Chlorine (Cl) in rice on the market (study of environmental health risk assessment in Bintoro, Demak Regency)

Sulistiyani Sulistiyani1*, Nina Dwi Anggraeni1, Nurjazuli Nurjazuli1

1Public Health Faculty, Diponegoro University

*Corresponding author:
Sulistiyani Sulistiyani
Public Health Faculty
Diponegoro University
Phone numbers: +62 85727625256
E-mail address: suлистyani@live.undip.ac.id

Abstract

Background: Chlorine (Cl) is a chemical that is sometimes misused in foods such as rice. The use of chlorine in food is not allowed. Aims: The purpose of this study was to analyze the environmental health risks due to chlorine (Cl) exposure in rice consumed by the people of Bintoro Village, Demak District, Demak Regency. Setting and Design: This was an observational study. The population included in this research consisted of people who consumed rice from the market in the Bintoro area, Demak district, Center of Java Province. A stratified random sampling technique was used. Method and Materials: Data from respondents were obtained by conducting interviews using a questionnaire and anthropometric measurements. The concentration of chlorine in rice was checked using a spectrometer. Statistical analysis was performed using the Environmental Health Risk Analysis (EHRA) by calculating the intake of rice to determine the consumer risk. Calculations are obtained based on data of risk level (RQ), which is the division between chlorine intake (Cl) (I) and reference dose (RFD). Result: The conclusion was that rice originating from the market in the Bintoro area was not safe for consumption in real-time conditions and for lifetime (30 years and 50 years).

Keywords: Chlorine (Cl), Rice, Environmental Health Risk Analysis, Market, Demak

How to cite this article: Sulistiyani S, Angraeni ND, Nurjazuli N (2021): Chlorine (Cl) in rice on the market (study of environmental health risk assessment in Bintoro, Demak Regency), Ann Trop Med & Public Health; 22(S01): SP24154. DOI: http://doi.org/10.36295/ASRO.2021.24154

Introduction

Indonesian people consume rice as their main source of carbohydrates. Rice is easy to find because all markets sell rice, including traditional markets. Currently, the food safety of rice sold in markets is a problem. Some rice sellers add chemicals to rice. The addition of chemicals to rice is in the interest of the buyer. The chemical that is often added to rice is chlorine (Cl), as it causes rice to appear higher quality. Chlorine is used in rice for its anti-fungal properties and whitening effect, it is applied to the rice through a process of soaking or spraying. Rice that contains chlorine is white in color, more shiny, slippery, and smells of chemicals; if washed, the washing water looks clear. If the rice is soaked for 3 days it becomes clear and odorless\(^1\).

According to the Ministry of Health Regulation Number 33 of 2012 concerning Food additives, chlorine is not classified as a food additive, it’s not allowed to be added or consumed in food\(^2\). Chlorine is a greenish yellow gaseous halogen element at normal temperatures and functions as a bleach, stain remover, and disinfectant. Chlorine is now widely used for rice bleaching so that lower quality rice can appear higher quality. In its liquid form, Chlorine is very toxic and corrosive and causes irritation to mucous membranes; therefore, it can cause damage to the gastric mucosa, which makes the stomach susceptible to gastritis, is highly reactive, and is a very strong oxidizing agent\(^3\). Given that people in Indonesia consume rice every day in their lives, this can be very dangerous for their health. It is important to conduct a study on the risk analysis of environmental health impacts on their habits of consuming chlorinated rice. Bintoro Village, Demak Regency in the Center of Java Indonesia is the center of rice agriculture, and products are mostly sold in the Bintoro Market. This article aims to present an environmental health risk assessment regarding the chlorine content of rice sold in the Bintoro Demak market, Demak Regency.

Subjects and Methods

This research was an observational study conducted using an environmental health risk assessment (EHRA) approach\(^4\). This research was conducted in Bintoro, Demak Regency from August - September 2019. The population in this study was the people of Bintoro village who consumed rice purchased from the Bintoro Market. The number of respondents in this study was calculated using the Slovin formula, and amounted to 98 people. The sampling technique used was stratified random sampling. To be included in this study, each respondent had to be willing to participate and sign an informed consent sheet. Data from respondents were obtained through interviews using a questionnaire and anthropometric measurements.

The research protocol was ethically approved by Health Research Ethics Committee, Faculty of Public Health Diponegoro University. Rice samples came from rice sellers in Bintoro Market. The concentration of chlorine in rice was checked using a spectrometer.
Data analysis used the risk analysis method by calculating the intake of rice to determine consumer risk. Calculations were obtained based on data on risk agent concentration (chlorine: mg/kg), intake rate (rate), frequency of annual exposure (days/year), duration of exposure in years (real time, life time 30, life time 50), consumer body weight (kg), and mean time period (30 years × 365 days/year for non-carcinogens).

