Formaldehyde Content in Indonesian Food and the Analysis Method: A Review

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Abstract: Apart from being rich in culture, Indonesia is also rich in food culture. However, in some cases, there are illegal additions of formalin (37% formaldehyde) to food to extend shelf life. If humans consume food containing formaldehyde, it will have a harmful impact. Formaldehyde has the potential to cause cancer. In recent years, formaldehyde has still been found in several Indonesian foods. There are several analytical methods developed to detect formaldehyde levels in food. This review overview of the formaldehyde effect to human health, formaldehyde content in fish and Indonesian food, and the detection methods.

Keywords: formaldehyde; Indonesia; food; analysis

1. INTRODUCTION

Indonesia is a diverse country that has various cultures. In line with its diverse culture, food in Indonesia is also diverse. However, there are illegal acts of deliberately adding formaldehyde to food to extend its shelf life. Formaldehyde (FA) (CH2O) is a type of colorless gas at ambient temperature. In liquid form, FA commonly known as “formalin” (37 up to 40 % w/w formaldehyde), is a low-cost chemical [1, 2]. FA is normally used in embalming to disinfect and preserve human corpses [3, 4]. In the food industry, FA is used to inhibit bacterial growth during juice production of sugar and as a bacteriostatic agent in some varieties of Italian cheese and fresh white cheese in El Salvador [1,5-6]. FA is a useful and important chemical to the global economy and is used in many industries i.e., construction (wood processing, furniture, textile, carpeting), consumable household product industries (antiseptics, medicines, cosmetics, dish-washing liquids, glues, lacquer), etc [7].

FA is a carcinogenic and hazardous substance for human health [2, 6], therefore FA is prohibited for use as food preservatives. But FA content is still found in some foods such as noodles [9], fish and seafood [10], fruits and vegetables [9, 10], fruit juice [13], mushrooms [14], and milk [15] because it has low-cost and effective as food preservatives.

The addition of formaldehyde to food poses a significant threat to Indonesia’s diverse food culture in several ways:

1. Health Risks: The consumption of food contaminated with formaldehyde poses serious health risks to consumers. Given its toxic nature, prolonged exposure to formaldehyde-laced foods can lead to various health complications, undermining the well-being of the population [16-18].
2. Cultural Degradation: Indonesian cuisine is characterized by its vibrant flavors, fresh ingredients, and traditional cooking methods. The use of formaldehyde compromises the authenticity and integrity of traditional dishes, distorting their original taste and quality. This threatens to erode the cultural significance of Indonesian cuisine over time.

3. Economic Impact: Indonesia’s culinary heritage is not only a source of cultural pride but also a significant driver of the economy, supporting local farmers, food producers, and businesses. The tarnished reputation resulting from the presence of formaldehyde in food products can lead to decreased consumer trust and demand, negatively impacting the livelihoods of those involved in the food industry.

4. Environmental Concerns: The illegal use of formaldehyde in food production may also have adverse environmental effects, such as contamination of water sources and soil degradation, further exacerbating ecological challenges faced by the country.

This review overview of the formaldehyde effect on human health, formaldehyde content in fish and Indonesian food, and the detection methods of formaldehyde content in Indonesian food.

2. METHODS

The articles related to the formaldehyde content in Indonesian food were identified and selected from databases. The databases used in this review were ScienceDirect, PubMed, and Google Scholar with keywords of formaldehyde+ Indonesian food. Inclusion criteria for the articles were open access and published in the last 20 years.

3. RESULTS AND DISCUSSION

3.1. Formaldehyde effect to human health

FA is highly toxic and carcinogenic [14, 15]. FA has been reported as one of the chemical mediators that caused programmed cell death (apoptosis). Since FA can generate crosslinking with proteins and DNA, this action may alter the mitochondrial membrane, open the mitochondrial transition pore, release cytochrome c into the cytosol, activate caspases and induce apoptosis [16, 17].

