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Egg Quality and Heavy Metal Concentrations in Meat, Eggs and Inner Organs of Laying Ducks Fed under a Conventional Feeding in Lombok, Indonesia

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Abstract. The search for alternative protein sources for duck feed is important considering its high cost. An experiment involving 100 forty-wk-old laying ducks was conducted for eight weeks to study the effects of fresh water fish (sapu-sapu fish -SSF) as single protein sources on egg quality and heavy metal concentration. The SSF levels were 28 and 35% of the feed and the remaining constituent was rice bran with metabolizable energy approximately 2,943 and 2,934 kcal/kg, respectively. Fresh water fish did not effect on egg quality measured except egg weight and shell thickness (63.2±0.30 to 67.9±0.22g) and shell thickness (0.50±0.04 to 0.52±0.04g) with increasing dietary SFF($P<0.05$). Mean concentrations of heavy metals in local duck samples decreased in the order kidney>liver>egg>meat for Pb and liver>kidney>meat>egg for Cu. Lead concentrations in meat, eggs, liver and kidney were 1.267± 0.825, 1.311±0.737, 1.762±0.729 and 2.172±0.770 mg/kg respectively. These values were higher than the admissible amounts under the Indonesian National Standards (1.0 mg Pb/kg) and FAO (0.1 mg Pb/kg). Accumulation of Cu in the meat, eggs, liver and kidney was 12.798±4.181, 7.011±1.949, 30.165±16.561 and 14.392± 4.208 mg/kg respectively. These levels were also higher than that recommended by the European Commission. The conclusion of this study proved that feeding SSF to laying ducks raised by small farmers contained a significantly high concentration of heavy metals not appropriate for human consumption when high levels of SSF was fed.

Keywords: sapu-sapu fish, laying duck performance, copper, lead

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1.Introduction

Previous study by the author [1] revealed that feeding fresh sapu-sapu fish (SSF)"(Hyposarcus pardalis) as a single protein for laying Mojosari ducks at level 20% offered the maximum egg production. Another study conducted to evaluate the properties of SSF revealed that although its protein content ranged from 33.32 to 41.7% [2] or higher (42.49%) [1], the fish contained copper (Cu) and lead (Pb), ranging from 2.48 to 16.70 and from 4.22 to 15.23 mg/kg respectively [2]. This implies that while SSF is a potential protein source, it may be highly contaminated with heavy metals and may even endanger human health. SSF has been used in duck's feeding by small

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farmers in Lombok, Indonesia for years where their skill and knowledge regarding the negative effect of the fish were limited. Other side, duck meat, duck eggs, and inner organs (kidney and liver) are commonly consumed as a protein source for human. Therefore, the present study was undertaken to evaluate the concentrations of these two heavy metals (Pb and Cu) in tissues, eggs and inner organs of laying ducks fed with SSF under rural feeding management and also to save the consumers from toxicity.

2.Materials and Methods

2.1.Animals and management.

This research was carried out at the farm of a duck grower who practiced village condition management (as described below). Laying ducks of the Mojosari breed approximately 40 wks. of age (laying plateau period) were obtained from local growers who procured and reared day-old ducks. One hundred laying ducks were procured from two groups of small duck growers and wing-banded, weighed, and distributed to 20 cages (1.5 m long, 1.0 m width, and 0,45 m high). The ducks were raised in a traditional way where they were group–housed in an intensive pen made from bamboo with average density of 10 birds/1.50 m2 or and zinc roof in an open–sided house with uncontrolled temperature. Rice bran and SSF were the main ingredients used for feeding the laying ducks and were offered in different amounts, depending on the availability of SSF. Birds of group A were fed 28% with SSF whilst group B was provided with 35% SSF: the remaining constituent of the feed was rice bran (Table 1). Ducks were housed in colony cages of 10 birds with floors constructed from solid soil. The cages were equipped with two rounded plastic feeders (30 cm diameter) for 10 birds. They had free access to drinking water. No routine disease controls were carried out except when disease outbreak occurred.

2.2.Diets and Treatments

A total of 100 laying ducks were divided into two treatment groups of 50 birds each and these were further subdivided into five replicates of 10 each. They were fed with two dietary treatments which were prepared from different levels of SSF containing 16.78 and 19.28% crude protein with energy levels of 2,943 and 2,934 kcal of ME/kg for T-A and T-B groups respectively until 8 weeks of the experimental period. SSF was calculated on wet basis, weighed and then ground. SSF used for feeding was ground fresh and mixed with rice bran with addition of two cups of water and fed in a slurry form. Both SSF and rice bran were analysed for proximate composition as per AOAC [3]. Feeding was restricted to 200 g/bird/day and twice a day to avoid over-spilling due to the duck eating behavior. Spillage of the feed was calculated by weighing and drying the remaining feed on the feeder. No vitamin and mineral mix were added into the ration.