Risk characteristics are expressed as a risk level (Risk Quotient) which is the division between chlorine intake (I) and reference dose (RfD) (equation 1). In addition, to determine chlorine intake (CI), anthropometric parameters (body weight and inhalation rate) and activity patterns (time, frequency, and duration of exposure) are also needed. The risk level was calculated using equation 1, and the intake (I) is calculated using equation 2:\(^5\):

\[
RQ_{\text{real time}} = \frac{I}{\text{RfD}}, \tag{1}
\]

\[
I_{nk} = \frac{C \times R \times F_E \times D_t \times W_b}{t_{\text{avg(nk)}}} \tag{2}
\]

\[
I_{nk} = \text{Total concentration of risk agents (mg) that enter the human body with body weight (kg) every day}
\]

\[
C = \text{Concentrations of risk agents in food}
\]

\[
R = \text{The rate of consumption or the amount of weight of food that enters each hour}
\]

\[
F_E = \text{The length or number of days the exposure occurs each year}
\]

\[
D_t = \text{The length or number of years the exposure occurred}
\]

\[
W_b = \text{Human body weight}
\]

\[
t_{\text{avg(nk)}} = \text{Mean time period of days for non-carcinogenic effects}
\]

Result

EPA (IRIS 2007) has established an oral reference dose (RfD) for chlorine of 0.1 mg/kg/day.\(^6\)-The average Chlorine concentration in rice samples was 24.03± 4.2186 mg/kg, with a minimal concentration of 22.93 mg/kg and maximal concentration of 35.61mg/kg. The intake rate was defined as the amount of rice a person consumes per hour. In this study, the intake rate for each respondent was calculated based on the amount of rice consumed per hour measured by with the mass of rice eaten in grams\(^5\). The average rate of intake of respondents in the study was 18.07± 8.69 gram/hours (g/h). The lowest intake rate was 4.17g/h and the maximum intake was 50g/h.

The frequency of exposure is defined as the length or number of days in a year the respondent consumes rice from Bintoro Market. The average frequency of exposure from respondents was 248.33± 124.62 days/year. The lowest frequency of exposure was 104 days/year and the maximum was 364 days/year. The duration of exposure is the length or number of years the respondent consumes rice from the Bintoro Market. The average duration of exposure from respondents was 34.97±16.26 years. The lowest exposure duration was 2 years, and the highest duration of exposure was 65 years.
The average body weight of the respondents was 63.61±10.18 kilograms. The lowest body weight was 45 kg, and the highest body weight was 90 kg. Table 1. shows the results of chlorine concentration, intake rate, frequency of exposure, duration of exposure, and body weight.

Table 1. Distribution of frequency of Chlorine Concentration, Intake rate, Frequency of exposure, Duration of exposure, Body weight

<table>
<thead>
<tr>
<th>Variables</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concentration of Chlorine in rice (mg/kg)</td>
<td>10</td>
<td>27.026</td>
<td>4.2186</td>
<td>22.925</td>
<td>35.610</td>
</tr>
<tr>
<td>Intake rate (gram/hours)</td>
<td>98</td>
<td>18.07</td>
<td>8.69</td>
<td>4.17</td>
<td>50</td>
</tr>
<tr>
<td>Frequency of exposure (days/year)</td>
<td>98</td>
<td>248.33</td>
<td>124.615</td>
<td>104</td>
<td>364</td>
</tr>
<tr>
<td>Duration of exposure (years)</td>
<td>98</td>
<td>34.97</td>
<td>16.255</td>
<td>2</td>
<td>65</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>98</td>
<td>63.61</td>
<td>10.180</td>
<td>45</td>
<td>90</td>
</tr>
</tbody>
</table>

The mean time period for this study was the mean time period for the onset of non-carcinogenic effects. The average time period used was 10.950 days obtained from 30 years × 365 days/year. The mean time period for non-carcinogenic effects for adults corresponds to the default value from the EPA.

In this study, the intake value was calculated based on real time and lifetime projections (30 years and 50 years). The frequency distribution of the projection intake value for real time, life time of 30 years, and lifetime of 50 years are given in Table 2.

Table 2. Projection of exposure with intake values

<table>
<thead>
<tr>
<th>Projected exposure</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real time</td>
<td>0.00616</td>
<td>0.62567</td>
<td>0.14223</td>
<td>0.09218</td>
</tr>
<tr>
<td>Life time (30)</td>
<td>0.01013</td>
<td>0.35155</td>
<td>0.12566</td>
<td>0.09433</td>
</tr>
<tr>
<td>Life time (50)</td>
<td>0.01689</td>
<td>0.58591</td>
<td>0.20943</td>
<td>0.15722</td>
</tr>
</tbody>
</table>

The level of risk for non-carcinogenic effects is expressed as a risk quotation (RQ) notation. To characterize the non-carcinogenic effects, a calculation was performed by comparing or dividing the intake with RfD. The level of risk is expressed as a number. If the RQ value was 1, the risk level was safe. Meanwhile, if the RQ value was > 1, the risk level was unsafe\(^6\). Table 3 shows the frequency of respondents with RQ values >1 and RQ values of 1.