FA can cause respiratory symptoms, irritation of eyes, nose, and throat when inhaled by humans [23-26]. Increasing exposure can increase the risk of cancers in pharynx, nasopharynx, and brain, as well as dermatitis and allergic reactions [27-29]. Acute effects of airborne formaldehyde exposure: Odor detection, 0.05-1.0 ppm; Eye irritation, 0.01-2 ppm; Upper respiratory tract irritation (e.g., irritation of the nose or throat), 0.10-11 ppm; Lower airway irritation (e.g., cough, chest tightness, and wheezing), 5-30 ppm; Pulmonary edema, inflammation, pneumonia, 50-100 ppm; Death >100 ppm [20, 21].

In the case of food additives, the effects of CH₂O on the human body depend mainly on the volume and concentration in which the formaldehyde is present. For example, given a large quantity of CH₂O, the formic acid produced during the metabolism process can cause local corrosive action on the gastrointestinal tract; resulting in both oral and gastrointestinal mucosa. Moreover, the ingestion of 90 ml or more of 37% formaldehyde solution leads almost inevitably to death (more than 100 ppm) [20, 21].

3.2. Formaldehyde content in Indonesian food

Table 1 was shown the formaldehyde content in Indonesian food. The imported fruit (apple, pear, and grape) that was sold in Manado was analysed [9]. The research was found that the washing
fruits contain 0.060-0.136 µg/mL and unwashed fruits contained 0.080-0.195 µg/mL of formaldehyde. It was proven that imported fruit still contain formaldehyde. Noodles that were sold in Ambon contained 9.07-10.01 mg/kg of formaldehyde [7]. While in West Java, wet noodle was found containing formaldehyde in range 801-1684 mg/kg [32]. Kembung and Cucut salted fish from Bandung were found containing formaldehyde at level 0.252 and 0.482 ppm, respectively [33]. From the literature studies conducted, formalin was mostly found in wet fish samples.

<table>
<thead>
<tr>
<th>Place</th>
<th>Sample</th>
<th>Instrument Analysis</th>
<th>FA Levels</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manado</td>
<td>Apple, pear, and grape (Imported fruit)</td>
<td>UV-Vis spectrophotometry</td>
<td>Washed fruits: 0.060-0.136 µg/mL</td>
<td>[9]</td>
</tr>
<tr>
<td>Ambon</td>
<td>Noodle</td>
<td>UV-Vis spectrophotometry</td>
<td>9.07-10.01 mg/kg</td>
<td>[7]</td>
</tr>
<tr>
<td>Bandung</td>
<td>Kembung salted fish and Cucut salted fish</td>
<td>UV-Vis spectrophotometry</td>
<td>0.252 ppm and 0.482 ppm</td>
<td>[33]</td>
</tr>
<tr>
<td>Bali</td>
<td>Moonfish (Lampris guttatus)</td>
<td>UV-Vis spectrophotometry</td>
<td>133 mg/kg</td>
<td>[34]</td>
</tr>
<tr>
<td>West Java</td>
<td>Wet noodles</td>
<td>UV-Vis spectrophotometry</td>
<td>801-1684 mg/kg</td>
<td>[32]</td>
</tr>
<tr>
<td>Jakarta</td>
<td>Saurida tumbil fish</td>
<td>NMR</td>
<td>14 mg/kg</td>
<td>[35]</td>
</tr>
<tr>
<td>Hindia Ocean</td>
<td>Opah fish (Lampris guttatus)</td>
<td>UV-Vis spectrophotometry</td>
<td>27.82 ± 1.66 mg/kg to 133.12 ± 1.56 mg/kg</td>
<td>[36]</td>
</tr>
<tr>
<td>Banten</td>
<td>Short mackerel (Rastrelliger brachysoma)</td>
<td>UV-Vis spectrophotometry</td>
<td>1.4-1.7 ppm</td>
<td>[37]</td>
</tr>
<tr>
<td>Jakarta</td>
<td>Moonfish (Lampris guttatus), hardtail scad (Megalaspis cordyla), rank goby (Saurida tumbill), and mackerel scad (Decapterus spp.)</td>
<td>UV-Vis spectrophotometry</td>
<td>0 to 6.51 mg/kg</td>
<td>[38]</td>
</tr>
<tr>
<td>North Sumatera</td>
<td>Bawal, Kerapu, Kakap, Tuna, Tongkol</td>
<td>Formaldehyde test kit</td>
<td>Tongkol: 1.73 mg/L; Tuna: 1.40 mg/L; Bawal: 0.528 mg/L; Kakap: 3.42 mg/L; Kerapu: 2.47 mg/L</td>
<td>[39]</td>
</tr>
<tr>
<td>West Java</td>
<td>Rebon, Teri Medan, Teri Cue, Pakang</td>
<td>UV-Vis spectrophotometry</td>
<td>Rebon: 0.389 ppm; Teri Medan: 0.156 ppm; Udang Rebon: 0.389 ppm; Teri Cue: 0.182 ppm</td>
<td>[40]</td>
</tr>
<tr>
<td>South Sulawesi</td>
<td>Anchovy</td>
<td>UV-Vis spectrophotometry</td>
<td>0.196-0.270 ppm</td>
<td>[41]</td>
</tr>
<tr>
<td>West Kalimantan</td>
<td>Snakehead dried salted fish</td>
<td>UV-Vis spectrophotometry</td>
<td>0.64-0.83 ppm</td>
<td>[42]</td>
</tr>
</tbody>
</table>
3.3 Analysis method to determine formaldehyde content

