
Ukik Agustina1*, Reny Mareta Sari1, Mika Vernicia Humairo1, Etha Oktavia Puspita Dewi1

1 Institut Ilmu Kesehatan STRADA Indonesia, Kediri, Indonesia
*Corresponding author: ukikagustina@iik-strada.ac.id

I. Introduction

Ending hunger, achieving food security, improving nutrition and promoting sustainable agriculture are the second vision of the Sustainable Development Goals (SDGs) (UN, 2015). Food safety is the first objective of the 5 Food and Agriculture strategic objectives (FAO) to achieve SDGs in 2030 (FAO, 2019). Fruit is one of the imported commodities in Indonesia that continues to increase from 2010 to 2021. In 2021 imports in Indonesia reached 775.422,4 kg (BPS, 2022). The biggest fruit importing countries are China, Thailand and the United States with the dominance of imported fruits namely apples 235.02 million USD, pears 164.12 million USD, grapes 120.80 million USD, lemons 10.98 million USD and oranges 6.83 million USD (BPS, 2018).

Fruit is one of the foods that contain micronutrients needed by the body for everyone in the world and is an export commodity that has a risk of damage during the shipping process. One of the compounds that can preserve fruit during the shipping process is formaldehyde. Formaldehyde is a gas-shaped compound that is colorless, soluble in water and flammable at room temperature. Formaldehyde can be found in the form of liquid formalin with water and methanol (NIEHS, 2020). At high temperatures formaldehyde will decompose into methanol (wood alcohol) and carbon monoxide and are reactive to other chemicals. Formaldehyde has a pungent odor and causes a burning sensation in the eyes, nose and lungs at high concentrations (Services, 2016).

Formaldehyde is produced naturally in the body as part of the body's normal metabolism with very small amounts. Formaldehyde can be found in the air at home or work and food. The main sources of formaldehyde in the air we breathe are lower amounts of...
atmospheric mist, car exhausts, cigarettes or other tobacco products, gas stoves and open fireplaces (Services, 2016). In everyday life formaldehyde is used to make resins in building materials, paper coatings, clothing fabrics, synthetic fibers and includes certain insulation materials, glues and wood products. Formaldehyde is also used for making other chemicals. In the medical world, formaldehyde is used for preserving corpses, antimicrobial agents and disinfectants in industry and some household needs (NIEHS, 2020).

Formaldehyde occurs naturally in food. Food contamination may be possible through fumigation (for example grains), cooking (as a combustion product) and apart from formaldehyde resin based tableware. Formaldehyde has been used as a bacteriostatic agent in some foods, such as cheese. Formaldehyde is irritating to tissue when in direct contact. Formaldehyde can cause nasopharyngeal cancer and leukemia, respiratory irritation such as asthma, pulmonary edema and irritation of the eyes, nose, throat and skin. Formaldehyde can enter the body through breathing, ingestion and skin (NIEHS, 2020).

In this study, data on formaldehyde concentration and fruit intake rate are used to estimate health risks through maximum body weight by getting a value of RQ = 1 (Risk Quotient). In addition, this study conducts a health risk analysis which include hazard identification, dose-response assessment, exposure assessment and risk characterization.

II. Methods

This research was descriptive analytic study. We were looking for research related to the measurement of formaldehyde levels on imported fruit in Indonesia from 2014-2022. While the 2019 data were obtained from primary data. Daily intake rate is obtained from the 2016 National Socio-Economic Survey (SUSENAS), fruit intake recommendations based on WHO and the results of projections and realization of Indonesian people's fruit consumption based on the Ministry of Agriculture's Food Security Agency in 2018 (Kemenkes, 2016)(Agency, 2018). Estimates of safe weight were determined based on the calculation of health risk assessments (EHRA, 2012).

\[
RQ = \frac{\ln k}{R/D}
\]

\[
\ln k = \frac{CxRxExDt}{Wbxavg}
\]

One evaluation of the risk of chemical exposure through inhalation and ingestion was through a risk assessment. Risk assessment was a scientific evaluation of known or potential health effects resulting from human exposure to foodborne hazards. Health Risk Assessment was assessed from the components of hazard identification, dose-response assessment, exposure assessment and risk characterization. The following were the stages of data analysis for health risk assessment of the content of formaldehyde on imported fruit in Indonesia in 2014-2019. The ethical consideration was not needed in this research.
III. Results and Discussion