2.3.Measurements.

Egg quality characteristics viz. albumen index, egg yolk index, Haugh unit, shell thickness and yolk color were measured on wk 4 and 8 for two consecutive days. Ten eggs per diet group were randomly collected and evaluated for egg quality. A total number of 80 eggs (40 eggs from each

dietary treatment) per collection were taken and the contents were taken in a clean Petri dish and then yolk color was measured against the Roche Yolk Color Fan scale (RYCF) as a tool for a standard color. This study was carried out at the Laboratory of Animal Product Processing Technology- Faculty of Animal Science, Mataram University.

Table 1. Composition of experimental diets for laying ducks feed different dietary SSF

Ingredients: (%)	Diets	
	T-A	T-B
Rice bran	72	65
Sapu-sapu fish	28	35
Total	100	100
Calculated nutrient composition		
Metabolizable Energy (ME) (kcal/kg)	2,943	2,934
Crude protein	16.78	19.28
Crude fiber	22.52	21.40
Ether extract	6.23	7.02
Ash	20.6	21.16
Calcium	1.14	1.40
Available phosphorus	0.90	0.90
Cu	1.22	1.52
Pb	1.03	1.28

Ducks fed sapu-sapu fish 28% and rice bran 72% (T-A) ; ducks fed sapu-sapu fish 35% and rice bran 65% (T-B). SSF=Sapu-sapu fish
No vitamin and mineral added

2.4. Meat, liver and kidney samples.

Two ducks were randomly selected from per treatment replicate and were killed with a sharp knife. Approximately 1 g (wet weight) of tissues from the thigh or breast, liver and kidney were dissected using surgical knife and rinsed thoroughly with distilled water. All samples were labeled according to their parts of the tissues and frozen and stored at -20oC.

Sample analysis.

Samples were thawed and placed in a plastic bottle with top cover were added with 5 ml HNO3 and 1 ml HClO4, and left for 24 hours. On the following day, the samples were heated at a constant temperature of 300oC for 90 minutes. The dried samples were dissolved with distilled water to 25 ml. The samples were allowed to cool, and then were filtered with a filter paper "Sartorius 393" to determine Cu and Pb which were quantitatively analyzed using atomic absorption spectrometry method (AAS) "Perkin Elmer". The absorption wavelengths were 217.00 nm for Pb and 324.765 for Cu respectively. All samples were analyzed in 4 replicates.

2.5. Egg sample

Two eggs were randomly selected and broken and after evenly mixing the albumen and yolk, approximately 5 g were weighed out. The samples were dried into the oven at 450oC for 16 hours. Subsequent analytical procedures were similar to the previous samples. The analyses were

conducted in the Analytical Laboratory of Mataram University.

2.6. Statistical analysis

The data were represented as means and standard error and analyzed using procedure of SAS package version 8 [4]. The Student's t-test was used for data with two groups, while One way Analysis of Variance was used to compare data at significant differences.

3. Results and Discussion

3.1. Egg quality

For data on egg quality, from this study it is known that laying ducks fed with different SSF showed differences in egg shell thickness and egg weight ($p<0.05$) but did not demonstrate any differences ($p>0.05$) in egg index, egg yolk color, Haught unit and height albumen during the experimental period (Table 2). Improved shell thickness was shown by T-B which was fed with 35% SSF containing 1.40% calcium compared to the T-A containing 1.14%. The present results are consistent with the findings of [5] who found that feed consumption and egg production were significantly reduced by feeding a diet containing 1% calcium. In addition, eggshell thickness was 0.352 mm and increased to 0.410 mm when the diet had 5% calcium. In our study, egg shell thickness was 0.520 mm with 1.4% calcium diet and 2.33 g calcium intake (Table 1 and 2). This may be explained by the high bone fish containing high minerals contributing to the eggshell thickness. Again that the SS fish is fresh water which is its dorsal fin have barbed hard bone. Although SSF is at present not commonly used for animal feeding, it can be easily grown in any fresh water body and can form a potential feed for ducks without any further processing as a fish meal under farmer management. Khatoon et al. [6] reported that there was a variation in composition of fish meal which is dependent on species of the fish and the processing method. In this study, the fish was offered in ground fresh, therefore the quality of calcium sources and other nutrients might be higher than that the processed fish. This was reflected in egg weight increasing from 63.2±0.30 to 67.9±0.22 g or 7.43% improvement from low to high SSF.

