Pb) and Cadmium (Cd). Bioaccumulation of heavy metals in fish happened when it lives in contaminated water with heavy metals. Bioaccumulation of heavy metals in broiler usually happened when broiler fed by diets contain fish meal contaminated by heavy metals. Broiler chicken grow through starter phase and finisher phase, they usually raised 28-35 days. The broiler chicken grow well follow the sigmoid curve, hence the growth increase during the starter phase until puberty phase then decline until zero point when the slaughter weight obtain. Feed cost is the highest cost in broiler chicken raising, this cost reach 60-80% from the total cost. Fish meal usually used as the feed ingredient in broiler chicken diet. Fish meal is the protein sources in the broiler diet. However even fish meal rich in protein, sometimes contain heavy metals which essentials

and non essentials. This condition happen caused most of FM harvested from the open sea which polluted by industry and ship waste. The utilization of FM contain high Pb and Cd on the diets could bioaccumulate the Pb and Cd content in broiler meat.

Previous researchers stated some of fish which live in Nevrata, Croatian river upstream contain Pb, Cd, Hg, and As (Has-Schon et al., 2006a), further they reported fish which life in "Busko Blato" Lake in Bosnia Herzegovina contain Hg, Pb, Cd, As, Cu, Zn and Cr (Has-Schon et al., 2006b). Arsen also was found in fish which sold at wet market in Norway. Five species of fish and shrimp which live in in Tanjung Karang, Selangor also contain Pb, Ni, and Cd with concentration 0.123±0.064 mg kg⁻¹; 0,123 ± 0,064 mg/kg; 0,467 ± 0,473 mg kg⁻¹ on average wet weight respectively (Lihan et al., 2006). The research was done by Rahman (2006) found that some shrimps contain from 7.14±1.1 to 13.25 ± 2.2 mg kg⁻¹. Carp fish was caught from Jakarta coastal contain (Muara baru, Muara kamal, Muara karang and Muara Angke) also contain Cr from 1.602 ± 0,039 to 5.606 ± 0,925. That fish also contain Zn from 102.032 ± 6.615 to 158.134 ± 12.93 (Ratnawati et al., 2008). The study was conducted to determine the bioaccumulation of Pb and Cd on Broiler chicken fed by difference diets contain fish meal from the area.

II. MATERIALS AND METHODS

A. Materials

Day old chick of Broiler chicken strain unsex Arbor Arces (CP 707) with weight 45.12 ± 3.52 g/head on average produced by PT. Central Proteina Prima Semarang were used in the study. To conduct lead and cadmium level, after broiler were slaughtered, the leg, wing and breast of chicken were analyzed. The heart, liver, gizzard and ileum and feces were analyzed The broiler chicken were raised for 6 weeks. And the level of lead (Pb) and cadmium (Cd) in the parameter were compared with the standard of IAEA. The atomic absorption spectrometer Double beam produced by Hitachi were used in the study.

B. Methods

Complete Random Design (CRD), four treatment with five (5) replication. Total 300 head of broiler were used. The treatment conducted in the study as follow:

T₁ : Broiler fed by Brand X diet

T₂ : Broiler fed by Brand Y diet

T₃ : Broiler fed diet contain fish meal

T₄ : Broiler fed diet without fish meal, contain Cadmium (Cd.Cl₂.4H₂O)

C. Pb and Cd Analysis

Pb and Cd analysis were done in National Atomic Office in Jakarta. The Procedure of Pb and Cd used SAA followed the standard of SNI 01-2896-1998.

D. Data Analysis

Bioaccumulation of heavy metals broiler body were analyzed using quadratic regression model with equation as follow: $Y = b_0 + b_1X_1 + b_2X^2$, where Y = Heavy metal bioaccumulation, X = age of broiler, b_0 = constant and b_2 : coefficient of regression. SPSS (for Windows Release 17.0) were used in the study. Model was fit when $R^2 \geq 0.5$

III. RESULTS AND DISCUSSION

Result of the study showed all part of body contain Pb and Cd in safety consumption. Pb content on gizzard and ileum were fed T3 and T4 with total accumulation on carcass, liver, heart, gizzard and small intestine were high, the Pb content of T3 and T4 were 75.9273% and 78.008 % respectively (Table 1).

