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LEAD AND CADMIUM MOBILIZATION FROM *ANAS MOSCHA* AND *CAIRINA MOSCHATA* TISSUE USING PINEAPPLE EXTRACT AS CHELATING AGENTS

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ABSTRACT

An assesment of dietary risk of heavy metal exposure to humans is important since it is the main source of exposure. This study aimed to measure the level of contamination of heavy metal especially Lead (Pb) and Cadmium (Cd) and the efforts to reduce contamination Pb and Cd in *Anas moscha* and *Ciarina moschata* Tissue. The concentration of Pb and Cd in *Anas moscha* and *Ciarina moschata* tissues were lower than the maximum acceptable level for Pb and Cd respectively. (1 mg/Kg for Pb; 0.5 mg/Kg for Cd, SNI 2009). The result indicated that after soaking and boiling in citric acid solution form pineapple extract at concentration 100 % for 60 min at 100 °C reducing heavy metals Pb in *Anas moscha* from 0.03 mg.Kg⁻¹ to 0.003 mg.Kg⁻¹ and Cd in *Anasmoschata* and *Cairinamoschata* from 0.027 mg.Kg⁻¹ to 0.003 mg.Kg⁻¹ and 0.022 mg.Kg⁻¹ to 0.001 mg.Kg⁻¹. The highest reduction of Pb and Cd level up to 80 % when samples were boiled in pineapple extract for 1 hour at 100°C. The study concludes that boiled samples in pineapple extract has a potential to reduce the contamination of Pb and Cd.

KEY WORDS : Citric Acid solution, Pineapple extract, Heavy metal

INTRODUCTION

Human activities such as industrial and mining operations, population increase and urbanization and to unplanned, unscientific disposal methods are the major contributing factor for rapid increase in the concentrations of heavy metals such as lead, copper, zinc, chromium, cobalt, cadmium in quiferss (Kumari and Sobha, 2016). Lead and cadmium pollution is increasing due to anthropogenic activities such as mining, metallurgical industry, the application of phosphorus fertilizer and pesticides (Zhang *et al.*, 2015) and former additive in automotive gasoline as tetra ethyl lead ((CH₃CH₂)₄Pb) (Mielke and Reagen, 1998).

Lead and cadmium have no known biological functions for the physiological and biochemical processes in cells and are toxic even when present at low concentrations to living organism (Salt *et al.*,

1995). The accumulations of metals in the edible plants part and dietary food can adverse health effect to the human. Contamination of lead poses a serious problem of human health such as human depressed immune status, mental impairment, cancer, High blood pressure, IQ loss, neurological disorder, DNA damage and hematological, pathological dysfunctions (Fextrell *et al.*, 2004; Flora *et al.*, 2007; Ahamed and Siddiqui, 2007; Manikantan *et al.*, 2010; Poreba *et al.*, 2011). Cadmium (Cd) is known for its effect at cellular level with the inhibition of the mitochondrial electron transfer chain and the induction of reactive oxygen species (ROS) (Wang *et al.*, 2004).

Lead and Cadmium have contaminated various foodstuff product such as traditional food, vegetables, fruits, cereals, meat, fish, chicken and white pekin ducks (Ali and Al-qohtani, 2012; Amani *et al.*, 2012; Djohan, 2015; Bordeleau *et al.*, 2016; Sigma *et al.*, 2017). These metals cannot be degraded

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or destroyed, although they can change their formula forms. Once the lead cadmium are dispersed into water, soil air, plants, animals and dietary food can accumulate them (Cheng *et al.*, 2017). Although the relative contributions for heavy metal intake have not been clearly established, dietary intake is considered to be critical exposure pathway, accounting for >90 % of exposure, with inhalation and dermal contact the other exposure routes (Kachenko and Singh, 2006; Islam *et al.*, 2015)

The technologies used to reduce contaminations in food are using organic acids as a chelating agent. Citric acid has potential as chelating agent to remove toxic metals (Chen *et al.*, 2003; Astuti *et al.*, 2016; Aderholt *et al.*, 2017). Pineapple (*Ananas comosus*) is one of the fruits that have high concentrations of citric acid. Citric acid includes a chelating agent which is a stabilizer at food processing. Citric acid binds the heavy metals in the form of complex bond and can reduce side effects of heavy metals in food (Hikmawati and Lilis, 2016).

Interaction of citric acid with heavy metals can be enhanced by soaking (Ulfa *et al.*, 2014) and boiling process at high temperature (Sari *et al.*, 2014). The aim of the experimentations was to evaluate the metal mobilization induced by citric acid from pineapple extract when samples were soaking and boiled until 60 minutes.