The mean concentrations of Cu in local duck samples were in the order of liver>kidney>meat>egg while that of Pb was in the order of kidney>liver>egg>meat (Table 3). Mean concentration of Cu and Pb in liver and kidney was higher than that in muscle and eggs. This is consistent with earlier reports [7; 8; 9] Metal uptake is generally dependent on feeding habits [8], the time of exposure to the metals [10;11], the concentration on the feed [7;12;13;14], and heavy metal source [12]. As an essential metal, copper have an important role in the physiological function of animals but excessive amount will make it toxic [15] and may reduce growth rate [16]. Our study found that accumulation of Cu in the meat, eggs, liver and kidney was 12.798±4.181, 7.011±1.949, 30.165±16.561 and 14.392± 4.208 mg/kg respectively. These levels were higher than that recommended by the European Commission [17] in chickens (range; 17 to 23 mg/kg, 16 to 24 mg/kg and 0.66 mg/kg to 1.1 mg/kg for liver, kidney and eggs respectively).

Table 2. Feeding of SSF in laying ducks on egg quality during the 8 -wk of experimental period (Mean +SE) from 40 to 48 weeks of age.#

Parameters	Diets	
	T-A	T-B
Egg weight (g)	63.20±0.30[b]	67.9±0.22[a]
Egg index	76.42±1.82	77.54±1.24
Egg yolk color (R.Y.C.F)	4.9±0.20	4.7±0.48
Egg shell thickness (mm)	0.50±0.04[b]	0.52±0.04[a]
Haught unit	95.82±5.13	95.97±7.25
Height albumen (mm)	9.71±0.81	10.04±1.06

Ducks fed sapu-sapu fish 28% and rice bran 72% (A) ; ducks fed sapu-sapu fish 35% and rice bran 65% (T-B).
[a-b] Means within a row with no common superscript differ significantly ($p<0.05$).
SE= standard error SSF=Sapu-sapu fish
[#] Means represent 5 replicates and 8 eggs in each, comprising 40 eggs per treatment.

3.2. Heavy metal concentration (Cu and Pb)

Table 3. Metals concentration mg/kg of sample of meat, eggs and inner organs of laying ducks fed different SSF levels from 40 to 48 weeks of age (Mean +SE).#

Metals	T-A				
	Meat	Egg	Liver	Kidney	
Cu	13.40±4.76	7.67±1.10	34.66±17.21	15.37±5.60	
Pb	1.063±0.71	0.87±0.52	1.51±0.83	2.08±0.58	
Metals	T-B				Pooled
	Meat	Egg	Liver	Kidney	
Cu	12.18±3.96	6.34±2.49	25.66±16.44	13.41±2.45	16.091±12.155
Pb	1.47±0.49	1.74±0.68	2.02±0.58	2.25±0.98	1.628±0.825

Ducks fed sapu-sapu fish 28% and rice bran 72% (A) ; ducks fed sapu-sapu fish 35% and rice bran 65% (T-B).
SE= standard error SSF=Sapu-sapu fish
[#] Means represent 5 replicates and 2 samples in each, comprising 10 per treatment.

Lead, not an essential metal [11], derives its concentration in the body mainly due to uptake from contaminated or polluted feed sources. In this study, the SSF have become an alternative common fish meal and fed to the laying ducks since the starting period. Thus for at least 6 months the ducks were fed with animal protein source containing heavy metals. According to Kalay and Canli [11], accumulation of heavy metals was higher than their elimination, indicating there are difficulties of the body to remove the accumulated heavy metals that occurred in important organs of living animals. Lead is the most common industrial metal [18] and its accumulation and contamination of edible poultry tissues and eggs represent a potential public health hazard [19]. The distribution of lead (Pb) in body tissues is dependent on the entry point of this metal in the body and its chemical form. However, most of the lead enter through the intestinal wall will accumulate in

bone and liver [20]. In current study, the lead concentrations in the meat, eggs, liver and kidney were 1.267±0.825, 1.311±0.737, 1.762±0.729 and 2.172±0.770 mg/kg respectively higher than the 1.0 mg/kg admissible amount set by the Indonesian National Standard [21]and FAO [22].

4. Conclusion

This study indicates that feeding SSF to laying ducks at high level on rice bran diet resulted in copper and lead accumulated in meat, eggs and inner organs (liver and kidney). Inner organs accumulated higher levels of heavy metals than that of meat and eggs. Therefore, there is a need to identify the appropriate levels of SSF with no risk for humans.

REFERENCES

[1] Indarsih B., A. Asnawi, and D. K. Purnamasari. 2016. "Sapu-sapu fish (Hyposarcus pardalis) as a single protein source for laying mojosari ducks". *Journal of the Indonesian Tropical Animal Agriculture*, 41 (3) : 117-124. https://doi.org/10.14710/jitaa.41.3.117-124.

[2] Purnamasari, D.K., Asnawi and Aziz, A. 2011. "Evaluasi nutrisi kandungan logam berat ikan sapu- sapu (Hypostomus luteus) (kajian potensi pakan itik)". *J. Penelitian*, 2: 52-58

[3] AOAC International, 1990. "Official Methods of Analysis". 15th ed. Washington, DC: Association of Analytical Chemist

[4] SAS Institute, l999. "SAS® User's Guide: Statistics, Version 8". SAS Institute Inc., Cary, NC., USA

[5] Wang, H., Gao, W., Huang, L., Shen, J. J., Liu, Y., Mo, C. H., Zhu, Y. W. 2020. "Mineral requirements in ducks: an update". *Poultry science*, *99*(12), 6764-6773.