TABLE 1
PERCENTAGE OF Pb CONTENT ON CARCASS, HEART, LIVER, GIZZARD AND SMALL INTESTINE AND EXCRETA OF BROILER FED DIFFERENT DIETS

No	Component	Average of Pb content on broiler organ fed by different diets ⁽¹⁾ (%)			
		T ₁	T ₂	T ₃	T ₄
1.	Carcass	8.3599	2.7648	17.7298	11.7136
2.	Heart	1.0203	0.7296	17.5405	11.0483
3.	Liver	0.1040	0.1783	1.4659	1.0921
4.	Gizzard	3.6847	4.8679	36.6579	15.2830
5.	Small Intestine	1.6755	0.6443	2.5332	38.8717
6.	Total of number 1-5	14.8444	9.1849	75.9273	78.0087
7.	Excreta	0.4633	1.2528	10.7899	8.2242
8.	Total number 1-6	15.3077	10.4377	86.7172	86.2329
9.	Other component	84.6923	89.5623	13.2828	13.7671
10.	Feed and drinking ⁽²⁾	100.0000 (3.8170)	100.0000 (1.9002)	100.0000 (0.1438)	100.0000 (0.2100)

Note : ⁽¹⁾ Percentage was counted from Pb content in the sample X sample weight. ⁽²⁾Number in parenthesis () was Pb content in diet and drink (mg/kg)

Broiler fed T₃ for almost 6 weeks contained was 75.9273% from 0.1438 mg/kg Pb which come from feed and drink of broiler. However broiler which fed T₄ contained 78.0087% from 0.2100 mg/kg Pb come from feed and drink. Broiler fed by T₁ and T₂, contained percentage of Pb in all organ lower than 5%, except on carcass of broiler fed T₄ (8.3599%), however percentage of Pb on other component (blood tissue, non-carcass tissue except liver, heart, gizzard, and small intestine usus) were high, 84.6923% on T₁ and 89.5623% on T₂. Percentage of accumulation of Pb which appear in liver, heart, gizzard and small intestine was caused Pb and Cd was excreted to faeces was low. The high content of Pb was caused broiler were fed diet contained Cd tend to increase the Pb content in the liver, heart, gizzard, and small intestine of broiler. This condition happen because Cd in live animal bounded in metallonein. Metallonein contained 11 % Cd which

bounded in sulfhidril group which content in high number in liver (JECFA, 1989). Metallotionein which content Cd would inhibit animal grow. Hence usually, Metallotionein also bound Pb. Absorbtion on retention of Pb would influence by Ca, P, Fe, Cu, dan Zn in diet which potency to reduce the growth of animal (Parakkasi, 1999)

Although accumulation of Pb in broiler organ was low on broiler which fed by diet contain Cd, but Accumulation of Pb on carcass, liver, heart, gizzard and intestine should be careful because Pb was toxic. Percentage of Cd in intestine an all treatment was higher that that of other organ (Table 2). In Broilers fed T₁, percentage Cd on carcass, liver, heart, gizzard and intestine were higher than those fed T₂, T₃ and T₄. Broiler fed T₄, even percentage of Cd in feed and drink were higher than that of other treatment (1.3280 mg/kg), T₁ (0.0063 mg/kg) and T₂ (0.1446 mg/kg), but percentage of Cd which accumulated to carcass, liver, heart, gizzard, and intestine were low. One of the reason, Cd content in T₄ was low because Cd Excretion in T₄ was very high.

