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Heavy Metal Contamination in Packaged Foods and Health Risks: A Literature Review

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Abstract

The development of the food industry has increased the consumption of packaged food products, particularly those using metal packaging. However, the use of such packaging has the potential to cause the migration of heavy metals into food, which can impact human health. This study aims to analyze heavy metal contamination in packaged food and evaluate its potential health risks through a literature review. Data were collected from various scientific literature published over the past five years. The results of the review indicate that metals such as Fe, Zn, Pb, and Cd can be found in food due to interactions between food ingredients, the environment, and packaging. Factors such as storage duration, acidity, and environmental conditions influence the rate of metal migration. Long-term exposure to heavy metals, particularly non-essential ones like Pb and Cd, can cause toxic effects and health issues. Risk assessments indicate that although metal concentrations are relatively low, cumulative effects still warrant attention. Therefore, food safety monitoring and increased consumer awareness are crucial.

1. Introduction

The development of food technology in recent decades has driven an increase in the production and distribution of processed foods, including food products in

metal packaging. Metal packaging, such as cans, is widely used because of its ability to extend shelf life and maintain product quality. However, the use of this packaging also poses potential risks, especially related to the migration of heavy metals into food during the storage process (Massadeh & Al-Massaedh, 2018). This phenomenon has become a global concern because the consumption of processed food products continues to increase in various countries, both in developing and developed regions.

Heavy metals such as lead (Pb), cadmium (Cd), zinc (Zn), and iron (Fe) can enter food products through various pathways, including raw materials, the production environment, as well as the interaction between the product and the packaging (Fathabad et al., 2018). The process of metal migration from packaging to food can be affected by several factors, such as storage time, acidity level, and storage environmental conditions. Under certain conditions, the chemical interaction between the food material and the metal surface can speed up the corrosion process and increase the release of metal into the product.

Heavy metal contamination in food is a serious issue because of its toxic, bioaccumulative, and biodegradable nature. Long-term exposure to heavy metals can lead to a variety of health problems, including organ damage, nervous system disorders, as well as an increased risk of chronic diseases (Jain & Gauba, 2017). Some metals such as Zn and Fe are needed in small amounts as essential elements, but still have safe consumption thresholds. In contrast, metals such as Pb and Cd have no biological function in the human body and can cause toxic effects even at low concentrations (Ali et al., 2019).

In addition, the increase in processed food consumption is also accompanied by increasing concerns about food safety globally. International health organizations such as the WHO and EFSA have emphasized the importance of contaminant control in food to protect public health (WHO, 2017; EFSA, 2018). Health risk assessment is one of the approaches used to evaluate the impact of heavy metal exposure through sustainable food consumption.

A number of previous studies have shown the presence of heavy metal content in various processed food products, including those packaged in cans, as well as their potential risks to human health (Sultana et al., 2019). However, there are still limitations in comprehensively understanding the relationship between storage factors, packaging characteristics, and metal migration rates. Therefore, a more in-depth study is needed to provide a clearer picture of these potential risks.

Based on this background, this study aims to analyze the phenomenon of heavy metal contamination in metal packaged food products and evaluate the potential health risks posed through a literature review approach. The results of this study are expected to contribute to the development of food safety policies and increase public awareness of the importance of safe food consumption.

2. Literature Review

The study of heavy metal contamination in food has become an important concern in the field of food safety and environmental health. Heavy metals can enter the food system through a variety of sources, including soil, water, air, as well as processing and packaging processes. According to Rehman et al. (2018), heavy metal

contamination in food products is not only influenced by environmental factors, but also by industrial practices and processing technologies used.

Metal packaging, especially cans, is known to have the potential to be an additional source of contamination. The interaction between food and metal surfaces can cause the migration of metal elements into the product, especially in long storage conditions or acidic environments. Proshad et al. (2021) stated that the increase in storage time is positively correlated with an increase in the concentration of metals in food products, indicating a gradual diffusion or corrosion process.