[6] HOSSAIN, M. E., AKTER, K., & DAS, G. B. 2016." Nutritive value of fish meal". *Online Journal of Animal and Feed Research*, *6*, 14-19.

[7] Fei, W., Ling, Q., Yujun, S., Yihong, G., & Yueqing, H. 2015. "Investigation and analysis of heavy metal contents from livestock feed and manure in North China". *Transactions of the Chinese Society of Agricultural Engineering*, *31*(5).

[8] Zhang, F., Li, Y., Yang, M., & Li, W. 2012. "Content of heavy metals in animal feeds and manures from farms of different scales in northeast China". *International journal of environmental research and public health*, *9*(8), 2658-2668.

[9] Akan, J.C., Mohmoud, S., Yikala, B.S., and Ogugbuaya, V.O. 2012. "Bioaccumulation of some heavy metals in fish samples from river Benue in Vinikilang, Adamawa State, Nigeria". *Am. J. Anal. Chem*., 3: 727-736.

[10] Briels, N., Torgersen, L. N., Castaño-Ortiz, J. M., Løseth, M. E., Herzke, D., Nygård, T., Bustnes, J.O., Ciesielski, T.M., Poma, G., Malarnannan, G., Covaci, A., & Jaspers, V. L. B. 2019. "Integrated exposure assessment of northern goshawk (Accipiter gentilis)

nestlings to legacy and emerging organic pollutants using non-destructive samples". *Environmental research*, *178*, 108678.

[11] Kalay, M., and Canli, M. 2000. "Elimination of essential (Cu, Zn) and non-essential (Cd, Pb) metals from tissues of a freshwater fish Tilapia zilli". *Turk J. Zool*., 24: 429-436.

[12] Xiang-Qi, Z., Ke-Yi, Z., Xue-Mei, D., and Shi-Ping, B. 2009. "Effects of dietary supplementation with copper sulfate or tribasic copper chloride on carcass characteristics, tissular nutrients deposition and oxidation in broilers". *Pak. J. Nutr*., 8: 1114-1119.

[13] Hashish, S.M., Abdel-Samee, L.D., and Abdel-Wahhab, M.A. 2012. "Mineral and heavy metals content in eggs of local hens at different geographic areas in Egypt". *Global Vet*., 8: 298-304.

[14] Das, S., and Gupta, A. 2013. "Accumulation of copper in different tissues and changes in oxygen consumption rate in Indian flying barb, Esomus danricus (Hamilton-Buchanan) exposed to sub-lethal concentrations of copper". *Jordan J. Biol. Sci*., 6: 21-24.

[15] Chowdhury, M.Z.A., Siddique, Z.A., Hossain, S.M.A., Kazi, A.I., Ahsan, A.A., Ahmed, S., and Zaman, M.M. 2011. "Determination of essential and toxic metals in meats, meat products and eggs by spectrophotometric method". *J. Bangl. Chem. Soc*., 24: 165-172.

[16] Salajpal, K., Grbesa, D., Kaps, M., Kis, G., and Karolyi, D. 2006. "Effect of added copper and full fat soybean meal on growth performance and carcass properties in broiler chickens". *Acta Agr. Kaposváriensis*, 10: 207-213.

[17] EU Council Directive 70/524/ EEC. 2003. "Opinion of the Scientific Committee for Animal Nutrition on the use of copper in feeding stuffs. (European commission Health and consumer protection directorate general)". p:20. http://ec.europa.eu/food/fs/sc/scan/out115_en.pdf

[18] Gupta, A. R., Bandyopadhyay, S., Sultana, F., & Swarup, D. 2021. "Heavy metal poisoning and its impact on livestock health and production system". *Indian J. Anim. Health*, *60*(2).

[19] Hossain, M.A., Akanda, M.R., Belal, S.A., Hasan, M.M.I., Islam, S., Uddin, M.N. Akhand, R.N., Islam, M.S., and Roy, A.C. 2014. "Environmental deposition of lead (Pb) in chickens and litter samples collected from selected area of Bangladesh". *J. Vet. Adv*., 4: 677-685.

[20] Pilliang, W.G. 2004. "Nutrisi Mineral". Institut Pertanian Bogor. Bogor.

[21] Indonesian National Standard. 2009. "Batas maksimum cemaran logam berat dalam pangan". The Indonesian National Standard No: 7389

[22] FAO. 2000. "Report of the 32 second session on the codex committee on food additives

and contaminants". Beijing, People's Republic of China, 20-24 March.