TABEL 2
PERCENTAGE OF Cd CONTENT ON CARCASS, HEART, LIVER, GIZZARD AND SMALL INTESTINE AND EXCRETA OF BROILER FED DIFFERENT DIETS

No	Component	Average of Cd content on broiler organ fed by different diets ⁽¹⁾ :			
		T ₁	T ₂	T ₃	T ₄
1.	Carcass	6.7971	2.4788	0.0197	0.2284
2.	Heart	2.9601	0.1251	0.0024	0.0031
3.	Liver	11.3344	0.2470	0.0031	0.0338
4.	Gizzard	10.4103	0.9485	0.0429	0.2837
5.	Intestine	18.2120	1.6000	0.0229	4.0892
6.	Sum of 1 – 5	49.7139	5.3994	0.0910	4.6383
7.	Excreta	4.7127	0.0641	0.0023	0.3210
8.	Sum of 1 – 6	54.4266	5.4635	0.0933	4.9592
9.	Other component	45.5734	94.5365	99.9067	95.0408
10.	Feed and Drink ⁽²⁾	100.0000 (0.0063)	100.0000 (0.1446)	100.0000 (4.4078)	100.0000 (1.3280)

Note : ⁽¹⁾ Percentage was counted from Cd content in the sample X sample weight. ⁽²⁾Number in parenthesis () was Cd content in diet and drink (mg/kg)

Quadratic model of Pb and Cd bioaccumulation in carcass, heart, liver, gizzard, intestine and faeces of broiler were fed different diets. Bioaccumulation of Pb dan Cd have R² was fit ($\geq 0,5$), Bioaccumulation of Cd is shown in Fig.1.

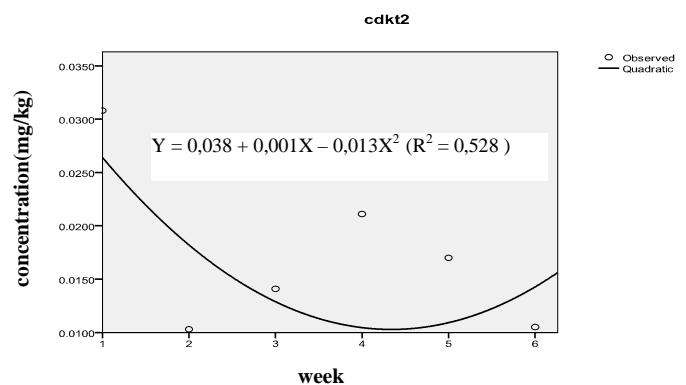


Fig. 1. Quadratic Cd bioaccumulation curve on broiler carcass based

on age with R^2 value = 0,528 (note : cdk2 = Cd concentration on T_2)

As shown in Fig. 1, Based on age of broiler Pb and Cd content tend to decrease from week 1 to week 6 on all organ (carcass, liver, heart, gizzard and intestine of broiler. Pb content on all organ tend to decrease from week 1 to week 4, then tend to increase from week 5 to week 6. Pb content in liver, heart, gizzard and small intestine tend to sharply decrease even almost 0 mg/kg and tend to increase on week 5. Cd content also decrease even still detected in week 5. In physiology reason, proportion of Pb and Cd from week 1 to week 6 is shown in Fig. 2 (a and b).

Quadratic accumulation pattern of heavy metals in this study showed decreasing content of heavy metals fith with increasing number of time. In fact, there was increasing content of heavy metals in broiler carcass with quadractic trend Fig. 3 (a dan b).

Accumulation of Pb dan Cd tend to decrease because the increasing of Pb and Cd from week 1 to week 6 were lower than increasing the weight of broiler. The increasing of broiler weight followed the exponential equation

$X_t = X_0 \cdot e^{bt}$ (where X_t = Weight of broiler in time t, X_0 = Initial weight, e = coefficient, b = Rate of growth, dan t = age) as shown in Fig. 3a, broiler were fed by commercial diet were followed the increasing of Pb accumulation on it carcass. In Ilustration 3b followed the exponential equation $X = 150 \cdot 130 e^{0,359}$. ($R^2 = 0.915$) were Fig. 3a have followed quadratic equation $Y = 2.238 + 0.099X - 0.956X^2$ ($R^2 = 0.876$). First Equation (Fig. 3b) showed rate of growth in exponential was greater than that of increasing content of Pb and Cd in carcass and other component (Fig. 3a).

