

The Cost Prediction for Chromium Detox Using Foods Intake Containing Glutathione at the Leather Tanning Industry in Magetan, Indonesia

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Abstract

Citation: Tualeka AR, Rahmawati P, Ahsan A, Russeng SS, Sukarmin S, Wahyu A. The Cost Prediction for Chromium Detox Using Foods Intake Containing Glutathione at the Leather Tanning Industry in Magetan, Indonesia. Open Access Maced J Med Sci. 2019 Nov 15; 7(21):3698-3703.
<https://doi.org/10.3889/oamjms.2019.557>

Keywords: Chromium; Cost; Detoxification; Glutathione; Workers

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Received: 04-Apr-2019; **Revised:** 11-Jun-2019; **Accepted:** 12-Jun-2019; **Online first:** 15-Aug-2019

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Funding: This article was supported by Activity Budget Plans 2017, Faculty of Public Health, Airlangga University, Indonesia

Competing Interests: The authors have declared that no competing interests exist

BACKGROUND: Chromium was an organic compound which was used in metal alloys such as stainless steel, chrome plating, metal ceramics, leather tanning, etc. To reduce and eliminate toxin of chromium from the human body could be using detoxification process, one of them was using foods.

AIM: The aim was to calculate the foods intake contain glutathione to improve chromium detoxification and calculate the cost of foods intake.

METHOD: The type of research was a descriptive study. The subjects were 10 workers. Inclusion criteria of subjects were workers who had worked for more than or equal to 10 years. Variables were body weight, duration of work, and chromium concentration. After getting all variables above, breathing rate and intake non-carcinogen per respondent can be calculated. Then, the effective dose of foods rich in glutathione and costs of foods will be obtained.

RESULTS: The results of this research indicated that the highest cost of foods intake containing glutathione was 5948 idr of broccoli per week and the lowest cost of foods intake was 535 idr of avocado per week.

CONCLUSION: Intake of foods containing glutathione (avocado, broccoli, carrot, tomato, and grape) was expected to increase detoxification of chromium. Each individual had a different amount of cost. This depends on the effective dose, chromium concentration, weight, and duration of work per respondent.

Introduction

The development of the industry is quite rapid in recent times. The industry has various work activities such as the use of equipment, the use of machinery, the use of chemicals as raw materials, and the production of chemical emissions, and so on. The use of chemicals, especially hazardous chemicals, can certainly provide a threat at work. This can be a potential source that can trigger danger to the health and safety of workers [1]. One of the chemicals that are dangerous or carcinogenic is chromium. Chromium is one of the chemicals that use in the leather tanning industry. The leather tanning industry

is an industry that produces finished leather that can be used as an ingredient in making sandals, shoes, bags, jackets and more. One of the processes in making leather is the tanning process. In this process, it aims to change raw skin that is easily damaged due to the activity of microorganisms into tanned skin that is more resistant, using chemicals. Chemical substances are often used in the tanning process, one of which is chromium sulfate ($\text{Cr}_2(\text{SO}_4)_3$). Chromium is chosen because it provides advantages and eases in the process, is better, and more durable [2]. Also, tanned skin using chromium has several advantages because it is suitable for the production of a variety of leather goods and has better compatibility with chemicals for the process of retaining and fatliquoring

[3]. Chromium tanned leather also has high tensile strength, is weaker, more durable to high temperatures, and gives good results on painting and has high hydrothermal stability.

Mineral skin tanning consists of 3 stages, namely: Beam House, Tanning, and Finishing. The raw materials used are animal skin (cows, buffaloes, goats, etc.), especially the results of slaughterhouses. Beam House Process (Pre Tanning), which includes dyeing skin into the water for one night to remove blood, dirt, salt solution, and protein. Then remove hair and skin parts that are not needed by immersion in lime, and sodium sulfide as a skin swelling material. Shaving and removing extra tissue from the flesh and skin, then separating using lime 2/3 the top layer from the bottom. Then the lime is removed using lactic acid and eradication uses auxiliary chemicals to remove leftover hair and broken proteins. Preservation uses saline and sulfuric acid to a certain pH to prevent precipitation of chrome salts on the skin fibres. Second is the Tanning Process. Chrome tanning is done using chrome sulfate. This process is useful for stabilising protein (collagen) tissue from the skin. Tanning aims to change the raw skin that is clean, which has an unstable nature into tanned skin that has a stable nature. The last is the Finishing Process (post tanning). This process includes pressing (slamming) to remove moisture from fresh skin, shaving, colouring and softening tanned skin using oil emulsion (fat liquoring), final drying and shaving, and surface coating and buffing (finishing) [4].

