Mycotoxin Occurrence and Risk Assessment in Infants and Young Children (IYC) Formulated Foods in Southwest Nigeria

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Biotechnological Approaches to Sustainable Development Goals

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Abstract

Mycotoxins are toxic secondary metabolites produced by fungi in foods and feeds. Over 400 mycotoxins have been described in the literature including

aflatoxins (Afs), fumonisins (FBs), ochratoxins (OTAs), citrinin (CIT), zearalenone (ZEN), trichothecenes (TCs), and patulin (PAT). These mycotoxins are produced by species of *Aspergillus*, *Fusarium*, *Penicillium*, *Alternaria*, *and Claviceps*. The occurrence of these mycotoxins and other mycotoxins such as beauvericin and moniliformin has been reported in foods consumed by infants and young children (IYC). Aflatoxin B_1, fumonisin B_1, and zearalenone were reported in stored maize grains in five agroecological zones (AEZs) of Nigeria. Also, aflatoxins, zearalenone, and trichothecenes were reported in infant formula samples routinely fed to IYC in Southwest Nigeria. In addition, a 100% occurrence rate of aflatoxin was reported in household processed complementary food samples consumed by IYC in Southwest Nigeria. In developing countries, the contamination rate is worsened by poor agricultural practices, low level of awareness, socioeconomic status, and lack of enforcement of regulatory limits. Mycotoxin exposure assessment has shown that children are most vulnerable to mycotoxins, mostly because of their lower detoxification capacity, rapid growth, and high intake of food and water per kg body weight. It is critical to emphasize the need for raising general knowledge about mycotoxin exposure, incidence, and potential health repercussions in children.

References

- Adejumo, O., Atanda, O., Raiola, A., Somorin, Y., Bandyopadhyay, R., & Ritieni, A. (2013). Correlation between aflatoxin M_1 content of breast milk, dietary exposure to aflatoxin B_1, and socioeconomic status of lactating mothers in Ogun State, Nigeria. *Food and Chemical Toxicology, 56*, 171–177. https://doi.org/10.1016/j.fct.2013.02.027

  Article Google Scholar

- Adeyeye, S. A. (2016). Fungal mycotoxins in foods: A review. *Cogent Food and Agriculture, 2*(1), 1213127. https://doi.org/10.1080/23311932.2016.1213127

  Article Google Scholar

- Alassane-Kpembi, I., Schatzmayr, G., Taranu, I., Marin, D., Puel, O., & Oswald, I. P. (2017). Mycotoxin co-contamination: Methodological aspects and biological relevance of combined toxicity studies. *Critical.*

Review for Food Science and Nutrition, 57, 3489–3507. https://doi.org/10.1080/10408398.2016.1140632

Article **Google Scholar**

- Alegbe, S. D., Yakubu, S. E., Olonitola, S. O., & Mukhtar, M. D. (2017). Assessing aflatoxin M1 levels among lactating mothers' in Damaturu Yobe State, Nigeria. *Bayero Journal of Pure and Applied Sciences, 10*(1), 198–203. https://doi.org/10.4314/bajopas.v10i1.40S

  Article **Google Scholar**

- Alhamoud, Y., Yang, D., Kenston, S. S. F., Liu, G., Liu, L., Zhou, H., & Zhao, J. (2019). Advances in biosensors for the detection of ochratoxin A: Bio-receptors, nanomaterials, and their applications. *Biosensors and Bioelectronics, 141*, 111418. https://doi.org/10.1016/j.bios.2019.111418

  Article **Google Scholar**

- Alshannaq, A., & Yu, J. H. (2017). Occurrence, toxicity, and analysis of major mycotoxins in food. *International Journal of Environmental Research and Public Health, 14*(6), 632. https://doi.org/10.3390/ijerph14060632

  Article **Google Scholar**

- Álvarez, M., Rodríguez, A., Peromingo, B., Núñez, F., & Rodríguez, M. (2020). Enterococcus faecium: A promising protective culture to control growth of ochratoxigenic moulds and mycotoxin production in dry-fermented sausages. *Mycotoxin Research, 36*(2), 137–145. https://doi.org/10.1007/s12550-019-00376-6

  Article **Google Scholar**

- Arce-López, B., Lizarraga, E., Vettorazzi, A., & González-Peñas, E. (2020). Human biomonitoring of mycotoxins in blood, plasma and serum in recent years: A review. *Toxins, 12*(3), 147. https://doi.org/10.3390/toxins12030147