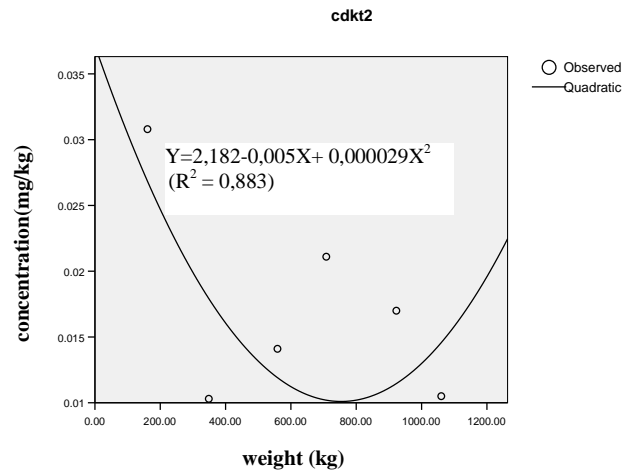


Fig 2.b Quadratic Cd bioaccumulation curve on broiler carcass based on age with R^2 value = 0,528 (note : cdk2 = Cd concentration on T_2)

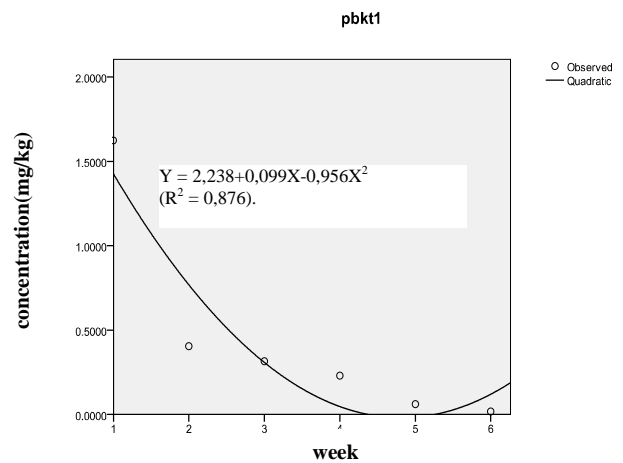


Fig. 3. a. Bioaccumulation of Pb on broiler carcass (note : pbkt1 = Pb concentration in T_1)

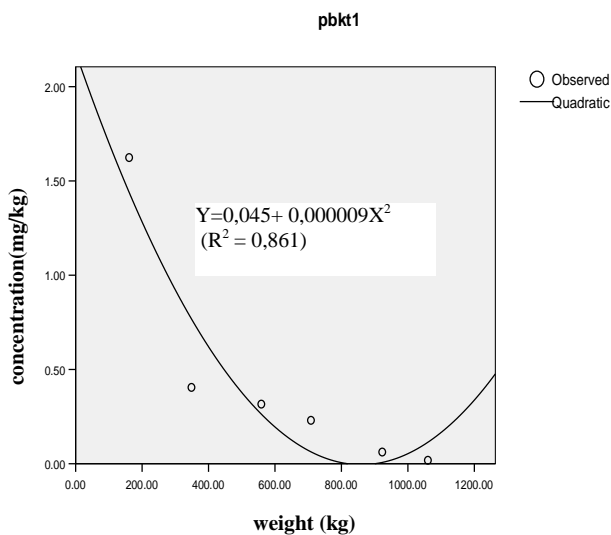


Fig. 2.a. Quadratic Pb bioaccumulation curve on broiler carcass based on age with R^2 value = 0.861 (note : Pbk1 = Cd concentration on T_1)

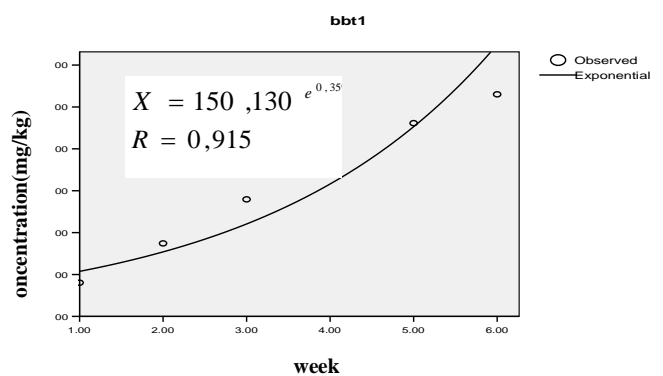


Fig. 3b. Growth rate of broiler which fed by Brand X diet

Growth of broiler with Pb bioaccumulation is shown in Fig. 4, which showed when the growth rate reach nol point (no growth rate anymore), hence heavy metals accumulation (in