Table 3. Projection of exposure with RQ value

<table>
<thead>
<tr>
<th>Projection of exposure</th>
<th>RQ</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>f</td>
<td>%</td>
</tr>
<tr>
<td>Real time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ &gt; 1</td>
<td>43</td>
<td>43.88</td>
</tr>
<tr>
<td>RQ ≤ 1</td>
<td>55</td>
<td>56.12</td>
</tr>
<tr>
<td>Life time (30)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ &gt; 1</td>
<td>46</td>
<td>46.94</td>
</tr>
<tr>
<td>RQ ≤ 1</td>
<td>52</td>
<td>53.06</td>
</tr>
<tr>
<td>Life time (50)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RQ &gt; 1</td>
<td>69</td>
<td>70.41</td>
</tr>
<tr>
<td>RQ ≤ 1</td>
<td>29</td>
<td>29.59</td>
</tr>
</tbody>
</table>

The results of the calculation of the RQ>1 in projection of real time show that people who consume rice 43.88% were unsafe. For projection of life time (30) with RQ> 1, as many as46.94% were to be unsafe. For the projection of lifetime (50) with RQ>1 70.41% were unsafe.
Discussion

The research results show the presence of chlorine in rice sold in Bintoro Market, Demak Regency, on an average, is 24.03+ 4.2186 mg/kg, which is currently disallowed by the Ministry of Agriculture Regulation No.32/PERMENTAN/OT.140/3/2007 regarding prohibition of the use of chemicals dangerous in the rice milling process, huller, and rice padding. Chlorine has an acute effect on the human body. It is a potent irritant in humans, affecting the eyes, the upper respiratory tract, and the lungs. Several acute (short-term) studies have reported the following effects: tickling of the nose at 0.014 to 0.054 parts per million (ppm); tickling of the throat at 0.04 to 0.097 ppm; itching of the nose and cough, stinging, or dryness of the nose and throat at 0.06 to 0.3 ppm; burning of the conjunctiva and pain after 15 minutes at 0.35 to 0.72 ppm; and discomfort ranging from ocular and respiratory irritation to coughing, shortness of breath, and headaches above 1.0 ppm. Higher levels of chlorine can result in the following effects in humans: mild mucous membrane irritation at 1–3ppm; chest pain, vomiting, dypsnea, and cough at 30 ppm; and toxic pneumonitis and pulmonary edema at 45-60 ppm.\(^7\)

The acute effects of high concentrations of chlorine (Cl) in the body are burning of the mouth, nausea, vomiting, stomach pain, and bloody stools. Meanwhile, chronic effects can continue to appear for days, weeks, or months because intoxication is slow. Chronic effects include mucosal erosion of the esophagus and stomach, perforation (formation of holes) at the gastroesophageal junction, and extensive necrosis (permanent death) of nearby soft tissues. Chlorine (Cl) is not included in the group that can cause carcinogens.\(^7\)

In this study, the intake rate for each respondent was calculated based on the amount of rice consumed per hour multiplied by the mass of rice eaten in grams\(^5\). The average intake rate was 18.07 grams/hours. The value of the intake rate affects the amount of chlorine intake (Cl) in the body, which can increase the value of the risk level (RQ).

The frequency of exposure is directly proportional to the intake. This may imply that the greater the frequency of exposure, the greater the intake of toxic substances in the body. Research in subcontracted workers who consume chlorinated shrimp showed that if chlorine (Cl) is consumed continuously, it will accumulate in the body and cause health effects.\(^8\)

Duration of exposure showed that the longer the exposure received by people who consume rice, the greater the intake received by the community and the greater the risk due to consumption of rice from Bintoro Market. The long-term use of chlorine (Cl) can result in poisoning and health complaints.

Our dose response analysis was intended to establish quantitative values of risk agent toxicity expressed in RfD for the non-carcinogenic effect of the ingestion exposure pathway. RfD is a non-carcinogenic toxicity that represents an estimated daily dose of exposure that is not expected to cause adverse health effects, even if the exposure continues throughout life. If the dose received by the population at risk exceeds the RfD value, the probability of negative health effects becomes even greater\(^5\). In this study, the dose response analysis was not a single trial but used was derived from the
available literature. The dose response, or what is known as the RfD of the pollutant (risk agent) chlorine (Cl), uses the reference concentration for ingestion set by the Integrated Risk Information System (IRIS) from the us-EPA, which is $1 \times 10^{-1}$ mg /kg /day.\(^{11}\). It is known that chlorine (Cl) has no cancer-causing properties; the effects to be analyzed are therefore systemic or non-carcinogenic effects.\(^{5}\)

**Conclusion**

Our estimation of risk characterization shows the level of risk received by people who consume rice in real time projection, with a level of 43.88% being unsafe (RQ>1). For a 30-year lifetime projection, 46.94% was said to be unsafe (RQ>1), and for the projection life time of 50 years 70.41% was identified to be unsafe (RQ>1).

**Acknowledgements**

Thanks to all of the rice seller in Bintoro Market and community of Bintoro village who participate in this research.

**Conflict of interest:** No conflict of interest

**References**