Some analysis method was developed to analyse formaldehyde content in fish and food. For qualitative analysis, formaldehyde can be determined using a formaldehyde test kit and TLC (thin layer chromatography) [33,34]. While quantification of formaldehyde can use UV-VIS spectrophotometry [11]; TLC-densitometry [32]; HPLC (High-performance Liquid Chromatography) [45]; NMR (nuclear magnetic resonance) [35]; and gas chromatography-mass spectrometric (GC-MS) [35]. Bianchi et al., [46] evaluated formaldehyde content in different frozen fish products using a Solid Phase Micro Extraction Gas Chromatography Ion Trap Tandem Mass Spectrometry (SPMEGC-MS) method based on fiber derivatisation with pentafluorobenzyl hydroxylamine hydrochloride. Table 1 shows the analysis of formaldehyde in Indonesian food and the analysis methods.

In the Spectrophotometric method, formaldehyde cannot be directly analysed using UV-VIS spectrophotometry because it does not have a chromophore. Formaldehyde must react with Nash reagent (acetylacetone, ammonia) to form 3,5-diacyl-1,4-dihydrrotoulidine. This reaction is called the Hantzch reaction, the mechanism was shown in Figure 1[22]. This form has maximum absorption at 550 nm [9]. Another way to analyse formaldehyde can react with 4-Amino-3-hydrazino-5-mercapto-1,2,4-triazol (AHMT), pararosaniline, 3-methyl-2-benzothiazolonehydrazone (MBTH) and chromotropic acid etc., but the colorimetric methods in general are relatively slow and less sensitive [17,37].

![Figure 1. The mechanism in Hantzch reaction][48]

High-Performance Liquid Chromatography (HPLC) method having better selectivity, precision, and accuracy were proposed to analyse formaldehyde in squid product [49]. In the determination of formaldehyde using HPLC, the most often used derivative reagent before analysis is DNPH (2,4-dinitrophenylhydrazine), which reacted with formaldehyde to form the corresponding hydrazone [50]. The reaction between formaldehyde and DNPH was shown in Figure 2. Wang et al, [51] analyse the formaldehyde content in fruit juice samples using magnetic strong cation-exchange resin modified with DNPH. The procedures of extraction and derivatization were carried out in a single step by stirring the resins and diluted fruit juice with water. When the procedures were
completed, the resins adsorbing the HCHO–DNPH derivative were easily separated from the sample matrix by an adscititious magnet. The HCHO–DNPH derivative eluted from the resins was directly determined by high-performance liquid chromatography with UV detector at 360 nm [42].

