Determination of Carcinogenic Toluena Detox Mass In Printing Industrial Workers In Surabaya

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Research

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Abstract

Background

This study aims to calculate the intake of foods rich in CYP2E1 enzymes and glutathione to increase toluene detoxification.

Methods

The research design used was a cross sectional method. The research location is printing industry in Surabaya, East Java. The number of respondents was 30 workers of the printing industry. The calculated variables included body weight, work duration (years), work frequency per week (days), average workday (hours) of the respondent and benzene concentration. After all variables were obtained, respiration rate and carcinogenic detox benzene food intake per respondent were determined.

Results

All respondents who were at work showed benzene concentrations below the threshold value (TLV). Foods containing CYP2E1 enzyme included beef liver, salmon and fish oil while food with glutathione included grapes, avocados and asparagus.

Conclusion

Adequacy levels of CYP2E1 enzymes and glutathione are different and varied. The effective dose required by each respondent depends on body weight, length of work, and toluene concentration at work. In sum, the greater the toluene concentration, the greater the dietary needs which are rich in enzymes and CYP2E1 glutathione. Each respondent can choose benzene detox food depending on their needs and appetite.

Background

Almost every workplace has a threat in the form of hazardous chemicals. One source of danger is found in printing industry¹. One of the chemicals in question is toluene². Toluene is safe for the environment and health if it does not exceed the threshold value of 50ppm³.

In printing, toluene is used as an organic solvent used in various processes⁴. Aside from being a solvent, the volatile property makes it desirable as a fast-drying and useful printing material on high-speed printing presses. Its use dominates work activities (75%). The biggest use of toluene (around 50–200 ppm or 188 mg / m³) is done in the automatic cleaning process⁵.

Toluene ($C_6H_5CH_3$) is an aromatic hydrocarbon group with the physical properties of colorless, sweet-smelling and spicy liquid like benzene. Toluene is soluble in diethyl ether, ethanol, benzene, chloroform, glacial acetic acid, carbon disulfide and acetone, insoluble in cold water with water solubility of 0, 561 g / L at 25 °C^{6 7}. Short-term toluene exposure occurs through inhalation, eye contact, skin contact and swallowing. In the long run this enters the body by inhalation. It causes damage to the liver and kidneys, peripheral nerve neuropathy, changes in the bone marrow, etc. This can happen if workers do not use Personal Protective Equipment (PPE) such as gloves and masks⁹.

Activities to reduce or even eliminate toxins in chemical compounds in the body that usually use biotransformation^{10 11}. Biotransformation is a change in catalysts that are catalyzed by certain enzymes in living things. The aim is to convert nonpolar to polar, then hydrophilic so that it can be removed from 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 phase of the conjugate reaction which involves several types of endogenous metabolites in the body in the endoplasmic reticulum¹².

This can be performed by using food as a detoxification. The food ingredients used need to contain certain substances, for example CYP2E1 enzyme and Glutathione. Foods that contain CYP2E1 include fish oil, salmon and beef liver¹³. Foods that contain glutathione are asparagus, avocados and grapes¹⁴. This is in line with a research conducted by Abdul Rohim Tualeka, et al in 2019 on Requirements Prediction for Toluene Detox with Foods Intake Rich in CYP2E1 Enzyme and Glycine to Prevent Nerve and Kidney Damage at Shoe Home Industry Workers in Romokalisari Surabaya, which concluded that the level of adequacy everyone's enzymes and glycine CYP2E1 are different and varied. This suggests that the greater the concentration of toluene, the greater the food requirements which are rich in the enzyme and CYP2E1 glycine¹⁵. Even so, research using the food approach as a detoxification of toluene is limited.

Based on the background above, this study aims to calculate the intake of foods rich in CYP2E1 enzymes, namely fish oil, salmon and beef liver as well as glutathione-rich foods such as asparagus, avocados and grapes as detoxification of toluene in the printing industry in Surabaya. An effective dose is also needed for detoxification of toluene.

Method

The research design used was a cross sectional method. Research subjects were workers in the printing industry in Surabaya with a total sample of 30 respondents. The variables calculated were toluene concentrations, average work per day (hours) of respondents, duration of work (years), working time per week (days) and body weight. Measurement of toluene concentrations in the work environment used the NIOSH 1501 (2003) measurement method with aromatic hydrocarbon sampling methods. Air samples were taken using a personal calibrated sampler pump. The filter used to absorb toluene vapor is SKC 226-01 charcoal tube. Air samples were analyzed using Gas Chromatography-Flame Ionization Detector (GC-

FID) ¹⁶. Measurements of the average work day, duration of work per year and working time per week were performed by using in-depth interviews with respondents. Measurement of respondent's body weight used manual measurement method with body scale. Willingness to participate in the study was made in writing through informed consent and this study had received prior ethical approval by the Ethics Committee of the Faculty of Public Health, Airlangga University.