  Article **Google Scholar**

- Atanda, O., Oguntubo, A., Adejumo, O., Ikeorah, J., & Akpan, I. (2007). Aflatoxin M_1 contamination of milk and ice cream in Abeokuta and

Odeda local governments of Ogun State, Nigeria. *Chemosphere, 68*(8), 1455–1458. https://doi.org/10.1016/j.chemosphere.2007.03.038

Article Google Scholar

- Bogalho, F., Duarte, S., Cardoso, M., Almeida, A., Cabeças, R., Lino, C., & Pena, A. (2018). Exposure assessment of Portuguese infants to Aflatoxin M_1 in breast milk and maternal social-demographical and food consumption determinants. *Food Control, 90*, 140–145. https://doi.org/10.1016/j.foodcont.2018.02.043

Article Google Scholar

- Calori-Domingues, M. A., Bernardi, C. M. G., Nardin, M. S., de Souza, G. V., dos Santos, F. G. R., de Abreu Stein, M., da Gloria, E. M., dos Santos Dias, C. T., & de Camargo, A. C. (2016). Co-occurrence and distribution of deoxynivalenol, nivalenol and zearalenone in wheat from Brazil. *Food Additive and Contaminants: Part B Surveillance, 9*, 142–151. https://doi.org/10.1080/19393210.2016.1152598

Article Google Scholar

- Cameron, H. M., & Warwick, G. P. (1977). Primary cancer of the liver in Kenyan children. *British Journal of Cancer, 36*(6), 793–803. https://doi.org/10.1038/bjc.1977.264

Article Google Scholar

- Chilaka, C. A. (2017). *Fusarium* mycotoxins and their modified forms in Nigerian foods: Occurrence and influence of traditional processing methods. Doctoral Thesis, Ghent University, Ghent, Belgium. http://hdl.handle.net/1854/LU-8539914

- Chilaka, A. C., & Mally, A. (2020). Mycotoxin occurrence, exposure and health implications in infants and young children in Sub-Saharan Africa: A review. *Foods, 9*(11), 1585. https://doi.org/10.3390/foods9111585

Article Google Scholar

- Chukwudi, U. P., Kutu, F. R., & Mavengahama, S. (2021). Mycotoxins in maize and implications on food security: A review. *Agricultural Reviews, 42*(1), 1–8. https://doi.org/10.18805/ag.R-140

Article Google Scholar

- Council for Agricultural Science. (2003). *Mycotoxins: Risks in plant, animal, and human systems* (No. 139). Council for Agricultural.

  Google Scholar

- De Ruyck, K., De Boevre, M., Huybrechts, I., & De Saeger, S. (2015). Dietary mycotoxins, co-exposure, and carcinogenesis in humans: Short review. *Mutation Research/Reviews in Mutation Research, 766*, 32–41.

  Article Google Scholar

- Degen, G. (2011). Tools for investigating workplace-related risks from mycotoxin exposure. *World Mycotoxin Journal, 4*(3), 315–327. https://doi.org/10.3920/WMJ2011.1295

  Article Google Scholar

- Ezekiel, C. N., Wilfred, A. A., Dominik, B., Bojan, S., Kolawole, I. A., Oluwawapelumi, A. O., Emmanuel, C. M., Victoria, C. E., Beatrice, M., Chinonso, P., Rudolf, K., Michael, S., Paul, C. T., & Benedikt, W. (2020a). Comprehensive mycotoxin exposure biomonitoring in breastfed and non-exclusively breastfed Nigerian children. *Food and Chemical Toxicology, 128*, 171–178. https://doi.org/10.1016/j.envint.2021.106996

  Article Google Scholar

- Ezekiel, C. N., Oyedele, O. A., Kraak, B., Ayeni, K. I., Sulyok, M., Houbraken, J., & Krska, R. (2020b). Fungal diversity and mycotoxins in low moisture content ready-to-eat foods in Nigeria. *Frontiers in Microbiology, 11*, 615. https://doi.org/10.3389/fmicb.2020.00615