![Figure 2. Reaction between formaldehyde and DNPH](image)

3.4 Preventing the use of formaldehyde in Indonesian foods

Protecting Indonesia’s culinary heritage is crucial for preserving its cultural identity, promoting public health, and sustaining the country’s economic development. These measures include:

a. Legislation and Enforcement: Indonesia has regulations in place that prohibit the use of formaldehyde as a food additive. The Food and Drug Supervisory Agency (BPOM) is responsible for enforcing these regulations and ensuring compliance with food safety standards. BPOM conducts inspections of food production facilities, tests food samples for chemical contaminants, and imposes penalties on violators found using formaldehyde or other harmful additives.

b. Public Awareness Campaigns: The government has also launched public awareness campaigns to educate consumers about the dangers of consuming food products contaminated with formaldehyde. These campaigns aim to raise awareness about food safety practices, encourage vigilant consumption habits, and empower consumers to report suspected cases of food adulteration to authorities.

c. Collaboration with Stakeholders: The Indonesian government collaborates with various stakeholders, including food producers, retailers, and industry associations, to promote compliance with food safety regulations and encourage responsible practices along the food supply chain. This collaboration involves providing guidance on proper food handling and storage techniques, as well as supporting initiatives to develop alternative preservative methods that are safe and effective.

Despite these regulatory efforts, challenges remain in effectively combating the illegal use of formaldehyde in food products in Indonesia. Some of these challenges include: inadequate regulatory oversight, and the presence of informal or unregistered food producers operating outside the purview of regulatory authorities. These factors can enable the continued illegal use of formaldehyde in food production despite existing regulations.

4. CONCLUSION

The illegal addition of carcinogenic formaldehyde to food is a serious concern to public health. Several analytical methods can be used to analyze the formaldehyde content in food, either for qualitative or quantitative analysis.

Foods containing formaldehyde are still found in Indonesian foods until now. So, consumers must be careful in choosing the food that they consume. Here are some recommendations and preventive actions consumers can take to avoid foods containing formaldehyde:
a. Choose Fresh Foods: Option for fresh foods over processed or packaged ones whenever possible. Fresh produce, meats, and seafood are less likely to contain added preservatives like formaldehyde.

b. Buy Organic products: Organic products are less likely to contain synthetic preservatives like formaldehyde. Look for certified organic labels when shopping for fruits, vegetables, meats, and other food items.

c. Avoid Highly Processed Foods: Processed foods, such as canned goods and ready-to-eat meals, often contain preservatives, including formaldehyde. Minimize consumption of these items.

d. Inspect Seafood: Formaldehyde is sometimes used to preserve seafood. When buying fish or shellfish, ensure they are fresh and have no off-putting odors. Avoid seafood that appears unnaturally firm or glossy.

e. Proper Storage: Properly store perishable foods in the refrigerator or freezer to prevent spoilage and the need for preservatives. Use airtight containers or wraps to maintain freshness.

f. Rinse Fruits and Vegetables: Wash fruits and vegetables thoroughly under running water to remove any surface residues, including potential traces of formaldehyde. Scrub firm produce with a brush to remove dirt and contaminants effectively.

g. Peel and Trim: Peeling and trimming fruits and vegetables can help remove surface contaminants, including any residual preservatives. However, keep in mind that some nutrients are located just under the skin, so balance this consideration.

h. Choose Trusted Suppliers: Purchase foods from reputable sources and suppliers known for their adherence to food safety regulations. Farmers’ markets, local farms, and trusted grocery stores may offer fresher and less preserved options.

i. Stay Informed: Keep yourself updated on food safety guidelines and any recalls related to formaldehyde contamination. Government health agencies often provide information on food safety and recalls through websites, newsletters, and social media platforms.

By following these recommendations, consumers can reduce their exposure to formaldehyde in foods and make healthier choices for themselves and their families.

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**References**