<table>
<thead>
<tr>
<th>Study Author</th>
<th>City</th>
<th>Study Location</th>
<th>Fruits</th>
<th>Number of Sample</th>
<th>Measurement Methods</th>
<th>Units of Measurement</th>
<th>Measurement Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manoppo, G; Abidjulu, J; Wehantouw, Frenly</td>
<td>Manado</td>
<td>Large supermarkets (supermarkets A, B and C)</td>
<td>Apples, pears, grapes</td>
<td>9</td>
<td>Qualitative analysis (color test of Schiff reagents) and quantitative analysis (Schiff reagents measured by UV-VIS spectrophotometer)</td>
<td>µg/mL</td>
<td>a. Qualitative analysis All samples are yellow b. Quantitative analysis Supermarket A Apple = 0.195 Pear = 0.156 Grape = 0.075 Supermarket B Apple = 0.136</td>
</tr>
</tbody>
</table>
Lasaiba, J & Kotala, S (2015)

Ambo

Modern market (supermarkets)

Apples 6

Qualitative (Schiff reagent test dyes) and quantitative (Schiff reagents and measured with UV-VIS spectrophotometer) Mg/kg

Pear = 0.095

Grape = 0.085

Supermarket C

Apple = 0.095

Pear = 0.095

Grape = 0.080

Suparto; Prawiras, R (2015)

Jakarta

Level of local retailers and distributors in the Keramat Jati market

Fuji apples 4

Quantitative (quantitative formaldehyde content analysis, Pharmacopoeia III edition 1979) ppm

a. Retailers

Fuji apple 3.4 ± 0.47

Washington apple 2 ± 0.37

b. Local distributor

Fuji apple 2 ± 0.2

Washington apple 7.7 ± 1.6

Zalukhu, M.E.R; Nuriani, D; Chahaya, I (2015)

Medan

Berastagi Supermarkets, Carrefour supermarkets, Hypermart supermarkets

Apples, grapes and oranges 15

Quantitative analysis (iodine titration) with calculations:

\[
\text{ml Na}_2\text{S}_2\text{O}_3 = \frac{\text{amount of penetration}}{14.008} = \frac{N}{160}
\]

\[\text{ml Na}_2\text{S}_2\text{O}_3 = \text{amount of penetration}\]

\[N = \text{Na}_2\text{S}_2\text{O}_3\text{ concentration}\]

\[14.008 = \text{Coefficient}\]

Fuji Wang Shan Apples (1.779), Blue Cheland Apples (2.451), Granny Smith Apples (1.863), Honey NZ Apples (1.863), Fuji PRC Apples (3.152), Red Delicious Apples (4.412), Japanese Fuji Apples (4.552)

Grape

Autum Royal Wine (3.165), Red Globe wine (3.572), Calmeria wine (4.692)

Orange

Study Author | Date of Publication | City | Study Location | Fruits | Number of Sample | Measurement Methods | Units of Measurement | Measurement Results
--- | --- | --- | --- | --- | --- | --- | --- | ---
Lasaiba, J & Kotala, S (2015) | | | | | | | | 
Suparto; Prawiras, R (2015) | Jakarta | | | | | | | 
Zalukhu, M.E.R; Nuriani, D; Chahaya, I (2015) | Medan | Berastagi Supermarkets, Carrefour supermarkets, Hypermart supermarkets | | | | | | 
Indrayati, W; Lin, Y.J; Holik, H.A (2015) | Jatina gor | Modern market | A = green grapes | 10 | Qualitative and quantitative with Nash reagents measured using UV-VIS spectrophotometry (Specord 205) | ppm | 
Indriyati, | | | B = red grapes | | | | 