Chromium (Cr) is a metal that is grey, shiny, hard and brittle that requires high polishing, durability, and has a high melting point. This metal is one of the toxic heavy metals. Its toxicity depends on the valence of the ion. By its nature, chromium metal has an oxidation number of +2, +3, and +6. At Cr^{+2} it forms an alkaline compound, the compound formed from Cr^{+3} ions has an importer, and Cr^{+6} ions are more acidic. In the case of chronic ionic acid (CrO_4^{-2}), it can cause a very strong reduction event. Chromium is widely used for industrial activities such as electroplating, leather tanning, and painting of chromate and dichromate compounds [5]. And the toxicity of Cr^{+6} is equal to one hundred times the toxicity of Cr^{+3} . Besides, Cr^{+3} is also highly corrosive and carcinogenic [6].

There are many types of chromium ions, but chromium (III) sulfate is used in this study. The chrome compound (Cr) in the tannery industry wastewater comes from the leather tanning production process, in which tanning using chromium sulphate compounds between 60% -70% in the form of chromium sulfate solution can not all be absorbed by the skin during the tanning process so that the remainder is released in the form of liquid as liquid waste [7]. Hexavalent chrome (Cr^{+6}) from the leather tanning industry is usually in the form of chromate (CrO_4^{2-}). Chromatic poisoning can cause irritation to the skin, accumulate in the liver, and systemic poisoning. Chromate vapour when inhaled can cause

infection (inflammation) in the respiratory tract and lung cancer, and skin damage by chrome salts [8]. Chromium has a role in the body. In humans and animals, chromium in the lower concentration is an essential micronutrient, but in high concentrations, it can cause carcinogens. Chromium can be called heavy metal because, in the long run, it can cause a health disorder such as allergic to cancer in humans. Accumulation of heavy metals can cause interactions between heavy metals can result in interactions between heavy metals with cells or body tissues. The toxic nature of chromium can cause acute poisoning and chronic poisoning. These metals and their compounds can interfere with the function of organs that work in metabolic processes when they enter the human body.

To reduce and even eliminate toxins in chemical compounds in the body, a biotransformation process is needed. Biotransformation is a change in the toxin catalysed by certain enzymes in living things. The purpose of biotransformation is to convert non-polar to polar, then to become hydrophilic so that it can be excreted out of the body. Biotransformation occurs in two phases. The first phase is the functional phase where the functional group matches the oxidation, reduction and hydrolysis reactions. Then the second phase is the conjugate reaction phase involving several types of endogenous metabolites in the body in the endoplasmic reticulum [9].

Research using foods approach as chromium detoxification is still very limited. Foods containing glutathione such as avocado, broccoli, carrot, tomato, and grape [10], [11], [12]. But there has never been researching that explains how much intake of these foods is needed to improve chromium detoxification, especially in a population that exposed to chromium in a long time. Based on the background above, this research aims to calculate the intake of foods containing glutathione (avocado, broccoli, carrot, tomato, and grape) are needed (effective dose) to detoxify chromium at leather tanning industry workers in Magetan and to calculate the cost of foods intake containing glutathione to detoxify chromium.

Material and Methods

The type of research was a descriptive study. Subjects were workers in the leather tanning industry in Magetan. The inclusion criteria were all workers who had worked in this industry for more than or equal to 10 years, workers who worked on the tanning process using chromium, and willing to be used as research respondents. The sample of this research was 10 respondents. The research location was in the Technical Implementation Unit of the Leather Products Industry in Magetan.

Research technique started from collecting secondary data such as work processes that include the number of workers involved. While the primary data includes the worker's weight, duration of working (years), working time per week (days), an average of working every day (hours), the concentration of chromium in the blood of workers. Measurement of chromium concentration was carried out at 10 respondents. Measurement of respondents weight using manual measurement method with body scales. Measurement of the duration of work, working time per week, and an average of working every day were obtained with an in-depth interview with respondents. Then, measurement of chromium concentration in the blood of workers using method by Atomic Absorption Spectrophotometer method. Blood collection of respondents was carried out by skilled medical personnel from a laboratory. Blood is taken through a vein that has been adopted using alcohol. Blood is taken as much as 5 ml and put in a tube containing Ethylene Diamine Tetra Acetate (EDTA) as a coagulant material so that the blood does not clot when going to the laboratory. Blood in the laboratory will be analysed using Atomic Absorption Spectrophotometer method.