  Article Google Scholar

- Franco, L. T., Petta, T., Rottinghaus, G. E., Bordin, K., Gomes, G. A., Alvito, P., Assunção, R., & Oliveira, C. A. (2019). Assessment of mycotoxin exposure and risk characterization using occurrence data in foods and urinary biomarkers in Brazil. *Food and Chemical Toxicology, 128*, 21–34. https://doi.org/10.1016/j.fct.2019.03.046

  Article Google Scholar

- Gong, Y. Y., Watson, S., & Routledge, M. N. (2016). Aflatoxin exposure and associated human health effects, a review of epidemiological

studies. *Food Safety, 4*(1), 14–27. https://doi.org/10.14252/foodsafetyfscj.2015026

Article **Google Scholar**

- Gratz, S. W., Currie, V., Duncan, G., & Jackson, D. (2019). Multi-mycotoxin exposure assessment in UK children using urinary biomarkers—A pilot survey. *Journal of Agricultural and Food Chemistry, 68*(1), 351–357. https://doi.org/10.1021/acs.jafc.9b03964

  Article **Google Scholar**

- Greeff-Laubscher, M. R., Beukes, I., Marais, G. J., & Jacobs, K. (2020). Mycotoxin production by three different toxigenic fungi genera on formulated abalone feed and the effect of an aquatic environment on fumonisins. *Mycology, 11*(2), 105–117. https://doi.org/10.1080/21501203.2019.1604575

  Article **Google Scholar**

- Hellström, A., Ley, D., Hansen-Pupp, I., Hallberg, B., Löfqvist, C., van Marter, L., van Weissenbruch, M., Ramenghi, L. A., Beardsall, K., Dunger, D., & Hård, A. L. (2016). Insulin-like growth factor 1 has multisystem effects on foetal and preterm infant development. *Acta Paediatrica, 105*(6), 576–586. https://doi.org/10.1111/apa.13350

  Article **Google Scholar**

- Henry, S. H., Bosch, X. F., Bowers, J. C., & Bolger, P. M. (2002). Aflatoxin, hepatitis and worldwide liver cancer risks. In *Proceedings of the American Chemical Society Meeting* (pp. 229–233). https://doi.org/10.1007/978-1-4615-0629-4_24

  Chapter **Google Scholar**

- Hernández, M., Juan-García, A., Moltó, J. C., Mañes, J., & Juan, C. (2021). Evaluation of mycotoxins in infant breast milk and infant food, reviewing the literature data. *Toxins, 13*(8), 535. https://doi.org/10.3390/toxins13080535

  Article **Google Scholar**

- IARC. (1993). Aflatoxins. In *IARC monographs on the evaluation of carcinogenic risks to humans* (Vol. 56, pp. 243–395). IARC.

Google Scholar

- Javed, A., Naeem, I., Benkerroum, N., Riaz, M., Akhtar, S., Ismail, A., et al. (2021). Occurrence and health risk assessment of aflatoxins through intake of eastern herbal medicines collected from four districts of Southern Punjab—Pakistan. *International Journal of Environmental Research and Public Health, 18*(18), 9531. https://doi.org/10.3390/ijerph18189531

  Article Google Scholar

- JECFA. (2008). Safety evaluation of certain food additives and contaminants. In *Prepared by the Sixty-Eighth Meeting of the Joint FAO/WHO Expert Committee on Food Additives* (*JECFA*). Food Agric. Organ. United Nations, World Health Organ. IPCS-Int. Program. Chem. Safety, WHO Food Addit. Ser. No. 59; World Health Organ. Available online: https://apps.who.int/iris/bitstream/handle/10665/198360/9789240694897_eng.pdf?sequence=1. Accessed 22 July 2021.

- Kew, M. C. (2015). Epidemiology of hepatocellular carcinoma in sub-Saharan Africa. *Annals of Hepatology, 12*(2), 173–182. PMID: 23396727.

  Article Google Scholar

- Kew, M. C., Hodkinson, J., Paterson, A. C., & Song, E. (1982). Hepatitis-B virus infection in black children with hepatocellular carcinoma. *Journal of Medical Virology, 9*(3), 201–207. https://doi.org/10.1002/jmv.1890090307

  Article Google Scholar

- Khanna, R., & Verma, S. K. (2018). Pediatric hepatocellular carcinoma. *World Journal of Gastroenterology, 24*, 3980–3999. https://doi.org/10.3748/wjg.v24.i35.3980

  Article Google Scholar

- Luttfullah, G., & Hussain, A. (2011). Studies on contamination level of aflatoxins in some dried fruits and nuts of Pakistan. *Food Control, 22*(3–4), 426–429.