From a health perspective, exposure to heavy metals through food consumption can have various negative impacts. Ametepey et al. (2018) show that the consumption of foods contaminated with heavy metals can increase the risk of health problems, especially in vulnerable groups such as children and the elderly. This risk increases if exposure occurs chronically over a long period of time.

Health risk assessment is an important approach in evaluating the impact of heavy metal contamination. This method usually involves calculating the daily intake of the metal as well as comparing it to the recommended threshold value. Arora & Chauhan et al. (2021) emphasize that a risk-based approach is indispensable to understand the level of hazards posed as well as as a basis for contamination control policymaking.

Thus, the existing literature shows that heavy metal contamination in food is a complex problem involving a variety of factors, ranging from the source of contamination to the health impact. This emphasizes the importance of a comprehensive study to understand the phenomenon comprehensively.

3. Methods

This study uses a literature review approach as the main method in data collection and analysis. This method was chosen because it allows researchers to in-depth examine various previously published scientific findings related to heavy metal contamination in food and its impact on human health. Through this approach, research does not involve collecting primary data, but rather utilizing secondary data sources from scientific journals, research reports, and official documents from related institutions.

The data collection process is carried out by identifying, selecting, and reviewing literature relevant to the research topic. The literature selection criteria are focused on publications published in the last 5 years to ensure the novelty and relevance of the information used. In addition, the selected source is an article published in reputable scientific journals, both national and international, so it has high credibility.

The next stage is to analyze the literature that has been collected. The analysis was carried out descriptively by grouping information based on key themes, such as the source of heavy metal contamination, the mechanism of metal migration, the factors that affect the level of contamination, and the health impacts caused. The data obtained is then compared and integrated to find existing research patterns, relationships, and gaps.

To maintain the consistency and accuracy of the analysis, the researcher also conducts an evaluation process on the quality of each source used. This includes an assessment of the research methods used in previous studies, the clarity of the results

presented, and the relevance to the research objectives. Thus, only valid and relevant information is used in the preparation of results and discussions. Through this literature study method, it is hoped that the research can provide a comprehensive picture of the phenomenon of heavy metal contamination in food and its implications for human health, without having to conduct direct experiments in the laboratory.

4. Results and Discussion

The results of the literature review show that heavy metal contamination in food products is a multifactorial phenomenon and is influenced by the interaction between foodstuffs, the environment, and the packaging system. In the context of metal packaging food, one of the key findings is the process of metal migration from packaging into products, which occurs gradually during the storage period. This process is generally triggered by a chemical reaction between food components and metal surfaces, especially under certain conditions such as high acidity levels and long storage times (Massadeh & Al-Massaedh, 2018).

The migration of heavy metals from packaging into food is influenced by the physical and chemical properties of the food itself. Food products that have a high acid content tend to accelerate the corrosion process in the inner layers of metal packaging, thereby increasing the release of metal ions into the product (Fathabad et al., 2018). In addition, temperature factors and storage conditions also play an important role in determining the rate of migration. The longer the product is stored,

the more likely it is that heavy metals will accumulate in the food, which can ultimately increase the risk of exposure for consumers.

In general, heavy metals that are often found in food products include iron (Fe), zinc (Zn), lead (Pb), and cadmium (Cd). Fe and Zn are essential metals that are needed by the body in certain amounts to support biological functions, such as enzyme metabolism and the immune system. However, excessive consumption can still have negative effects on health (Jain & Gauba, 2017). In contrast, Pb and Cd are non-essential metals that have no biological function in the body and are toxic even at low concentrations (Ali et al., 2019).

The results of the analyzed study showed that the concentration of heavy metals in food tends to increase along with increasing storage time. These findings are consistent with previous research that stated that there is a linear relationship between storage duration and the rate of metal migration from packaging to product (Proshad et al., 2021). This process is related to the degradation of the protective layer in the metal packaging which weakens over time, allowing the diffusion of the metal into foodstuffs.

