VOL. 10 NO. 3,
NOVEMBER, 2025
E-ISSN 3026-8702
P-ISSN 3026-8745

African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Clinical and Metabolism Studies (JCMS)

Mycotoxin-Producing Molds in Ready-to-Eat Foods: The Health Implications

Hanis, B.; Egbulefu, C. S.; Mbambam, F.; Alozie, A.; & John, C. I.

National Biotechnology Research and Development Agency (NBRDA), Abuja, Nigeria.
Corresponding Author: detola2005@yahoo.com
DOI: https://doi.org/10.70382/ajcms.v10i3.035

Abstract

In many food products, some filamentous fungi species produce secondary metabolites that may persist in the foods during storage. This mycotoxin metabolites may be found in a variety of processed foods such as peanut and other cereal by-products. Early detection and a general study of molds associated with this class of foods in any given study area might inform the individual about the risk to health as well as being educated as to the best prevention and control strategies. Therefore, the aim of this study was to investigate the mycological quality of some ready-to-eat foods sold within the Federal Capital Territory (FCT), Abuja, Nigeria and the potential health risks to consumers. A study on a set of ready-to-eat food material viz; based on cereals, nuts and vegetables was carried out to determine the natural presence of mycotoxin-producing molds by culturing on Potato Dextrose Agar (PDA) supplemented with antibacterial agent. After incubation at 28^0C for 5-7days, the occurrence of mycotoxin-producing fungi was highest in cereal meal samples with 37% of samples contaminated by at least two mycotoxin-producing molds followed by vegetables (24%), nuts (19%) and lastly, dairy products (8%) were contaminated. The need for awareness in food safety and in reducing the risks associated with the consumption of these foods become necessary. It is imperative that governments, the food industry, and the scientific community collaborate to reduce this risk and ensure consumer safety.

Keywords: Mycotoxins, Fungi, Health, Risks and Foods

Introduction

In recent time, Ready-to-eat food are transforming the food industry, driven by the growing demand for convenience without compromising quality. As busy lifestyles become the norm, more consumers are turning to quick and easy meal solutions that still deliver the taste and nutritional qualities (1). Ready to eat foods ranging from pre-prepared ingredients to meal kits offer the perfect balance between fast food and traditional cooking (2). But it's more than just a time-saver; it enhances the overall cooking experience, giving consumers the flexibility to prepare fresh, delicious meals with minimal effort. Ready-to-eat foods have become an integral part of modern diets, offering convenience and ease of consumption without the need for additional preparation. These foods can range from fresh fruits and vegetables to packaged and processed items (3). The concept of RTE foods is broad, encompassing a wide variety of products that are safe for immediate consumption. They are seen as foods that are intended for direct human consumption without any further preparation, such as cooking, reheating, or washing. RTE foods can be categorized based on their production processes, ingredients, or the level of processing they undergo (4). Raw agricultural commodities, such as fruits, vegetables, nuts, and seeds, are inherently ready to eat. These foods are grown, harvested, and may undergo minimal processing such as cleaning, sorting, and packaging before they reach consumers. Fresh produce is a significant component of the RTE food category, with many items being consumed raw. The safety and quality of these foods depend heavily on proper handling and storage practices from farm to table (5). The safety of RTE foods is a critical concern, as these products are consumed without further cooking or processing that could kill pathogens. Pathogen control is paramount, as RTE foods can be contaminated with harmful fungi, among others. The risk of foodborne illness from RTE foods can be mitigated through adherence to strict food safety practices, including proper hygiene during production, handling, and storage, and the implementation of Hazard Analysis and Critical Control Points (HACCP) systems.

Mycotoxins are a large family of secondary metabolites produced by filamentous fungi species that may be present in food following fungal growth. The ingestion of mycotoxins by humans, which occurs mainly through plant-based foods and the residues and metabolites present in animal-derived foods, may result in poor liver and kidney function (6). Moreover, mycotoxins are exogenous compounds with low molecular weight, defined as xenobiotics or contaminants of natural origin. These toxic substances have the potential to cause a range of adverse effects on human and animal health (7). The genera of fungi and mycotoxin producers that have been most extensively studied are *Penicillium*, *Aspergillus*, and *Fusarium*. The major mycotoxins of food safety importance include aflatoxins (AFs), fumonisin (FUM), ochratoxin A (OTA), citrinin (CIT), deoxynivalenol (DON), zearalenone (ZEN), and *Alternaria*. These mycotoxins could be found in foodstuffs in