Uzik Agustina et al. (Food Safety Monitoring: Formaldehyde Health Risk Assessment on Imported Fruits in Indonesia 2014-2022)
Ukik Agustina et.al (Food Safety Monitoring: Formaldehyde Health Risk Assessment on Imported Fruits in Indonesia 2014-2022)
<table>
<thead>
<tr>
<th>Study Author</th>
<th>City</th>
<th>Study Location</th>
<th>Fruits</th>
<th>Number of Sample</th>
<th>Measurement Methods</th>
<th>Units of Measurement</th>
<th>Measurement Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lestari, M; Umar, B; Hasin, A</td>
<td>Makkasar</td>
<td></td>
<td>Fuji apple, Grand Smith apple, Red Delicious apple</td>
<td>3</td>
<td>Qualitative analysis (chromatophytic acid reagents and potassium permangate)</td>
<td>-</td>
<td>Negative</td>
</tr>
<tr>
<td>(2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Lestari et al., 2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rahmi, M; Dira; Herman, H.</td>
<td>Padang Supermarkets</td>
<td></td>
<td>Red apples, green apples, pears, orange s and grapes</td>
<td>5</td>
<td>Qualitative analysis (Nash reagents, KMnO₄ and fehling solution) and quantitative analysis (UV-VIS spectrophotometry)</td>
<td>µg/g</td>
<td>Qualitative analysis</td>
</tr>
<tr>
<td>(2018)</td>
<td>dan market</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Positive results = red apple, green apple and orange</td>
</tr>
<tr>
<td>(Rahmi, 2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quantitative Analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Red apple = 113.558</td>
</tr>
<tr>
<td>Khoirunisa, S</td>
<td>Semarang Supermarkets</td>
<td></td>
<td>Grapes (5 sample s) and apples (7 sample s)</td>
<td>12</td>
<td>Qualitative and quantitative analysis</td>
<td>ppm</td>
<td>Positive results (qualitative and quantitative analysis)</td>
</tr>
<tr>
<td>(Khoirunisa et al., 2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fuji Apple RRT (37.584)</td>
</tr>
<tr>
<td>Patri, D.R; Kumalasari, E.; Musiam, E</td>
<td>Banjarmasin</td>
<td>Supermarket</td>
<td>Apple (6 sample s), Grape (4 sample s), Pear (4 sample s)</td>
<td>14</td>
<td>Qualitative analysis</td>
<td>-</td>
<td>6 samples positive before washed and 3 samples positive after washed</td>
</tr>
<tr>
<td>(2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Putri et al., 2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Najhah, N.L</td>
<td>Medan Transmart Plaza Medan Fair</td>
<td></td>
<td>Purple grape from America, Kiwi from New Zealand, Sunkist orange from China, Delicious apple</td>
<td>5</td>
<td>Quantitative analysis</td>
<td>Mg/l</td>
<td>Purple grape (1.5 mg/l), Kiwi (1.5 mg/l), Delicious red apple (1.0 mg/l) and pear (0.6 mg/l)</td>
</tr>
<tr>
<td>(2018)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 3. Minimum Safety Body Weight According to Fruit Intake References and Fruit Intakes

<table>
<thead>
<tr>
<th>Variables</th>
<th>N</th>
<th>Mean ± sd (kg)</th>
<th>Maximum body weight (Kg)*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fruit intake references</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National economy social survey</td>
<td>34</td>
<td>2.07 ± 5.07</td>
<td>21.77</td>
</tr>
<tr>
<td>WHO’s intake Recommendation</td>
<td>44</td>
<td>49.28 ± 114.79</td>
<td>588.16</td>
</tr>
<tr>
<td>Projections of Indonesian Ministry of Agriculture’s Food Security Agency</td>
<td>35</td>
<td>39.47 ± 80.17</td>
<td>374.07</td>
</tr>
<tr>
<td>Realization of Indonesian Ministry of Agriculture’s Food Security Agency</td>
<td>29</td>
<td>31.13 ± 73.50</td>
<td>323.49</td>
</tr>
<tr>
<td><strong>Fruit intake</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple</td>
<td>70</td>
<td>16.07 ± 45.06</td>
<td>236.50</td>
</tr>
<tr>
<td>Grape</td>
<td>23</td>
<td>63.48 ± 151.25</td>
<td>588.16</td>
</tr>
<tr>
<td>Pear</td>
<td>3</td>
<td>0.09 ± 0.03</td>
<td>0.12</td>
</tr>
<tr>
<td>Orange</td>
<td>39</td>
<td>49.64 ± 85.31</td>
<td>333.16</td>
</tr>
<tr>
<td>Kiwi</td>
<td>3</td>
<td>0.56 ± 0.18</td>
<td>0.76</td>
</tr>
</tbody>
</table>