After getting all variables above, it can be found breathing rate and intake non-carcinogen of chromium per respondent. Then, an effective dose of foods rich in glutathione would be obtained by manual calculating used the formula below:

$$\begin{aligned} & \text{dose effective of food intake} \\ & = \left\{ \left(\text{intake nc} \times \frac{Mr \text{ enzyme}}{Mr \text{ toxin}} \right) - (C \text{ enzyme} \times 70) \right\} \times \frac{100}{A} \end{aligned}$$

Explanation:

$$\text{Intake NC (non-carcinogen)} = \frac{C \times R \times tE \times fE \times Dt}{Wb \times 30 \times 365}$$

C: Chromium concentration (mg/m³)

R: Breathing rate (m³/hour)

Dt: Duration of working (years)

fE: Working time per week (days)

tE: Average of working time per day (hours)

Wb: Weight (kg)

$$C \text{ enzyme (normal)} \times \frac{Mr \text{ enzyme}}{Mr \text{ enzyme}} =$$

$$\text{Glutathione} = \frac{0.00000099 \text{ mmol/ml}}{307.32}$$

A = Content of enzyme in 100 grams of the food

Glutathione

- Avocado: 31.2 mg
- Broccoli: 7.8 mg
- Carrot: 5.9 mg
- Tomato: 10.9 mg
- Grape: 14.6 mg

After getting all variables above, the cost of meeting food requirements containing glutathione released by each respondent to detoxify chromium can be calculated. The calculation of the cost of each food is calculated using the formula below:

$$\begin{aligned} & \text{cost of food intake} \\ & = \text{dose effective} \times \text{cost of food/kg} \end{aligned}$$

Results

Distribution of Chromium Concentration at Workplace

Figure 1 shows that most locations of the workplace have chromium concentration above the threshold limit value (TLV). The TLV of chromium concentration at the workplace is 0.5 mg/m³. The highest chromium concentration at the workplace is 1.7 mg/m³, while the lowest is 0.32 mg/m³. The average of chromium concentration at the workplace is 1.01 mg/m³.

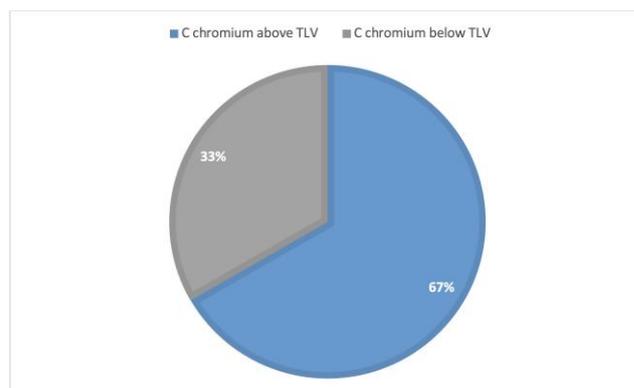


Figure 1: Distribution of Chromium Concentration at Workplace

Distribution of Chromium Concentration in the Blood of Workers

Figure 2 shows that all respondents have chromium concentration above the threshold limit value (TLV) in the blood. The TLV of chromium concentration in the blood is 1.6-5.1 mg/m³. The highest chromium concentration in the blood of workers is 48.3 mg/m³, while the lowest is 23.6 mg/m³. The average of chromium concentration in the blood of workers is 36.15 mg/m³.

