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Potential dangers of deoxynivalenol: A Review

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Abstract
Background: Deoxynivalenol (DON) is a type of mycotoxin produced by Fusarium fungi particularly Fusarium graminearum. This mycotoxin is commonly found in various crops, including wheat, maize, and barley. DON is one of the most commonly found mycotoxins in crops and can cause significant economic losses in the agriculture and livestock industries. Therefore, monitoring and controlling DON levels is crucial to ensure food safety and animal health.
Method: This study reviews literature on Fusarium graminearum contamination and the risks associated with deoxynivalenol. This review comprises 37 articles, with reference searches conducted in the PubMed database
Results: Effects on human health cause gastrointestinal disturbances, damage to the digestive tract, and toxic effects on the immune system, while on animals cause been shown to reduce the production of milk, eggs, and meat.
Conclusion: DON is a common mycotoxin found in agricultural products, posing a threat to human and animal health. Therefore, a rapid and effective detection method is needed to overcome DON contamination.

Keywords: Fusarium Graminearum; Deoxynivalenol; Mycotoxin; Fungus; Toxic.

INTRODUCTION

Deoxynivalenol (DON) is a type of mycotoxin produced by Fusarium fungi (1) particularly Fusarium graminearum (2). This mycotoxin is commonly found in various crops, including wheat, maize, and barley (3). DON is also referred to as “vomitoxin” due to its ability to induce emetic responses in animals that consume it (4). DON can lead to various toxic effects in both animals and humans, including gastrointestinal disturbances, immunotoxicity, cytotoxicity, carcinogenicity, genotoxicity, as well as reproductive and teratogenic effects (5). DON is one of the most commonly found mycotoxins in crops and can cause significant economic losses in the agriculture and livestock industries (6). Therefore, monitoring and controlling DON levels is crucial to ensure food safety and animal health.

In Indonesia, Deoxynivalenol (DON) has been detected in infant food (7), dried and fresh noodles (8), fresh fruits and their processed products (9), animal feeds (10), (11) as well as in maize contaminated by Fusarium fungi (12). According to PerBPOM 8 Tahun 2018 concerning chemical contaminants in food, the maximum allowable limit for DON contamination in processed food products and similar items is 1000 ppb (µg/kg), except for wheat-based complementary foods for infants (MP-ASI), which have a stricter limit of 200 ppb (µg/kg) (13). The threat is not only limited to DON contamination; Fusarium fungal infections in crops such as maize and wheat can also cause spoilage, ultimately leading to significant economic losses.

DON contamination poses a serious threat to global food safety and public health, particularly in developing countries.

Incidences of DON have been reported in cereal grains and processed products in many countries worldwide; however, global risk assessment of DON in food remains largely unclear (14). Intervention strategies aimed at reducing DON levels in wheat and its derivative products are essential to minimize human exposure to this contaminant. Therefore, this article aims to explore the potential risks associated with DON contamination.

METHOD

This is study literature review method by collecting various journals that investigate Fusarium graminearum contamination and the associated risks of deoxynivalenol, as well as reports that highlight the dangers of deoxynivalenol contamination. We searched and identified articles in the PubMed database. Initially, more than 90 articles discussing the hazards of deoxynivalenol in food were found, but after further examination, approximately 37 articles were considered suitable for review

RESULTS

Numerous studies on the toxicity of deoxynivalenol (DON) in animals, as well as reported cases in humans, have provided valuable insights into the potential hazards of DON contamination. Although DON is considered less toxic than other trichothecenes such as T-2 toxin, exposure to high doses of DON can be lethal (15). DON can be detected in plasma, liver, spleen, and brain within 5 minutes to 24 hours after exposure. It is also detectable in the heart and kidneys within 5 minutes to 8 hours post-exposure (16). Chemically, DON is classified as a type B trichothecene due to the presence of a double bond with oxygen at the carbon-8 position in its molecular structure. (17).