After all variables were obtained, the respiratory rate and toluene intake of carcinogens per respondent were determined. Below is the formula for toluene carcinogenic intake per respondent per day:

$$\text{Carcinogenic intake} = \frac{C \times R \times t \times E \times f \times D \times I}{Wb \times 70 \times 365}$$

C : Toluene Concentration (mg /m³)

R : Respiratory rate (m³/hour)

Dt : Duration of work (years)

I : Working time per week (days)

tE : Average work time per day (hour)

Wb : Weight (kg)

$$\text{Detox enzyme mass per day} = \frac{\text{Intake Karsinogen}}{\text{Mr Toksin}} \times \text{Mr enzyme}$$

Effective doses of foods rich in CYP2E1 enzymes and glutathione are obtained by manual count using the formula below:

Mr Toluen = 92.14

Mr CYP2E1 = 56.849,00

Mr Glutathione = 307,321

$$\text{Detox food mass per day} = \left(\frac{100}{\text{enzymes in detox foods}} \right) \times \text{mass of detox enzymes per day}$$

After the detox enzyme mass value per respondent per day was obtained, the mass calculation of toluene detox food per day was calculated using the following formula:

Below are the enzymes contained in 100 grams of food

CYP2E1 enzymes in 100 grams of food¹³

- Beef Heart = 5,6
- Salmon = 6,6
- Fish oil = 7,2

Glutathione in 100 grams of food¹⁴

- Avocado = 27,7
- Grape = 7,9
- Asparagus = 28,3

Results

Distribution of Toluene Concentrations in the Workplace

Figure 1 shows that 100% of workers were in the workplace with toluene concentrations below TLV of 188 (mg / m³). This means that 30 respondents worked in a safe place from toluene.

Comparison between Toluene Concentration and Body Weight

Based on Figure 2, the person who has the biggest weight (responsiveness 12) that is 87 kg has the highest concentration (C) of toluene of 8092 mg / m³. The person with the lowest body weight (respondent R28) is 45 kg having an average concentration (C) of toluene which is 3,337 mg / m³.

Effective Doses of Foods Containing CYP2E1 Enzyme for Toluene Detox

Figure 3 shows that the effective dose or mass of food containing the highest CYP2E1 enzyme is in beef liver, while the lowest is in fish oil. The highest effective doses of fish oil, salmon and liver were 1,671 kg, 1,823 kg and 2,148 kg, respectively. This was experienced by respondent 14. The lowest effective doses of fish oil, salmon and beef liver foods all had the same mass of 0.001 kg. The lowest dose of food was found in respondents 8.

Effective Doses of Foods Containing Glutathione for Toluene Detox

Figure 4 shows that the effective dose or mass of food containing glutathione is highest in grapes, while the lowest is in asparagus. The highest effective dosages of asparagus, avocado and grape foods are respectively 0.0022981 kg, 0.0023479 kg and 0.0082324 kg, respectively. This was found in respondents 14. The lowest effective dose of asparagus, avocado and grapes was 0.0000011 kg, 0.0000011 kg and 0.0000040 kg. The lowest dose of food was found in respondents 8.

Discussion

Threshold Value (TLV), Weight, and Toluene Concentration

Analysis of the distribution diagram between toluene concentration and TLV shows that all respondents had toluene concentrations below TLV. The TLV for toluene concentration is in accordance with the Regulation of the Minister of Manpower and Transmigration Number PER 13/MEN /X/2011 concerning Threshold Value of Physical and Chemical Factor Values in the Workplace is 50 ppm (188, 43 mg / m³)¹⁷.

Comparative diagram analysis between toluene concentration and respondent's weight shows that the respondent with the highest weight has the highest toluene concentration, while the respondent with the smallest weight has average toluene concentration. Research based on the research of Faradisha, et al in 2019 shows that toluene compounds are lipophilic (fat soluble) fats will bind toluene into residues in the body. It is assumed that the more obese respondents affected by toluene, the higher the health risk due to exposure toluene¹⁸. In sum, there is lower toluene toxicity in obese people than in low weighted people.

Detoxification of Toluene by Foods Rich in CYP2E1 Enzymes

The negative impact of toluene exposure on printing workers can be reduced or even eliminated, one way is by detoxifying the body's poisons. One detoxification method that can be used is food. Several publications using cells, animals, and clinical studies have shown that food-based components and nutrients can modulate the process of conversion and excretion of toxins from the body¹⁹. About 25–40% of toluene is inhaled by humans, then expelled by expiration. The remaining 60–75% are metabolized in the liver to benzyl alcohol.