MATERIALS AND METHODS

Experimental site

The experiment was performed in food and beverage analysis laboratory, faculty of health science, musi charitas catholic university, Palembang, Indonesia.

Sample preparations

Anasmoschata and *Cairina moschata* were purchased from Gandus Area in Palembang, South Sumatera, Indonesia. Samples of *Anasmoschata* and *Cairinamoschata* was washed and separated their shells and meat. Meat of *Anas moschata* and *Cairina moschata* was soaked in a extract of citric acid at 75 %, 100 % for 30 min, 60 min at 50 °C, 100 °C.

Heavy metals analysis

The heavy metals such as Pb and Hg at juaro fish meat were analyzed by atomic absorption spectrophotometer (AAS) AA 700 in industrial research and standardization laboratory Palembang

and environmental health and disease control laboratory Palembang. Sample (5 g) were dissolved in 25 mL $H_2SO_{4(p)}$, 20 mL $HNO_{3(p)}$, 20 mL $HNO_3-HClO_4(1:1)$ then analyzed using AAS.

Statistical analysis

The normality value of multiple groups were analyzed by one-way analysis of variance (ANOVA) with $p < 0.05$ was classified as statistically significant.

RESULTS AND DISCUSSION

Lead (Pb) Content in *Anasmoschata*

Lead is a soft metal that had many applications over the years. The main sources of this element are primarily from automobile emissions, paint chips, fertilizer, pesticides and Pb-acid batteries. The spreading of Pb pollution from major emission sources are mainly through air. The bioaccumulation of Pb in dietary food should be reduced by using chelating agent. Citric acid as a chelating agent with vary concentration from pineapple extract, soaking time and boiled temperature was used to reduce the level of Pb in *Anasmoschata*.

The level of Pb Studied were successfully reduced by citric acid and are presented in Fig. 1. The obtained results from AAS showed that Pb content in juaro fish before soaking and boiled treatment was $0,03 \text{ mg.Kg}^{-1}$. The value shows that the Pb levels in *Anas moschata* are under the permissible limit. Based on Indonesia National standard the permissible limits of Pb content was 1 mg.Kg^{-1} .

Lead (Pb) can enter the human body through uptake of food (65%), such as fruit, green vegetables, meats and crop products, edible sea life, cold drinks, cigarette and alcohol may contain significant amounts of Pb in water (20%) and air (15%) (Ahmad, 2016) . Lead (Pb) in *Anasmoschata* successfully remove above 80 % after soaked and boiled with 100 % pineapple extract for 60 min at 100 °C.

Citric acid was effective for the removal lead ions which is likely due to its C=C bond (Jiang *et al.*, 2017). Removal effect of toxic metals among organic acids is more effective at acidic condition. Citric acid has large pka (pka = 3.15) provide anions to complex with metals (Doores, 2005). The statistical analysis showed that each treatment was

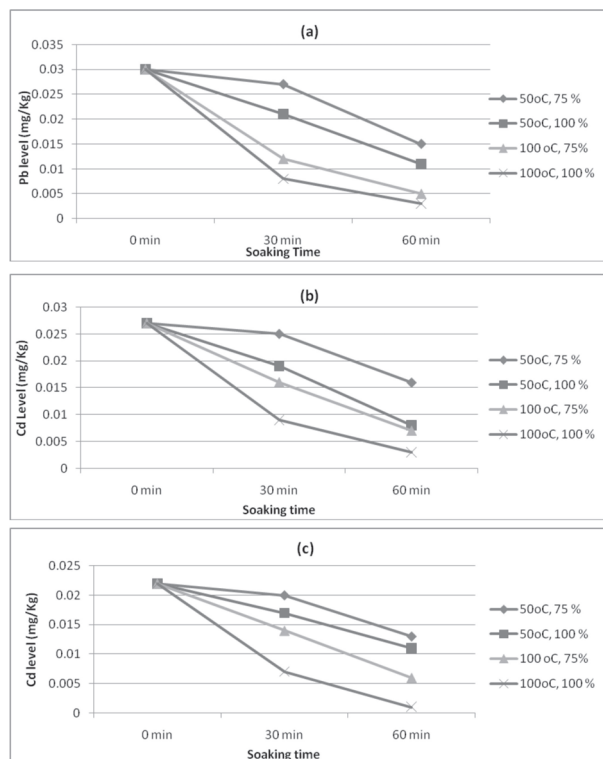


Fig. 1. Reduction of Heavy Metals. (a) Pb in *Anas moschata*, (b) Pb in *Anas moschata*, (c) Cd in *Cairina moschata*.

significantly different and suggest that the higher boiled temperature and longer period of treatment time at any concentration of citric acid can increase the removal of Pb out from *Anas moschata*.