In addition to the packaging factor, the source of heavy metal contamination can also come from raw materials and the production environment. Soil, irrigation water, and the use of pesticides and fertilizers in the cultivation process can be the initial source of heavy metals entering the food chain (Rehman et al., 2018). Thus, the contamination that occurs in packaged food products does not always come from the packaging itself, but is an accumulation of various sources that contribute to each other.

From a health perspective, exposure to heavy metals through food consumption is a very important issue. Heavy metals have bioaccumulative properties, which means they can accumulate in the tissues of the human body over time. This accumulation can lead to various health problems, such as kidney damage, nervous system disorders, as well as an increased risk of cancer (Arora & Chauhan, 2021). The toxic effects caused depend on the type of metal, the dose of exposure, and the duration of consumption.

Health risk assessment is a widely used approach to evaluate the impact of heavy metal exposure through food. This method generally involves calculating the daily intake of the metal and comparing it with the threshold values recommended by international health agencies. If the exposure value exceeds the safe limit, then the exposed individual has the potential to experience health risks (EFSA, 2018). This approach provides a quantitative picture of the level of harm that may be posed by the consumption of contaminated food.

Some studies show that although the concentration of heavy metals in food is relatively small, long-term exposure can still have significant cumulative effects. This is especially true for metals such as Cd and Pb which have high levels of toxicity and are difficult to remove from the body (Ametepey et al., 2018). Therefore, it is important to consider not only the concentration of metals in a single product, but also the overall consumption pattern.

In the context of global food security, the control of heavy metal contamination is a top priority for various international institutions. WHO has set maximum limits on the content of heavy metals in food and provides guidelines

related to risk evaluation to protect public health (WHO, 2017). This effort aims to ensure that food products circulating on the market are safe to consume and do not cause negative impacts in the long term.

In addition to regulation, increasing consumer awareness is also an important factor in reducing the risk of exposure to heavy metals. Consumers are expected to be more selective in choosing food products, including paying attention to the type of packaging, expiration date, and storage conditions. On the other hand, manufacturers also have a responsibility to ensure that the production and packaging processes are carried out in accordance with applicable safety standards.

The results of this study also show that there is a gap in research related to the interaction between various factors that affect metal migration. Most studies still focus on one specific aspect, such as the type of packaging or the length of storage, without considering other factors simultaneously. In fact, in real conditions, these factors interact with each other and affect each other in a complex way (Sultana et al., 2019).

In addition, limited data on the variety of food types and different storage conditions is a challenge in generalizing the results of the study. This suggests the need for more comprehensive follow-up research by considering various variables simultaneously. A multidisciplinary approach that combines chemical, biological, and public health aspects can provide a more comprehensive understanding of this phenomenon.

Based on the whole, these results and discussion confirm that heavy metal contamination in packaged foods is a complex problem and requires serious

attention. The combination of packaging factors, environment, and consumption behavior plays a role in determining the level of risk faced by the community. Therefore, collaborative efforts are needed between researchers, governments, and industry to develop effective strategies in controlling heavy metal contamination and protecting consumer health.

5. Conclusion

This study demonstrates that heavy metal contamination in packaged food products is a complex issue with significant implications for human health. Factors such as the type of packaging, storage conditions, and food characteristics play a crucial role in determining the rate of metal migration into the product. Furthermore, the findings indicate that exposure to heavy metals, particularly non-essential ones, can pose serious health risks if it occurs continuously over the long term.

The literature review approach used in this study allowed for the identification of various key findings from previous research, while also revealing gaps in studies regarding the relationship between storage factors and contamination levels. Therefore, more comprehensive follow-up research is needed, whether through experimental approaches or risk modeling. Based on this study, it underscores the importance of monitoring the quality of packaged foods as well as the need to raise public awareness in selecting products that are safe for consumption.

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