Toluene will be converted to benzyl alcohol through a hydroxylation reaction. The reaction was carried out by members of the cytochrome P450 (CYP) in the liver, namely CYP1A1, CYP1A2, CYP2B6, CYP2C8, and CYP2E1²⁰. Then, benzyl alcohol will be metabolized into benzaldehyde by CYP and alcohol dehydrogenase enzymes through oxidation reactions. CYP is more active than the alcohol dehydrogenase enzyme. A small amount of benzaldehyde will be converted to benzylmercapturic acid, while most of the other will be converted to benzoic acid. Benzoic acid will be metabolized to hippuric acid, which will be excreted through urine²¹.

Consumption of suitable substances can detoxify toluene from the body, such as foods that contain the enzyme CYP2E1. High concentrations of the CYP2E1 enzyme are found in some foods such as beef liver, salmon and fish oil. The content of the CYP2E1 enzyme in 100 grams of beef liver is 5.6 mg, in 100 grams of salmon is 6.6 mg and 100 grams of fish oil is 7.2²².

In Fig. 3, the effective dosage of each food is different depending on the individual's physical and toluene levels in his body. The higher the concentration of toluene, the higher the mass of toluene detoxification for beef liver, salmon and fish oil. This effective dose is also influenced by the weight and duration of work of the worker. This research is based on previous research, which states that it has a synergistic

relationship with the concentration of substances²³. Detox toluene food can be selected by each respondent based on their toluene concentration and taste. If the respondent is not interested in consuming beef liver, they can consume salmon, fish oil and vice versa. The consumption of each food can be arranged by each respondent and divided into several days according to the needs of the respondent's food intake.

Detoxification of Toluene by Foods Rich in Glutathione

The enzyme responsible for glutathione metabolism is the enzyme glutathione s-transferase (GST). It involves antioxidant responsive elements and xenobiotic response elements. Many foods upregulate this enzyme, including avocados, asparagus, grapes, broccoli, carrots, tomatoes, etc. Genetic, gender, and perhaps body weight variations can play a role in the effects of dietary factors on the GST enzyme²⁴.

In addition to foods containing the CYP2E1 enzyme, foods containing glutathione are also beneficial in this regard. High concentrations of glutathione are found in some foods such as avocados, asparagus and grapes. The content of glutathione in 27.7 grams of avocado, 100 grams of asparagus 28.3 and in 100 grams of wine is 7,9²⁵.

Based on the results of an effective dose of avocado, asparagus and grapes that the body needs to detox toluene from the body as shown in Fig. 4, the effective dose of each food differs depending on the individual's physical and toluene levels in his body. The higher the concentration of toluene, the higher the mass of toluene detoxification. This effective dose is also influenced by the weight and duration of work of the worker. Detox toluene food can be selected by each respondent based on their toluene concentration and taste. If the respondent is not interested in consuming avocados, they can consume asparagus, grapes and vice versa. The consumption of each food can be arranged by each respondent and divided into several days according to the needs of the respondent's food intake.

Conclusion

All respondents were at work with toluene concentrations below the threshold value (TLV). Food intake containing CYP2E1 enzymes (beef liver, salmon and fish oil) and glutathione (avocado, asparagus and grapes) is expected to increase toluene detoxification. The effective dose required by the respondent depends on body weight, length of work, and toluene concentration at work. The higher the concentration of toluene, the higher the food needs to contain the enzyme CYP2E1 and glutathione that the body needs. Weight and duration of work can also be other factors in individual income differences. Each respondent can choose food depending on their needs and appetites.

Abbreviations

C
Concentration
CYP

Cytochrome P450
Dt
Duration of work
GC-FID
Gas Chromatography-Flame Ionization Detector
GST
Glutathione s-transferase
I
Working time per week
PPE
Personal Protective Equipment
R
Respiratory rate
tE
Average work time per day
TLV
Threshold Value
Wb
Weight

Declarations

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Ethics approval and consent to participate

This study was approved by the institutional Ethical Board of the Public Health, Airlangga University.

Consent for publication

Not applicable

Availability of data and material

The datasets generated and analysed during the current study are not publicly available due but are available from the corresponding author on reasonable request.

Competing interests

All authors have no conflicts of interest to declare

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Authors' contributions

Authors' generated the initial idea for the study, data collection and processing. All authors provided critical input into the interpretation of the results, revisions to the manuscript and approved the final draft.

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Figures

Figure 1

Toluene C Distribution Diagram (mg / m3)

Figure 2

Comparison between Toluene Concentration and Body Weight

Figure 3

Effective Doses of Foods Containing the CYP2E1 Enzyme for Toluene Detox

Figure 4

Effective Doses of Foods Containing Glutathione for Toluene Detox