Cadmium (Cd) content in *Anas moschata* and *Cairina moschata*

Cadmium (Cd) is a transition metal with no known biological function in living organism. Cadmium compounds are extremely toxic even at low concentrations because of their bioavailability and solubility in environments. Citric acid with varying concentration of pineapple extract, soaking time and boiling temperature was used to reduce level of Cadmium in *Anas moschata* and *Cairina moschata*. The levels of Cd studied were successfully reduced by Citric acid presented in fig. 2 and 3. The Cd level in *Anas moschata* and *Cairina moschata* from AAS instrument before soaking and boiling treatment was 0.003 mg.Kg⁻¹ and 0.022 mg.Kg⁻¹. The value shows that the Cd levels in 0.003 mg.Kg⁻¹ under the permissible limit.

Heavy metals especially cadmium has contaminated aquatic system (Malvardi, 2017), seafood species (Morgano *et al.*, 2013) and duck (Waseloh, 1994). The cadmium accumulated in body

upon the consumption of contaminated duck. The adverse effect of Cd can caused kidney damage in humans. Cadmium in *Anas moschata* and *Cairina moschata* successfully removed above 80 % after soaked and boiled with 100 % pineapple extract for 60 min at 100 °C.

The statistically analysis showed that each treatment was significantly different and suggest that higher boiled temperature and longer period of treatment at any concentration of citric acid can increase removal of Cd out from in *Anas moschata* and *Cairina moschata*. It was indicates that an higher temperature related to increase the offered energy to separate the chemical bond of mercury metals in the materials and longer period of treatment time will give enough time for chelating agent to chelate with the heavy metals and extracted out from the juaro fish (Azele *et al.*, 2014; Gzar *et al.*, 2014)

CONCLUSION

Citric acid was able to chelate the lead and cadmium metals in in *Anas moschata* and *Cairina moschata*. The increasing of boiled temperature and longer period of treatment at any concentration of citric acid from pineapple extract can increase of removal heavy metals.

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REFERENCES

- Aderholt, M., Vogilien, D.L., Kother, M. and Greipson, S. 2017. Phytoextraction of contaminated urban soils by *Panicum virgantum* L. enhanced with applications of a plant growth regulator (BAP) and citric acid. *Chemosphere*. 175 : 85-96.
- Ahamed, M. and Siddiqui, M.K.J. 2007. Low level lead exposure and oxidative stress : current opinions. *Clin. Chim Acta*. 383 : 57-64.
- Ahmad, P. 2016. *Plant Metal Interaction. Emerging Remediation Techniques*. London: Elsevier.
- Ali, M. and Al-qohtani, K.M. 2012. Assesment of the same heavy metals in vegetables, cereals and fruits in saudi arabian markets. *Egyptian Journal of Aquatic Research*. 38 : 31-37.
- Amani, S., Alturiqi, S., Lamia, A. and Al Bedair. 2012. Evaluation of some heavy metals in certain fish, meat and meat product in saudi arabian markets.