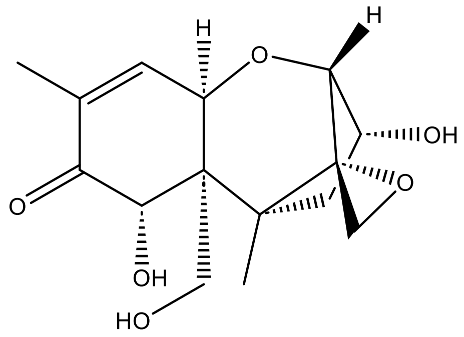

Figure 1. Chemical structure of deoxynivalenol (DON)

Table 1. Physico-chemical properties of deoxynivalenol

Name	Deoxynivalenol (DON)
Iupac Name	(3α,7α)-12,13-epoxy-3,7,15-trihydroxytrichothec-9-en-8-one
Molecular formula	$H_{15}O_{20}O_6$
Molar mass	296.31 g/mol
Physical state	White crystalline solid
Melting Point (°C)	151-153 °C
Soluble in	Polar organic solvents (e.g., aqueous methanol, ethanol, chloroform, acetonitrile, and ethyl acetate) and water

DISCUSSION

1. Effects on Human Health

In reported cases, deoxynivalenol (DON) has been associated with various health problems in humans. Human exposure to DON primarily occurs through the consumption of food contaminated with Fusarium fungi, particularly in crops such as wheat, maize, and barley (18). ommonly observed effects include gastrointestinal disturbances, damage to the digestive tract, and toxic effects on the immune system (19). In severe cases, DON contamination may lead to more serious health outcomes, such as kidney and liver damage (5) even long-term exposure to DON can increase the risk of cancer (4) and have long-term toxic effects on the immune system, growth, and reproduction (20).

2. Effects on Animals

Animal studies have demonstrated that DON contamination in feed can lead to impaired weight gain, anorexia, reduced nutrient efficiency, and immune dysfunction (21), (22), (23). Hogs are considered the most sensitive species to DON contamination, followed by poultry, cats, dogs, and rodents (24), (25). DON exposure has also been shown to reduce the production of milk, eggs, and meat (26). Sensitivity to DON varies among animal species; in cattle, the threshold is reported to range from 1.5 to 6.4 mg/kg (4) whereas in hogs, DON has been detected at 12 mg/kg, with vomiting observed at concentrations around 20 mg/kg (27). The average concentration of DON in feed is estimated to range from 64.2 to 996 µg/kg for cattle, In poultry, DON concentrations as low as 9 mg/kg in feed have been reported to negatively affect (4). These effects not only have economic impacts on humans but if animals are contaminated with DON through feed it will have an impact on human health.

3. Toxicity mechanisms DON

The mechanism of toxicity of DON is classified as a sesquiterpenoid and has a structure consisting of epoxy groups at C12–13 and hydroxyl groups at C3, C7, and C15, which are mainly responsible for its toxicity. (28). DON can inhibit protein synthesis by binding to ribosomes and inhibiting the translation process, causing damage to cells and tissues. In addition, DON can also activate the MAPK (Mitogen-Activated Protein Kinase) pathway which can cause inflammation and cell damage. (29). DON exposure also triggers oxidative stress through increased production of free radicals that can damage DNA and cell membranes. (30). DON causes ribosome damage, which triggers ribotoxic stress, inhibits the protein synthesis process, and ultimately triggers cell death. (31), (32), (33). DON can also cause damage to the intestinal lining and increase intestinal permeability, allowing toxins and other pathogens to enter the body. (34). In addition, DON can also modulate the immune system, causing changes in the immune response and increasing the risk of infection. (35). The toxic effects of DON have been extensively studied and documented, especially in pigs which have been shown to be highly sensitive to this toxin in animal production. However, in vitro studies have shown that microbial transformation can significantly reduce DON toxicity, by producing metabolites such as DOM-1 and 3-epi-DON (36).

4. Regulation regarding DON in foods

Mycotoxin contamination of food is a very important health problem and a top priority for humans. Since aflatoxin was discovered in the 1960s, many countries have established regulations to protect consumers from consuming food contaminated with mycotoxins and potentially harmful. In developing countries, protection efforts must take into account food availability. If food supplies are limited, overly stringent regulations can worsen food shortages and have significant impacts. Therefore, regulatory standards can vary between national and international agencies (6).

Table 2. Regulation limits of deoxynivalenol in Indonesia

Food	Maximum limit (ppb)	Ref
Maize, wheat	1000	(37)
Pasta, noodle, and related products	750	(37)
Ready-to-eat products (processed flour, pastry, bread, biscuit, snack)	500	(37)

CONCLUSIONS

DON is a common mycotoxin found in agricultural products, posing a threat to human and animal health. Therefore, a rapid and effective detection method is needed to overcome DON contamination in food or animal feed, especially in developing countries where its impact is often overlooked. Food safety efforts need to be prioritized, especially in Indonesia.

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