  Article Google Scholar

- Mahato, D. K., Lee, K. E., Kamle, M., Devi, S., Dewangan, K. N., Kumar, P., & Kang, S. G. (2019). Aflatoxins in food and feed: An overview on prevalence, detection and control strategies. *Frontiers in Microbiology, 1*, 2266. https://doi.org/10.3389/fmicb.2019.02266

  Article Google Scholar

- Mandy, M., & Nyirenda, M. (2018). Developmental origins of health and disease: The relevance to developing nations. *International Health, 10*(2), 66–70. https://doi.org/10.1093/inthealth/ihy006

  Article Google Scholar

- Marasas, W. F. (2001). Discovery and occurrence of the fumonisins: A historical perspective. *Environmental Health Perspectives, 109*(2), 239–243. https://doi.org/10.1289/ehp.01109s2239

  Article Google Scholar

- Marin, S., Ramos, A. J., Cano-Sancho, G., & Sanchis, V. (2013). Mycotoxins: Occurrence, toxicology, and exposure assessment. *Food Chemistry of Toxicology, 60*, 218–237. https://doi.org/10.1016/j.fct.2013.07.047

  Article Google Scholar

- Marin-Kuan, M., Cavin, C., Delatour, T., & Schilter, B. (2008). Ochratoxin A carcinogenicity involves a complex network of epigenetic mechanisms. *Toxicon, 52*(2), 195–202. https://doi.org/10.1016/j.toxicon.2008.04.166

  Article Google Scholar

- McMillan, A., Renaud, J. B., Burgess, K. M., Orimadegun, A. E., Akinyinka, O. O., Allen, S. J., Miller, J. D., Reid, G., Sumarah, M. W., & Sumarah, M. W. (2018). Aflatoxin exposure in Nigerian children with severe acute malnutrition. *Food and Chemical Toxicology, 111*, 356–362. https://doi.org/10.1016/j.fct.2017.11.030

  Article Google Scholar

- Meucci, V., Razzuoli, E., Soldani, G., & Massart, F. (2010). Mycotoxin detection in infant formula milks in Italy. *Food Additives and*

Contaminant Part A, 27, 64–71. https://doi.org/10.1080/02652030903207201

Article **Google Scholar**

- Milani, J. M. (2013). Ecological conditions affecting mycotoxin production in cereals: A review. *Veterinární Medicína, 58*(8), 405–411.

  Article **Google Scholar**

- Mollay, C., Kassim, N., Stoltzfus, R., & Kimanya, M. (2020). Childhood dietary exposure of aflatoxins and fumonisins in Tanzania: A review. *Cogent Food and Agriculture, 6*(1), 1859047. https://doi.org/10.1080/23311932.2020.1859047

  Article **Google Scholar**

- Morris, G., Puri, B. K., Frye, R. E., & Maes, M. (2018). The putative role of environmental mercury in the pathogenesis and pathophysiology of autism spectrum disorders and subtypes. *Molecular Neurobiology, 55*, 4834–4856. https://doi.org/10.1007/s12035-017-0692-2

  Article **Google Scholar**

- Ojuri, O. T., Ezekiel, C. N., Eskola, M. K., Šarkanj, B., Babalola, A. D., Sulyok, M., et al. (2018). Mycotoxin co-exposures in infants and young children consuming household-and industrially-processed complementary foods in Nigeria and risk management advice. *Food Control, 98*, 312–322. https://doi.org/10.1016/j.foodcont.2018.11.049

  Article **Google Scholar**

- Pascari, X., Marín, S., Ramos, A. J., Molino, F., & Sanchis, V. (2019). Deoxynivalenol in cereal-based baby food production process. A review. *Food Control, 99*, 11–20. https://doi.org/10.1016/j.foodcont.2018.12.014

  Article **Google Scholar**

- Piacentini, K. C., Larissa, S. F., Mariana, P., Bruno, G., & Liliana, O. R. (2019). Mycotoxin contamination in cereal-based baby foods. *Current Opinion in Food Science, 30*(1), 73–78. https://doi.org/10.1016/j.cofs.2019.06.008