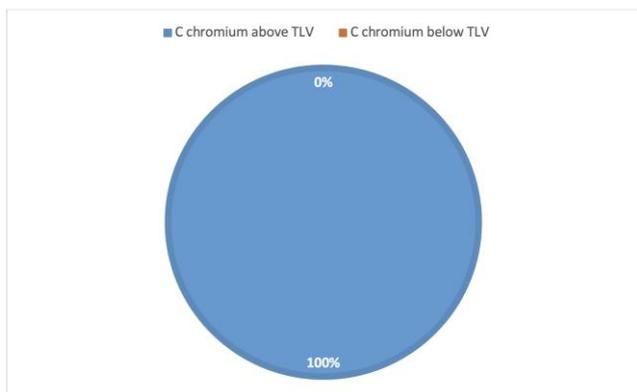


Figure 2: Distribution of Chromium Concentration in the Blood of Workers

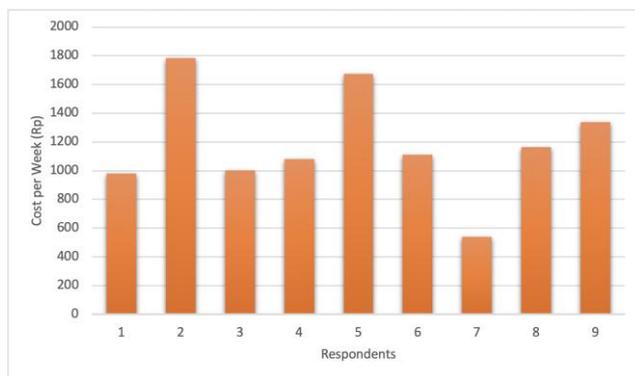


Figure 4: The Cost of Effective Dose of Avocado to Chromium Detox per Week

Effective Dose of Foods Intake Containing Glutathione to Chromium Detox per Week

In Figure 3 shows that the highest effective dose of avocado, broccoli, carrot, tomato, and grape to chromium detox are 297.42 mg, 1190 mg, 1572.82 mg, 851.34 mg, and 635.6 mg (respondent 3). While the lowest effective dose are 89.18 mg, 356.75 mg, 471.63 mg, 255.28 mg, and 190.6 mg (respondent 1). The average of an effective dose of avocado, broccoli, carrot, tomato, and grape are 186.92 mg, 747.7 mg, 988.5 mg, 535 mg, and 399.5 mg.

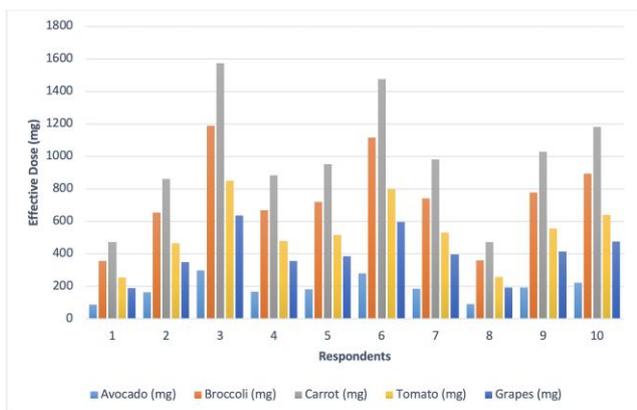


Figure 3: Effective Dose of Foods Intake Containing Glutathione to Chromium Detox per Week

The Cost of Effective Dose of Foods Intake Containing Glutathione to Chromium Detox per Week

A. The Cost of Effective Dose of Avocado to Chromium Detox per Week

Figure 4 shows that the highest cost of an effective dose of avocado to chromium detox is 1784 idr (respondent 3), while the lowest is 535 idr (respondent 1). The average the cost of an effective dose of broccoli to chromium detox on respondents is 1186 idr.

B. The Cost of Effective Dose of Broccoli Chromium Detox per Week

Figure 5 shows that the highest cost of an effective dose of broccoli to chromium detox is 5948 idr (respondent 3), while the lowest is 1783 idr (respondent 1). The average the cost of an effective dose of broccoli to chromium detox on respondents is 3738 idr.

C. The Cost of Effective Dose of Carrot to Chromium Detox per Week

In Figure 6 shows that the highest cost of an effective dose of carrot to chromium detox is 3932 idr (respondent 3), while the lowest is 1179 idr (respondent 1). The average of the cost of an effective dose of carrot to chromium detox on respondents is 2471 idr.

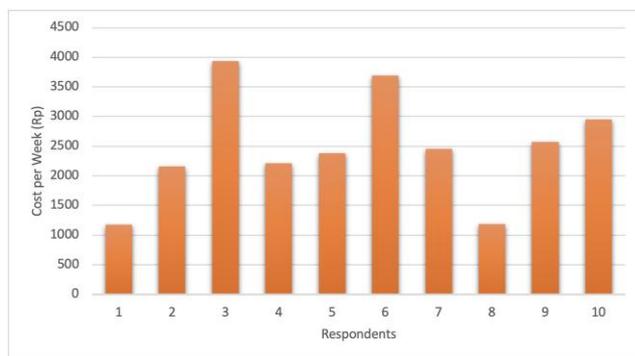


Figure 6: The Cost of Effective Dose of Carrot to Chromium Detox per Week

D. The Cost of Effective Dose of Tomato to Chromium Detox per Week

Figure 7 shows that the highest cost of effective dose of tomato to chromium detox is 2979 idr (respondent 3), while the lowest is 893 idr (respondent 1). The average of cost of effective dose of tomato to chromium detox on respondents is 1872 idr.