- Egyptian Journal of Aquatic Research*. 38(1) : 45-49.
- Astuti, W., Hirajima, T., Sasaki, K. and Okibe, N. 2016. Comparison of effectiveness of citric acid and other acid in leaching of low grade Indonesia saprolitic ore. *Mineral Engineering*. 85 : 1-16.
- Azelee, I.W., Ismail, R., Ali, R. and Bakat, W.A. 2014. Chelation technique for the removals of heavy metals (As, Pb, Cd and Ni) from green mussel (*Perna veridis*). *Indian Journal of Geo-Marine Sciences*. 43 (3) : 372-376.
- Bordeleau, S., Asselin, H., Mazerolle, M. and Limbeau, L. 2016. Is it still safe to eat traditional food ?. addressing traditional food safety concern in aboriginal communities. *Science of Total Environment*. 565 : 529-538.
- Chen, Y.X., Lin, Q., Luo, Y.M., He, Y.F., Zhen, S.J., Yu, Y.L., Tian, G.M. and Wong, M.H. 2003. The role of citric acid on the phytoremediations of heavy metals contaminated soil. *Chemosphere*. 50 : 807-811.
- Cheng, J., Zhang, X., Tang, Z., Yang, Y., Nie, Z. and Huang, Q. 2017. Concentrations and human health implications of heavy metals in market foods from a chinese col-mining city. *Environmental Toxicology and Pharmacology*. 50 : 37-44.
- Djohan, C.R. 2015. *Bioaccumulation of Lead (Pb) in Duck (Anas moscha)*. Gadjah Mada University Press.
- Doores, S. 2005. *Organic acids*. In: Davidson, P.M., Sofos, J.N. and Branen, A.L. (Eds.), *Antimicrobials in Food*. Boca Raton: CRC Press.
- Fextrell, L.J., Pruss-ustan, A., Ladrikan, P. and Ayusomateos, J.L. 2004. Estimation of global burden disease of mild mental retardation and cardiovascular diseases from environmental lead exposure. *Environ Res*. 94 : 120-133.
- Flora, S.J.S., Saxena, F.G. and Mehta, A. 2007. Reversal of lead-induced neuronal apoptosis by chelation treatment in rats : role of reactive oxygen species and intracellular Ca²⁺. *J Pharmacol. Exp. Ther*. 322: 108-116.
- Gzar, H.A., Abdul-Hameed, A.S. and Yahya, A.Y. 2014. Extraction of lead, cadmium and nickel from contaminated soil using acetic acid. *Open Journal of Soil Science*. 4 : 207-214.
- Hikmawati, A and Lilis, S. 2006. Mobilization of mercury levels in Tuna Fish with soaking treatment of lime solution. *Science & Technology Indonesia*. 3 : 67-76.
- Islam, M.S., Ahmed, M.K., Habibullah-almamun, M. and Raknuzzaman, M. 2015. The concentration, source and potential human risk of heavy metals in the commonly consumed foods in bangladesh. *Ecotoxicol Environ Saf*. 12 : 462-469.
- Jiang, J., Yang, M., Gao, Wang, J., Li, D. and Li, T., 2017. Removal of toxic metals from vanadium-contaminated soils using a washing method: Reagent selection and parameter optimization. *Chemosphere*. 180 : 295-301.
- Kachenko, A.G. and Singh, B. 2006. Heavy metals contaminations in vegetables grown in the urban and metal smelter contaminated sites in australia. *Water Air Soil Pollut*. 169 : 101-123.
- Kumari, A.R. and Sobha, K. 2016. Removal lead by adsorption with the renewable biopolymer composite of feather (*Dromaius novaehollandiae*) and chitosan (*Agaricus bisporus*). *Environmental Technology and Innovation*. 6 : 11-26.
- Malvardi, H. 2017. Preliminary evaluation of heavy metals contamination in zarrin-gol river sediment. Iran. *Mar Pollut Bull*. 15 (117) : 547-553.
- Manikantan, P., Balachandar, V. and Sasikala, K. 2010. DNA damage in worker occupationally exposed to lead, using comet assay. *Int. J. Biol*. 2(1) : 103-110.
- Morgano, M.A., Rabonato, L.C., Milani, R.F., Miyagusku, L. and Quintaes, K.D. 2014. As, Cd, Cr, Pb and Hg in seafood species used for sashimi and evaluation of dietary exposure. *Journal Food Control*. 36 : 24-29.
- Mielke, H.W. and Reagan P.L. 1998. Soil is an important pathway of human lead exposure. *Environ. Health Perspect*. 106(suppl 1): 217-229.
- Poreba, R., Gac, P., Poreba, M. and Andrzejak, R. 2011. Environmental and occupational exposure to lead as potential risk factor for cardiovascular disease. *Environ. Toxicol. Phar*. 31 : 267-277.
- Salt, D.E., Blaylock. M., Kumar, N.P., Dushenkov, V., Ensley, B.D., Chet, I. and Raskin, I. 1995. Phytoremediation : a novel strategy for removal of toxic metals from the environment using plants. *Biotechnology*. 13 : 468-474.
- Sari, K.A., Riyadi, P.H. and Anggo, A.D. 2014. The effect of boiling temperature and lime (*Citrus aurantifolia*) solution on lead and cadmium levels on blood clams (*Anadara granosa*). *Biotechnology Journal*. 3(2):1-10.
- Sigma, G., Mazzola, A. and Tranai, C.D. 2017. Differential effects of citric acid on cadmium uptake and accumulation between mall fescue and kentucky blue grass. *Ecotoxicol Environ Saf*. 145 : 200-206.
- Ulfah, S., Rachmadiarti, F. and Raharjo. 2014. Mobilization of lead content in *Mystus nigriceps* at Kali rivers of Surabaya using extract of pineapple skin. *Lentera Bio*. 3(1) : 103-108.
- Wang, Y., Fang, J., Leonard, S.S. and Rao, K.M.K. 2004. Cadmium inhibits the electron transfer chain and induces reactive oxygen species free radical. *Bio. Med*. 36 : 1434-1443.
- Zhang, J., Yang, S.Y., Huang, Y.J. and Zhou, S.B. 2015. The tolerance and accumulation of *Mischanthus sacchariflorus* (maxim) benth, an energy plant species to cadmium. *Int J Phytoremediation*. 17 : 538-555.