*Maximum body weight is more risk to health
Hazard Identification

Formaldehyde was a toxin compound that was classified as a carcinogen compound (group 1) in humans and animals (WHO, 2012). In Indonesia the use of formaldehyde in food was prohibited (Pengawasan Bahan Berbahaya Yang Disalahgunakan Dalam Pangan, 2013). Formaldehyde is also known as methanal, methylene oxide, oxymethylene, methylaldehyde and oxomethane. Formaldehyde could enter the body through inhalation, drinking or eating it, or when in contact with skin. Formaldehyde was quickly absorbed from the nose and breathing over the lungs. Formaldehyde ingestion was very quickly absorbed and in very small amounts absorbed through the skin. When formaldehyde was absorbed, it was very easily broken down and almost all body tissues could break down formaldehyde compounds. When formaldehyde was absorbed in the body, it would split into formate compounds (converted into non-toxic compounds) which would be excreted into the urine. Formaldehyde could also be converted to carbon dioxide and exhaled from the body. Formaldehyde could stick to deoxyribonucleic acid (DNA) or protein in the body and is not stored in fat (Services, 2016).

Dose-Response Assessment

Reference Dose (RfD) formaldehyde was 0.2 mg / kg / day where the dose could be dangerous to the gastrointestinal. Whereas formaldehyde reference concentration (RfC) was absent (Services, 2016). Estimated daily exposure dose of formaldehyde through inhalation, assuming a respiratory volume of 20 m³/day for an average adult with people spending 60-70% of the time at home, 25% at work and 10% outdoors at around 1 mg/day, with some exposure > 2 mg/day and a maximum of around 8 mg/day. Formaldehyde could also be in drinking water with an estimated content of less than 0.1 mg/L. In fruits and vegetables usually contained 3-60 mg/g, milk and milk products around 1 mg/g, meat and fish 6-20 mg/kg and shellfish 1-100 mg/kg. Daily intake was difficult to evaluate, but rough estimates of available data were in the range of 1.5-14 mg / day for the average adult (EPA, 2022).

Exposure Assessment

Based on the results of formaldehyde measurements on imported fruit in 15 cities in Indonesia, obtained varying levels of formaldehyde. In quantitative examinations, researchers used different methods so that different levels of levels were also obtained. The following was a reference to the rate of intake used to calculate the formaldehyde health risk assessment of imported fruit. Exposure analysis was the process of calculating the intake or intake of risk agents through the following calculation methods (EHRA, 2012).

\[ I = \frac{C \times R \times f \times E \times D \times t}{W \times b \times t \times a} \]

I was the number of risk agents that enter the body with a certain weight every day (mg / kg / day); C was the concentration of the risk agent (mg / L or mg / Kg); R was the rate of intake or consumption (L / day or kg / day); fE was the length or number of days of exposure (exposure to settlement 350 days / year); Dt was the duration of exposure with a projected 30 years for residential defaults; Wb was weight (kg); tavg was the average daily period (Dt x 365 days / year for non carcinogenic substances and 70 years x 365 days / year for carcinogenic substances).

Risk Characterization

Risk characteristics were determined based on calculations through the following formula.

\[ RQ = \frac{I}{RfD} \]
In this case, this study was conducted to determine the estimated safe body weight with the assumption of consuming imported fruits with concentrations according to table 1 with RfD = 0.2 mg / kg / day and the assumption of RQ = 1 through the following formula (EHRA, 2012).

\[
W_b = \frac{C \times R \times f \times E \times D}{RQ \times t \times a \times v \times g \times R \times f \times D}
\]

IV. Conclusion

The results from 82 samples (apple, grape, pear, orange, kiwi) showed varying levels of formaldehyde. The highest level (784.22 ppm) was found in red grape and the most frequently (90.90%) was found in orange. The highest risk from minimum body weight was got according to the intake of the national economic social survey of 21.77 kg (sd = 5.07), 333.16 kg (sd = 81.03) recommendation for intake, 374.07 kg (sd = 80.17) and 323.49 kg (sd = 73.50) projections and realization. Estimating body weight was gotten while RQ = 1 and daily intake per fruit for 30 years. The higher risk was from consumption projections for red grapes in Tasikmalaya (2017). If the body weight was under 374.07 kg, it could get a health risk because of RQ> 1. The conclusion is the monitoring of chemical contaminants has a priority in the distribution chain and the variation of fruit daily intake may decrease the health risk from chemical contaminants. The consumption of fruit has to be variation.

V. References