Article **Google Scholar**

- Salim, A., Nadri, S., Hosseini, M. J., Rokni-Zadeh, H., & Mohseni, M. (2020). Protective effect of probiotic *Lactobacillus acidophilus* against the toxicity of beauvericin mycotoxin on the Caco-2 cell line. *Toxicon, 185*, 184–187. https://doi.org/10.1016/j.toxicon.2020.07.003

Article **Google Scholar**

- Sarmast, E., Fallah, A. A., Jafari, T., & Khaneghah, A. M. (2021). Occurrence and fate of mycotoxins in cereals and cereal-based products: A narrative review of systematic reviews and meta-analyses studies. *Current Opinion in Food Science, 39*, 68–75. https://doi.org/10.1016/j.cofs.2020.12.013

Article **Google Scholar**

- Schothorst, R. C., & van Egmond, H. P. (2004). Report from SCOOP task 3.2. 10 “collection of occurrence data of Fusarium toxins in food and assessment of dietary intake by the population of EU member states”: Subtask: Trichothecenes. *Toxicology Letters, 153*(1), 133–143. https://doi.org/10.1016/j.toxlet.2004.04.045

Article **Google Scholar**

- Sengling Cebin Coppa, C. F., Mousavi Khaneghah, A., Alvito, P., Assunção, R., Martins, C., Eş, I., Gonçalves, B. L., Valganon de Neeff, D., Sant’Ana, A. S., Corassin, C. H., & Oliveira, C. A. F. (2019). Occurrence of mycotoxins in breast milk, fruit products and cereal-based infant formula: A review. *Trends in Food Science and Technology, 92*(1), 81–93. https://doi.org/10.1016/j.tifs.2019.08.014

Article **Google Scholar**

- Smith, L. E., Prendergast, A. J., Turner, P. C., Mbuya, M. N., Mutasa, K., Kembo, G., & Stoltzfus, R. J. (2015). The potential role of mycotoxins as a contributor to stunting in the SHINE trial. *Clinical Infectious Diseases, 61*(7), 733–737. https://doi.org/10.1093/cid/civ849

Article **Google Scholar**

- Tesfamariam, K., De Boevre, M., Kolsteren, P., Belachew, T., Mesfin, A., De Saeger, S., & Lachat, C. (2020). Dietary mycotoxins exposure and child growth, immune system, morbidity, and mortality: A systematic

literature review. *Critical Reviews in Food Science and Nutrition, 60*(19), 3321–3341. https://doi.org/10.1080/10408398.2019.1685455

Article Google Scholar

- Tshalibe, R. S. (2019). The effect of mycotoxin exposure on the growth of infants and young children in deep rural areas of the Eastern Cape Province, South Africa. Doctoral dissertation, North-West University (South-Africa). Potchefstroom+ Campus.

  Google Scholar

- Ware, L. Y., Durand, N., Nikiema, P. A., Alter, P., Fontana, A., Montet, D., & Barro, N. (2017). Occurrence of mycotoxins in commercial infant formulas locally produced in Ouagadougou (Burkina Faso). *Food Control, 73*, 518–523. https://doi.org/10.1016/j.foodcont.2016.08.047

  Article Google Scholar

- Westland, S., & Crawley, H. (2018). *Fruit and vegetable-based purées in pouches for infants and young children*. First Steps Nutrition Trust. ISBN e-book 978-1-908924-63-6.

  Google Scholar

- Wokorach, G., Landschoot, S., Anena, J., Audenaert, K., Echodu, R., & Haesaert, G. (2021). Mycotoxin profile of staple grains in northern Uganda: Understanding the level of human exposure and potential risks. *Food Control, 122*, 107813. https://doi.org/10.1016/j.foodcont.2020.107813

  Article Google Scholar

- Yip, K. Y., Wan, M. L. Y., Wong, A. S. T., Korach, K. S., & El-Nezami, H. (2017). Combined low-dose zearalenone and aflatoxin B1 on cell growth and cell-cycle progression in breast cancer MCF-7 cells. *Toxicology Letters, 281*, 139–151. https://doi.org/10.1016/j.toxlet.2017.09.022

  Article Google Scholar

- Zhang, X., Li, G., Wu, D., Liu, J., & Wu, Y. (2020). Recent advances on emerging nanomaterials for controlling the mycotoxin contamination: From detection to elimination. *Food Frontiers, 1*(4), 60–381. https://doi.org/10.3390/ijerph14060632

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