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The Management of Vegetable Cultivation to Protect the Consumer from Heavy Metal Pollution

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Abstract

Since heavy metals are potentially accumulated within vegetable organs, this research is conducted to identify those metals and their effects on the nutrient content. Two-Ways Analysis of Variance determined the effect of various location, vegetables, and vegetable organs towards metals. One-Way Analysis of Variance determined the effect of locations and fruit type on metals uptake. It is followed by examining heavy metals accumulation within edible parts of vegetables and its effects on protein, vitamin A and C. The Randomized Group Design of 3 factors (media, distribution, and vegetable organs) is employed considering 3 different harvesting times harvesting and cultivation adjustment (trimmed or not trimmed). The 3 factors Covariant Analysis defined the influences of media, time and way of harvesting on protein, vitamin A and C of water kangkoong stem and leaves. The results showed a significant influence of various areas (paddy field, industrial area, and highland) on Cd, Cr and Pb uptake within stems, leaves and fruits. Generally, the period and way of harvesting significantly influence the heavy metals uptake, level of protein, vitamin A and C, Mg and chlorophyll of water kangkoong. It is suggested to prune and harvest vegetables earlier to minimize heavy metals uptake and nutrient degradation.

Keywords*:* management of vegetable cultivation, consumer protection, heavy metals pollution

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1. Introduction

Varies of human activities commonly produces pollutants that impact negatively on the environment. Therefore, a waste control in those activities is needed. One of the main pollutants that should be considered is heavy metal. In lower concentration, these heavy metals are poisonous to plants, animals, and humans. The Research and Development Centre of Agriculture Department in 2008 showed that Pb contents within cabbage, tomato, and carrot which planted in West and East Java are beyond the minimum threshold [1]. Meanwhile, within rice, the contents of As, Cd and Zn are also beyond it.

The existence of the heavy metals in the environment naturally occurs from precipitation process, volcano activity and/or weathering of rocks [2]. However, several heavy metals such as Cd, Cr and Pb allegedly come from industrial process and human activities. They are usually produced as the waste of chemical factories, electroplating activity and residential waste [3]. The overuse of chemical fertilizer, as well as the transportation emission, are also contributed to heavy metals pollution in the environment [4].

These facts reveal that heavy metals get into the environment mostly from human activities such as industrial process, transportation, agriculture, and household activities. However, those metals are endangered human life if they are beyond the minimum threshold and get into human metabolism process. Every living organism has their own minimum threshold of heavy metals. The intake is different in every organism, such as inhaled, skin contact or eaten accidentally. As the top consumer, the human being will accumulate those metals within their bodies by consuming plants and animals that already polluted [4,5]. Heavy metals that accumulated in large number within body tissues are carcinogenic.

In the other hand, some species of plants are tolerant to heavy metals because they have the specific defence mechanism, which involves antioxidant cells and enzymes. They can protect some vital physiological processes in order to prevent the harm which caused by reactive oxygen forms following the stress by heavy metals pollution [6]. Those metals increase the free radicals, which will destroy enzymes so decrease the protein within the plant organs. The free radicals also can destroy the cell membranes, change DNA, alter the body chemically, increase the cancer risk and deactivate protein. Anti-oxidant (carotene/vitamin A, vitamin C, vitamin E, Zn and Se) can improve the body

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cells and neutralize the free radicals. Vitamin C prevent the oxidation in liquid based molecules, meanwhile vitamin E and A which are dissolved in fat work in lipid cells and cholesterol circulation [7]. The application of the anti-oxidant system is the plant's effort to withstand the pollutant stress [8].

Based on the understanding that there are differences of heavy metals distribution based on the pollutant source and plant cultivation adjustment (harvesting and pruning), thus this research was conducted. The objectives are: 1) identifying the difference of heavy metal distribution; 2) identifying the intake of Cd, Cr and Pb within vegetable and fruits; 3) determining the effect of harvesting time to heavy metals intake within vegetable organs; 4) determining the effect of pruning to heavy metals intake within vegetable organs; 5) determining the effects of harvesting time and pruning to nutrient level (vitamin A, C and protein) of vegetables; and 6) formulating the research outcome for consumer protection over heavy metals pollution.

2. Method

The research started by surveying both the clean and polluted environments. Two-Way Analysis of Variance was used to find out the effects of location, kind of vegetables and parts of vegetables to metals intake. Meanwhile, One-Way Analysis of Variance was used to determine the effects of location and kind of fruits to metals intake. Moreover, accumulated heavy metals within edible parts of vegetables were analysed for its effect on protein, vitamin A and C. Group Random Design 3 factors was used to analyse the effects of media, plant organs distribution, the variation of harvesting time and cultivation adjustment. Furthermore, Covariance Analysis with 3 factors was used to determine the effects of heavy metals polluted media, harvesting time and cultivation adjustment to the levels of protein, vitamin A and vitamin C within stems and leaves of water kangkoong.