significant quantities, with implications for human and animal health (8). Mycotoxins can proliferate on many agricultural and food products. Humans are most exposed to mycotoxins through contaminated cereals, cereal-based products, and ready-made food items derived from animals that have been exposed to them. The contamination of food products may occur at any stage of the food supply chain, from the pre-harvest to the post-harvest stages (9). The growth of fungi is not necessarily associated with the formation of mycotoxins, and because of their stability, they may be present in food in the absence of fungi. Therefore, when the environment was most favorable for further fungal growth, the fungi used a mycotoxin to multiply (10). There are many known mycotoxins, synthesized by a variety of fungi, that can be potentially found in different types of food (11). Mycotoxins are found in a variety of crops, including wheat, millet, maize, sorghum, peanut, soybean, and their by-products. Additionally, cereals, oilseeds, cottonseed, leguminous seeds, spices, and other foodstuffs used for animal feed may also contain mycotoxins.

In a preliminary investigation of peanut-based ready-to-use therapeutic foods, a nutritional supplement used for the treatment of AIDS patients and malnourished children, all samples tested exhibited aflatoxin levels exceeding the maximum tolerable level for dietary foods intended for health purposes. Furthermore, the concentration of aflatoxins in locally processed peanut butter is deemed unfit for human consumption according to prevailing global regulations (12).

A number of studies have demonstrated that storage time, incorrect temperatures, pH, moisture, and unsuitable packaging can have a negative effect on the safety of raw materials used in RTE foods (13). Furthermore, a study analyzing samples of whole discolored kernels present in RTE products revealed that the risk of contamination by aflatoxins (up to 1383.4 μg/g) is approximately 90%. Although RTE foods undergo peanut sorting processes, it is not always possible to perform sorting procedures that could have removed the discolored kernels (DKs). In light of these observations, the authors concluded that peanut-based RTE foods represent a significant threat to the people of India (14). In many food products, some filamentous fungi species produce secondary metabolites that may persist in the foods during storage. This mycotoxin metabolites may be found in a variety of processed foods such as peanut and other cereal by-products.

Early detection and a general study of molds associated with this class of foods in any given study area might inform the individual about the risk to health as well as being educated as to the best prevention and control strategies. Therefore, the aim of this study was to investigate the mycological quality of some ready-to-eat foods sold within the Federal Capital Territory (FCT), Abuja, Nigeria and the potential health risks to consumers. This investigation was prompted by a lack of data on the presence of certain mycotoxins in specific ready-to-eat (RTE) foods and their by-product categories in the studies areas.

Materials and Method

A study on a set of ready-to-eat food material viz; cereal based meal (Donkwa), Cashew nuts, vegetables (Carrot) and Dairy product (cheese) was carried out to determine the natural

presence of mycotoxin-producing molds by culturing on Potato Dextrose Agar (PDA) supplemented with antibacterial agent.

Food Sampling

A total of 40 dried RTE food samples consisting of cashew nut, Donkwa, Cheese and carrot (10 samples each) were randomly purchased from markets in the Federal Capital Territory, Abuja, Nigeria. Some of them were purchased as pre-packed foods in sealed polyethylene packs, and transported to the laboratory for analysis. In the laboratory, the food samples were comminuted into fine powder in an electric blender (Panasonic, India) and each sample was used for mycological analysis. The samples were stored at 4°C prior to analysis within 48 h. (16).

Isolation and Enumeration of Fungi

The dilution plating technique was applied for the isolation and enumeration of fungi present in the food samples. Each comminuted sample (10 g) was diluted in sterile distilled water (90 mL) and homogenized for 2 min. Exactly 100 µL of the homogenized mixture was surface-plated out in duplicate on Potato Dextrose Agar (PDA) supplemented with streptomycin to suppress bacteria growth. Incubation of all inoculated plates was performed at 25°C for 3 to 5 days. (17). Thereafter, fungal colonies were counted and are reported below as colony forming units per gram (CFU/g) of analyzed food sample. All distinct colonies on the PDA plates were transferred to freshly prepared plates of malt extract agar (MEA; Oxoid, United Kingdom). The purified cultures were retained at 4°C on MEA slants overlaid with sterile distilled water in 4 mL vials.