this study Pb and Cd) tend start increase until cross point with constant growth. The result was supported by Dermibas (1999) which found local chicken were raised in 18 months, the chicken contained 11 heavy metals (Cd, Ca, Cu, Fe, Pb, Mg, Mn, Hg, K, Na and Zn) and one (1) non metal which found in gizzard, liver, heart, and limpha were higher than standard. Heavy metals such as Hg, Cd, and Pb in herart and kidney increase sharply from 4 week to week 8 of raising period and continue to raise even moderate until week 18 for Cd and Pb content. Concentration of Hg in liver decrease in week 18 but in ureter tend to increase until week 18.

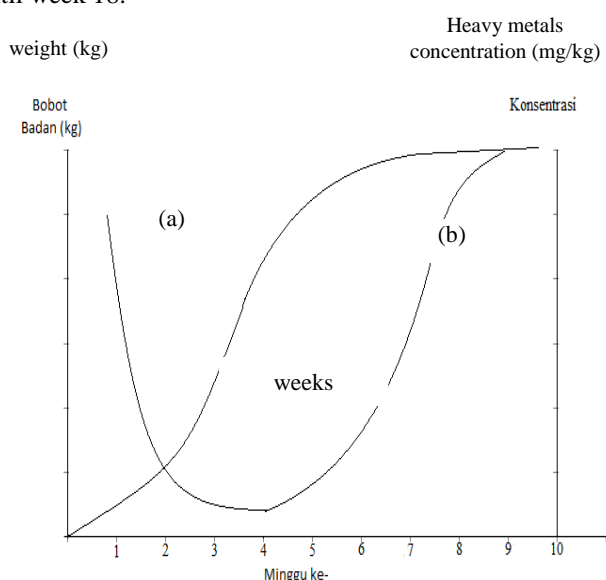


Fig. 4. (a) Growth rate of broiler (Leeson dan Summers, 1991) and (b) Heavy metals bioaccumulation followed quadratic equation.

The differences between this study and Dermibas study, Dermibas use local chicken with three differences group of age, 4 week, 8 week and 18 week of ages. Bioaccumulation of Pb and Cd broiler fed ($T_1 - T_4$), tend to increase from week 1 to week 5 and decrease in week 6. Pb and Cd content in all organ and excret tend to increase in T_4 (diets without fish meal and add with $Cd.Cl_2.4H_2O$). High Cd content also found in T_1 (Brand X) but in T_2 (brand Y) was not found Cd content. This result support when animal consume high Cd content would increase the Cd content in its organ. Pb content in body or organ were correlated with Pb and Cd in the diet, Pb would excreted through faeces (Palar, 1994). One phenomenon which be found in this study, could be used as references in slaughterhouse have not found Pb and Cd in Week 1 to week 4, and start to increase in week 5 and week 6.

IV. CONCLUSION AND RECCOMENDATION

A. Conclusion

Pb and Cd content in broiler organ (carcass, liver, heart, gizzard and small intestine) which fed by four kind of diets (brand X, Brand Y, diets contained fish meal, and diet without fish meal add with $Cd.Cl_2.4H_2O$), almost all result followed quadratic equation and form parabolic concave.

Pb and Cd content have not found in week 1 to week 4 and starting increase from week 5 to week 6. Decreasing pattern of Pb and Cd accumulation would guide broiler slaughtering because Pb and Cd have not found in week 1 to week 4.

B. Recommendation

Based on result, we recommended:

- Broiler slaughtered should be conducted on week 4 of raising period. Because Pb and Cd would not found in Week 4. And start to increase in week 5 and week 6.
- Further research was needed should be conducted in other poultry species to determine the bioaccumulation of Pb and Cd in other poultry species.

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