The heavy metals level measurement was used Vogel's method using Spectrophotometry UV-Vis [9]. The level of protein was measured by Semi-Micro Kjeldahl method. Spectrophotometry UV-Vis method was also used to measure the level of vitamin A, Vitamin C [10], and Chlorophyll level within stem and leaves of vegetables. The colours of leaves were measured using Leaf Colour Chart [11].

3. Results and Discussion

3.1. The effects of different area to heavy metals intake in vegetable plants

a. The profile of heavy metals intake to vegetables in different area

The figures below (Fig. 1 and Fig. 2) show the effects of different location to heavy metals intake:

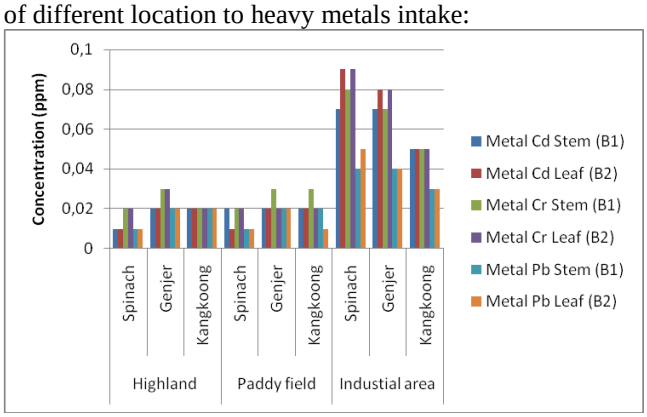

Fig 1. The correlation of different locations to heavy metals intake in different kinds of vegetables [17]

Based on Fig 1, it can be seen that vegetables, which are planted in the industrial area, accumulate more heavy metals than another area. Markedly, those metals are accumulated mostly inside the leaves. It is predicted that the number will increase the time.

b. The profile of heavy metals intake within the fruits from different locations

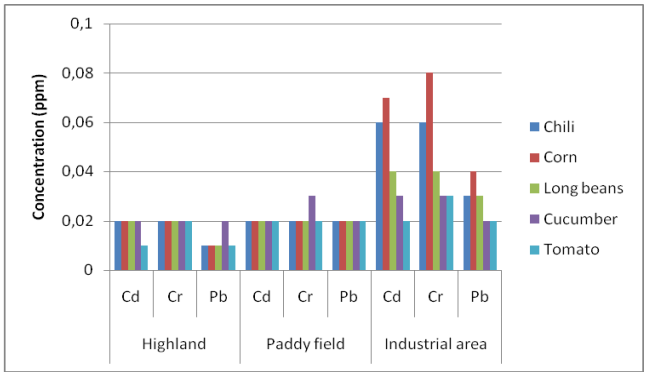

Fig 2. The profile of heavy metals intake within the fruits from different location [17]

It can be shown by Fig.2 that mostly heavy metals accumulated within corn, followed by chili, long beans, cucumber and tomato. Based on the kind of heavy metals, Cr is absorbed mostly, followed by Cd and Pb the least regardless that Pb has the highest number (2.49 ppm) in the environment than other heavy metals. The metals intake is also influenced by the age of the plant. The older the plants, the intake are getting higher. Due that, corn shows more intake than other plants.

In Indonesia, the same trend happens, which heavy metals pollution increases following the industrial area development. This pollution is dangerous for the human being, animal and plant depends on the dosage exposed and in which part of the body bind to the metals. [12] The effects are metabolism distraction, allergen reaction, mutagen, and cancer.

The previous research showed that there are heavy metals such as Pb and Cd that produced by agrochemical and industrial waste found in agricultural centres in Brebes and Tegal [13]. The level is beyond minimum threshold Ditjen POM Depkes, which are more than 0,24 ppm. Meanwhile, the soil sample from paddy fields in Juwana Pati showed that levels of Fe, Al, Ni, Co and Cr also beyond the minimum threshold. Within the rice, the level of Fe, Zn, Mn, Cr, Pb and Cd are high even though they are below the minimum threshold.

Based on the analysis, heavy metals intake in shoot, leaves and fruits are affected by different sampling location. Pb and Cd are the most important pollutant that found in the industrial area and even in the household area [14,2]. Moreover, it is stated that even though Al, Cd, Ag, Pb, As and Hg are elements found in plants, they are not useful and even destruct plant metabolism or poison the plant [15]. This condition can happen because there are several factors influence the heavy metals intake by the plants. Those factors are a) the form of metals in water; b) the presence of another metal; c) the physiological factors of the organism; d) the state of living organisms; and e) behaviour response [2]. Hence, vegetables can survive in the polluted area if they have supporting factors. The plants, which potentially become a hyper-accumulator, commonly are endemic species in the heavy metals polluted area [16].