Characterization of Fungal Isolates

All fungal isolates obtained from the food samples were cultivated and assessed for macroscopic and microscopic characters, and compared with descriptions in appropriate. Isolates were clustered into phenotypic groups and representatives of each group were selected for further identification using mycological approach. (18).

Fungal Occurrence (Load and Incidence) in Dried RTE Foods and Their Implications

After incubation at 28^0C for 5-7days, the occurrence of mycotoxin-producing fungi was highest in cereal meal samples with 37% of samples contaminated by at least two mycotoxin-producing molds followed by vegetables (24%), nuts (19%) and lastly, dairy products (8%) were contaminated. This indicated that all the food types examined in this study, were of risk due to fungal contaminations. The predominant fungi were Aspergillus spp. Penicillium spp., Alternaria spp., Mucor spp. and Rhizopus spp. Aspergillus had the highest occurrence in all the foods while Alternaria had the lowest load. This data indicate that the processing steps probably reduced the fungal levels in the food but due to further exposure, these levels remained high as a result of recontamination during transportation and storage (19). Therefore, avoiding recontamination might be a safer method of health risk management regarding these

foods (20). The kind of pathogens recorded in this work suggest high health concerns due to the possibility of mycotoxin production as their metabolic products (21). The fungal contamination of the carrot samples may be attributed to the kinds of soil in which they are cultivated (22). Whereas, the nut and cheese might be as a result of secondary, post-food production practices, because it is highly unlikely that the fungal propagules can survive the frying step of cheese at approximately 100°C for 15–20 min. To be precise, exposure of food materials like carrot in the unpackaged form to the busy open markets, where human activities including constant and high human traffic and motorist influx occur for more than 10 h on a daily basis, will result in massive food contamination by diverse fungi. Therefore, packaging after the frying step might limit fungal contamination and prevent the dissemination/dispersal of harmful strains (23). Future research may investigate the impact of packaging (diverse materials and duration) of major ready to eat foods on fungal contamination.

Conclusion and Recommendations

Prevention strategies have been shown to be highly effective in reducing mycotoxin-producing molds in foods, which are known to be produced during some phase of the food chain. However, it should be noted that pre-harvest natural contamination cannot be completely eliminated. Nevertheless, the application of good processing techniques has been demonstrated to minimize subsequent entry into the food and feed chain, thereby reducing the risk of mycotoxin contamination. Furthermore, wet cereals and nuts must be dried efficiently and promptly for medium- and long- term storage in hygienic silos, which must be free of insect pests and moldy material. It is also vital to ensure that there is traceability during silo storage and transport for processing. In order to achieve this, it is essential to implement Good Agricultural Practice and operation, as well as to establish approved supplier chains. The use of effective diagnostic tools must be implemented to monitor and quantify mycotoxins at a rapid rate. The need for awareness in food safety and in reducing the risks associated with the consumption of these foods become necessary. It is imperative that governments, the food industry, and the scientific community collaborate to reduce this risk and ensure consumer safety.

References

Abdullahi A., Muhammad R.G., Mohammed J.N., Mohammed A., Muhammad I.L. Diversity of Ochratoxin A in Ready-to-Eat Foods in Nigeria. Jewel J. Sci. Res. 2022;7:124–140.

Elkenany R., Awad A. Types of Mycotoxins and Different Approaches Used for Their Detection in Foodstuffs. Mansoura Vet. Med. J. 2021;22:25–32.

Hamad G.M., Mehany T., Simal-Gandara J., Abou-Alella S., Esua O.J., Abdel-Wahhab M.A., Hafez E.E. A Review of Recent Innovative Strategies for Controlling Mycotoxins in Foods. Food Control. 2023;144:109350.

Yang J., Li J., Jiang Y., Duan X., Qu H., Yang B., Chen F., Sivakumar D. Natural Occurrence, Analysis, and Prevention of Mycotoxins in Fruits and Their Processed Products. Crit. Rev. Food Sci. Nutr. 2014;54:64–83.