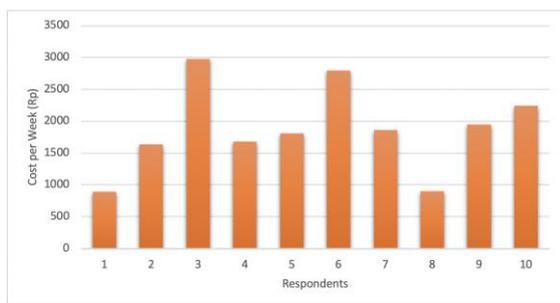


Figure 7: The Cost of Effective Dose of Tomato to Chromium Detox per Week

E. The Cost of Effective Dose of Grape to Chromium Detox per Week

Figure 8 shows that the highest cost of an effective dose of grape to chromium detox is 5084 idr (respondent 3), while the lowest is 1524 idr (respondent 1). The average cost of an effective dose of grape to chromium detox on respondents is 3195 idr.

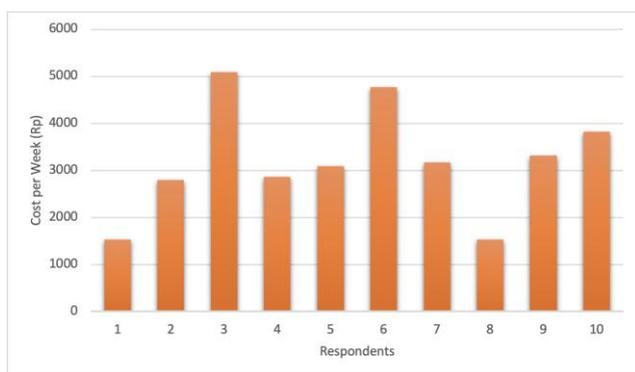


Figure 8: The Cost of Effective Dose of Grape to Chromium Detox per Week

Discussion

Detoxification is the process which toxic compounds to less toxic. The detoxification process becomes non-toxic eliminated through urine and bile [13]. Toxin detoxification is important in modern times. Many toxins are spread on this earth, such as in the sea, rivers, food, drinks, and objects around us. Detoxification is very important to be done to remove harmful or toxin chemicals in the body. Detoxification can be done foods approach. Food-based nutrition continues to be investigated for its role in modulating the metabolic pathways involved in the detoxification process. Several publications that have used cells, animals and clinical studies show that food-based components and nutrients can modulate the process of conversion and excretion of toxins from the body [14]. In this research, chromium detox can be done foods approach with foods that rich in glutathione,

such as avocado, broccoli, carrot, tomato, and grape (Dhivya, 2012) [10], [11], [12]. Glutathione is a potent antioxidant compound and detoxifying agent that is produced in the cytoplasm of every cell of the human body. In broad terms, these studies have found glutathione to protect against oxidative stress, detoxify chemicals and toxins, boost immune function, and support healthy ageing. One of the toxins that can be detoxified is chromium [15].

The main function of Cr is to increase insulin activity inside glucose metabolism and to maintain the speed of glucose transport from the blood into the cell. Cr also plays a role in activating the work of several enzymes. Cr deficiency causes impaired glucose tolerance (Glucose Tolerance). More severe deficiencies will result in disrupted growth, hyperglycemia (hyperglycemia), glycosuria (glycosuria) and increased levels of serum cholesterol. The GTF structure is composed of a complex between Cr^{3+} and 2 nicotinic acid molecules and 3 amino acids contained in glutathione, i.e. glutamate, glycine and cysteine. Chromium is biologically active as a component of GTF which increases cell and tissue sensitivity to glucose and insulin use, in the absence of inactive chromium GTF [16].

Based on the diagram analysis, the results show that each individual has a different cost. This is because each individual has a different effective dose of foods. The effective dose of foods can also depend on the amount of chromium concentration, weight and length of work of workers. The higher the concentration of chromium in the body, the greater the mass of detox for the foods is needed. This is consistent with the formulation that has been made in previous studies which states that it has a synergistic relationship with substance concentration [17]. Bodyweight, length of work, and chromium concentration can affect the intake of non-carcinogens in each respondent which can affect the effective dose of foods. This is following previous research which mentions that genetic variances, gender, and maybe body weight can play a role in biotransformation enzymes [18]. By knowing foods that can be used to detoxify chromium exposure from the body, leather tanning workers who have a high risk of exposure of chromium can prevent this exposure. Also, knowing the estimated costs that will be incurred to prevent chromium exposure through these foods, workers can choose foods that can detoxify chromium in the body with foods that are in line with the income of the leather tanning workers in Magetan.

In summary, intakes of foods containing glutathione (avocado, broccoli, carrot, tomato, and grape) were expected to increase detoxification of chromium. Each individual had a different amount of cost. This depends on the effective dose, chromium concentration, weight, and duration of work per respondent.

Acknowledgements

The authors would like to thank the rector of Airlangga University. The authors would like to acknowledge workers at Shoe Industry Romokalisari Surabaya, East Java, Indonesia.

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