The specific gravity of heavy metals allows them to be accumulated so they can be found easily in the sediment and water [2]. Therefore, they can be absorbed by plants from there. It is supported by plant root, which grows well within water and sediment. These plants thus known as phytoremediator, plants that are resistant to pollutant includes heavy metals. That is why those plants can be found in polluted environment (Cd in highland sediment 0,12 mg/L, paddy field 0,88 mg/L, industrial area 1,82 mg/L that are beyond the minimum threshold Cd 0,01mg/L; Cr in highland sediment 0,11 mg/L, paddy field 0,69 mg/L, industrial area 2,17 mg/L that are beyond the minimum threshold Cr 0,01 mg/L; Pb in highland sediment 0,19 mg/L, paddy field 0,62 mg/L, industrial area 2,49 mg/L that are beyond the minimum threshold Pb 1 mg/L) [17].

3.2. The Effect of Cultivation Adjustment and Harvesting Time to the Level of Protein, Vitamin A and Vitamin C in Cd, Cr and Pb Polluted Media

This research assumed that the heavy metals intake by the plant can be inhibited by controlling the transpiration. By pruning the leaves and harvesting the plants in the right time, transpiration can be minimized so the absorption from the polluted soil can be restricted. The common description of the analysis of harvesting time and cultivation adjustment effects to metals intake, the content of protein, vitamin A and C, Mg and chlorophyll can be seen from the figure below.

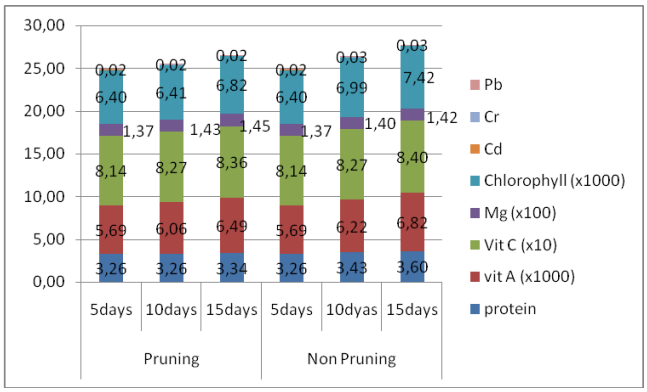

Fig 3. The Profile of Protein, Vitamin A, Vitamin C, Mg and Chlorophyll Content in Cd, Cr and Pb Polluted Media [17]

It can be described from the Fig 3 that there is a tendency of different harvesting time to affect the metal intake, the content of protein, Vitamin A, Vitamin C, Mg and Chlorophyll within leaf and shoot of water kangkoong. The longer harvesting time, the higher metal intake opportunity. This causes the decreasing of protein, Vitamin A, Vitamin C, Mg and chlorophyll content within leaf and shoot of water kangkoong. However, there is also a tendency of the increasing of those indicators. As known, people generally harvested kangkoong after 15 days, but that interval time still has the best time to produces protein, vitamin A and vitamin C. This indicates that the interval of harvesting time does not significantly affect the metal intake within the plants. Therefore, it is suggested to review the interval of harvesting time again so the perfect time of metal intake to affect the plant metabolism can be determined.

In Fig 3, there is a tendency of different cultivation adjustment to affect the metal intake, the content of protein, Vitamin A, vitamin C, Mg and chlorophyll within leaf and shoot of water kangkoong. Theoretically, pruning will decrease the transpiration rate so the absorption of heavy metal from the water can be restricted. Finally, it will prevent the reduction of protein, vitamin A, vitamin C, Mg and chlorophyll.

In plants, transpiration process has many important functions. It can a) generate the leaf suction; b) help the water and nutrition absorption; c) diminish the excessive water absorbed; d) stabilize the right temperature; and e) controlling the opening of stomata [18,19,20,21].

Based on that finding, it is suggested to prune the old leaf to suppress the transpiration rate. The less number of leaves, number of stomata is getting lessen, which lead to transpiration declining. Indirectly, it decreases the absorption of water and every element in it. Therefore, it can be concluded that pruning is one of the efforts to lessen the metal intake. The less of metal intake, the low metal accumulated within edible part of the vegetables. Moreover, the content of several nutrient also can be maintained.

The assumption is supported by previous research [22] showed that the harvesting time determines the level of the

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vegetable nutrient. In order to keep the nutrient level, the harvesting should be conducted at a perfect time. Delaying the harvesting time will increase the heavy metals intake. In the other hand, protein and vitamin content are not optimal if the plants are harvested too early.

4. Conclusion

It can be concluded that 1) the difference of location (highland, paddy field, and industrial area) affects the heavy metals existence within the parts of vegetables; 2) there is an effect of different location to the existence of heavy metals in vegetable fruits; 3) harvesting time potentially contributes to the content of protein, vitamin A, vitamin C, Mg and chlorophyll in water kangkoong; 4) cultivation adjustment potentially affects the content of protein, vitamin A, vitamin C, Mg and chlorophyll in water kangkoong; 5) there is a potential effect of harvesting time and cultivation adjustment to the content of protein, vitamin A, vitamin C, Mg and chlorophyll in water kangkoong; 6) the time management in harvesting and cultivation adjustment could be a right alternative to maintaining the nutrient level of the vegetables as well as reducing the heavy metals intake so they are safer to be consumed.

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