Fernández-Cruz M.L., Mansilla M.L., Tadeo J.L. Mycotoxins in Fruits and Their Processed Products: Analysis, Occurrence and Health Implications. J. Adv. Res. 2010;1:113–122.

Coppock R.W., Christian R.G., Jacobsen B.J. Veterinary Toxicology. Elsevier; Amsterdam, The Netherlands: 2018. Aflatoxins; pp. 983–994.

Silberbauer A., Schmid M. Packaging Concepts for Ready-to-Eat Food: Recent Progress. J. Package Technol. Res. 2017;1:113–126.

Chen F., Zhang M., Yang C. Application of Ultrasound Technology in Processing of Ready-to-Eat Fresh Food: A Review. Ultrason. Sonochem. 2020;63:104953.

Carballo D., Moltó J.C., Berrada H., Ferrer E. Presence of Mycotoxins in Ready-to-Eat Food and Subsequent Risk Assessment. Food Chem. Toxicol. 2018;121:558–565.

Cabañes F.J., Bragulat M.R., Castellá G. Ochratoxin A Producing Species in the Genus Penicillium. Toxins. 2021 ;2:1111–1120.

Luque M.I., Córdoba J.J., Rodríguez A., Núñez F., Andrade M.J. Development of a PCR Protocol to Detect Ochratoxin A Producing Moulds in Food Products. Food Control. 2013;29:270–278.

Lindermayr H., Knobler R., Kraft D., Baumgartner W. Challenge of Penicillin-Allergic Volunteers with Penicillin-Contaminated Meat. Allergy. 1981;36:471–478.

Dupont J., Magnin S., Marti A., Brousse M. Molecular Tools for Identification of Penicillium Starter Cultures Used in the Food Industry. Int. J. Food Microbiol. 2022;49:109–118.

Darwish S.M., Yousef N.M., Ismail M.A. Microbiological Quality and Elemental Analysis of Some Ready-to-Eat Meat Products. J. Food Dairy Sci. 2008;33:5865–5877.

Majeed M., Khaneghah A.M., Kadmi Y., Khan M.U., Shariati M.A. Assessment of Ochratoxin A in Commercial Corn and Wheat Products. Curr. Nutr. Food Sci. 2018;14:116–120.

Makun H.A., Dutton M.F., Njobeh P.B., Mwanza M., Kabiru A.Y. Natural Multi-Occurrence of Mycotoxins in Rice from Niger State, Nigeria. Mycotoxin Res. 2021;27:97–104.

Makinde O.M., Ayeni K.I., Sulyok M., Krska R., Adeleke R.A., Ezekiel C.N. Microbiological Safety of Ready-to-eat Foods in Low- and Middle-income Countries: A Comprehensive 10-year (2009 to 2018) Review. Comp. Rev. Food Sci. Food Safe. 2020;19:703–732.

Palermo D., Pietrobono P., Palermo C., Rotunno T. Occurrence of Ochratoxin A in Cereals from Puglia (Italy) Ital. J. Food Sci. 2022;14:447–454.

Imperato R., Campone L., Piccinelli A.L., Veneziano A., Rastrelli L. Survey of Aflatoxins and Ochratoxin a Contamination in Food Products Imported in Italy. Food Control. 2021;22:1905–1910.

Benkerroum N. Chronic and Acute Toxicities of Aflatoxins: Mechanisms of Action. Int. J. Environ. Res. Public Health. 2020;17:423.

Williams J.H., Phillips T.D., Jolly P.E., Stiles J.K., Jolly C.M., Aggarwal D. Human Aflatoxicosis in Developing Countries: A Review of Toxicology, Exposure, Potential Health Consequences, and Interventions. Am. J. Clin. Nutr.

Ezekiel C.N., Oyedele O.A., Kraak B., Ayeni K.I., Sulyok M., Houbraken J., Krska R. Fungal Diversity and Mycotoxins in Low Moisture Content Ready-To-Eat Foods in Nigeria. Front. Microbiol. 2020;11:615.

EFSA Panel on Contaminants in the Food Chain (CONTAM) Schrenk D., Bignami M., Bodin L., Chipman J.K., del Mazo J., Grasl-Kraupp B., Hogstrand C., Hoogenboom L., Leblanc J., et al. Risk Assessment of Aflatoxins in Food. EFS2. 2020;18:e06040.