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Perspective: Talking About Mycotoxins

John F. Leslie[1*†] *and Jeffery B. Morris*[2†]

[1] *Department of Plant Pathology, Kansas State University, Manhattan, KS, United States,* [2] *Division of Communications and Marketing, Kansas State University, Manhattan, KS, United States*

Talking about mycotoxins amongst scientists often is easy, as the potential consequences are viewed from a perspective that breeds familiarity with potentially serious health problems. Translating objective results into information that can be used profitably by non-scientists is a task for which scientists often are poorly equipped. Experts in communications also have a difficult time with the mycotoxin issue because they lack the technical background to understand the causes, consequences and potential remedies associated with mycotoxin contamination. Our objective is to provide a framework for both scientists and communicators as they think about how to convey potentially scary food safety information to the public without causing a panic in the process. The major concerns people have about mycotoxin contamination are health- and financial-related, which makes addressing these concerns critical. Stakeholders along the food chain have different backgrounds and interests and should be identified and grouped for effective communications, as "one size fits all" is not a good strategy. Similarly, distinguishing time-sensitive, e.g., crisis, communications from those that are time agnostic, e.g., background, education, and public awareness information, are crucial for either to have the desired impact. We provide some general guidelines and thinking/talking points to enable scientists to work with their counterparts in communications as they develop plans to increase food safety through effective communications regarding potential health and financial threats that can result from mycotoxin contamination.

Keywords: aflatoxin, communications, crisis, financial risks, food safety, health risks, public awareness, trusted relationships

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***Correspondence:**
John F. Leslie
jfl@ksu.edu

†ORCID:
John F. Leslie
orcid.org/0000-0002-6486-6992
Jeffery B. Morris
orcid.org/0000-0003-1467-6397

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INTRODUCTION: THE GENERAL PLAYING FIELD

Mycotoxins in developed countries are a significant food safety issue that is reasonably well controlled (World Health Organization, 2018). Regulatory checks at levels from grain elevators to in-house company checks usually identify contaminated lots and ensure that mycotoxins in both human foods and animal feeds do not exceed regulatory guidelines. Mycotoxin-related problems can be front page news, though such as the contamination of dog food (Becker, 2013).

In developing countries, however, mycotoxins are a persistent threat to financial well-being and to the health of humans and domesticated animals, and multiple deaths due to mycotoxin contamination of essential foodstuffs are well known, e.g., Nyikal et al. (2004). Spectacular headlines can be found in some local newspapers as well, for example: "Busted: How Rotten Tomatoes

Cause Cancer,"[1] or "Contaminated WFP Food Blamed for Four Deaths in Uganda"[2]. In some cases, research organization publicity releases, e.g., from the International Livestock Research Institute (ILRI) on aflatoxin M_1 levels in milk in Addis Ababa (Szonyi et al., 2015) based on journal article reports (Gizachew et al., 2015), can be spun in ways that damage the credibility of the research organization, the government in which the country occurred and the industry for which the research was done. Marketing and business models established on ridding a particular product(s) of mycotoxins also occur: "MilkLane: A Dairy Start-Up Launches Toxin and Antibiotic Safe Milk"[3]. Although mycotoxins can pose both financial and health problems, the first page newspaper headlines almost always focus on health, rather than financial issues. In addition, food supply contaminants such as mycotoxins, may represent a political threat to the existing power structure, as the inability to transparently address public health and the availability of safe food can cause lack of trust and unrest, e.g., "Bad Maize Could Find Its Way Into Your Plate Amid Cover-Up Claims"[4].

There are many ways to "spin" a news story. In some cases, the spectacular headline results in near panic amongst the affected population, as happened in Ethiopia in response to the ILRI release. In others though, careful thought is given to the message being delivered with the goal of informing without inflaming. Scientists often provide the raw information used for both types of headlines. Through careful work with colleagues in the field of communications, however, incendiary rhetoric can be minimized and effective solutions become the message of choice. Our goal is to help both scientists and communicators broaden their knowledge and thinking about how information on mycotoxins is passed from scientific experts to the general public, to help identify the variety of target audiences, and to think about how effective messages for one group might not be effective for others.

[1]www.vanguardngr.com/2019/02/busted-how-rotten-tomatoes-cause-cancer/ (accessed December 02, 2019).
[2]www.iol.co.za/news/africa/contaminated-wfp-food-blamed-for-four-deaths-in-uganda-24459290 (accessed December 02, 2019).
[3]www.bignewsnetwork.com/news/261149217/milklane-a-dairy-start-up-launches-toxin-and-antibiotic-safe-milk (accessed December 02, 2019).
[4]www.standardmedia.co.ke/article/2001303077/cover-up-bad-maize-may-land-on-your-plate (accessed December 02, 2019).

GETTING OUT OF THE DISCIPLINARY SILO

Academics often view their department, discipline, etc. as a silo with good communication within the silo and much less communication with those in other silos. Mycotoxins are inherently an interdisciplinary problem, with experts in diverse fields such as plant pathology, agronomy, toxicology, chemistry, economics, human and veterinary medicine, public health, and trade all playing a role in addressing the associated problems. Just getting these technical experts physically in the same room and intellectually on the same page can be a formidable challenge.

The technical experts, the general populace and the communicators who share information amongst groups often are found in distinct silos as well. When talking about mycotoxins in a general sense, there often is a gap between what scientists discover and their ability to communicate with clarity, timeliness and completeness to those who may be affected. The lack of a robust proven system of distributing information regarding food contaminants increases risk. The best way to address mycotoxin contamination is to bridge the gap between responsible institutions, trusted scientists and communicators. Typical barriers to effective communications (**Figure 1**) may include the complex tribal language of science, the need for instantaneous communications to feed a voracious news cycle, and the opacity that comes from dealing with multiple governmental and non-governmental entities. The desired state occurs when the scientific community, public authorities and

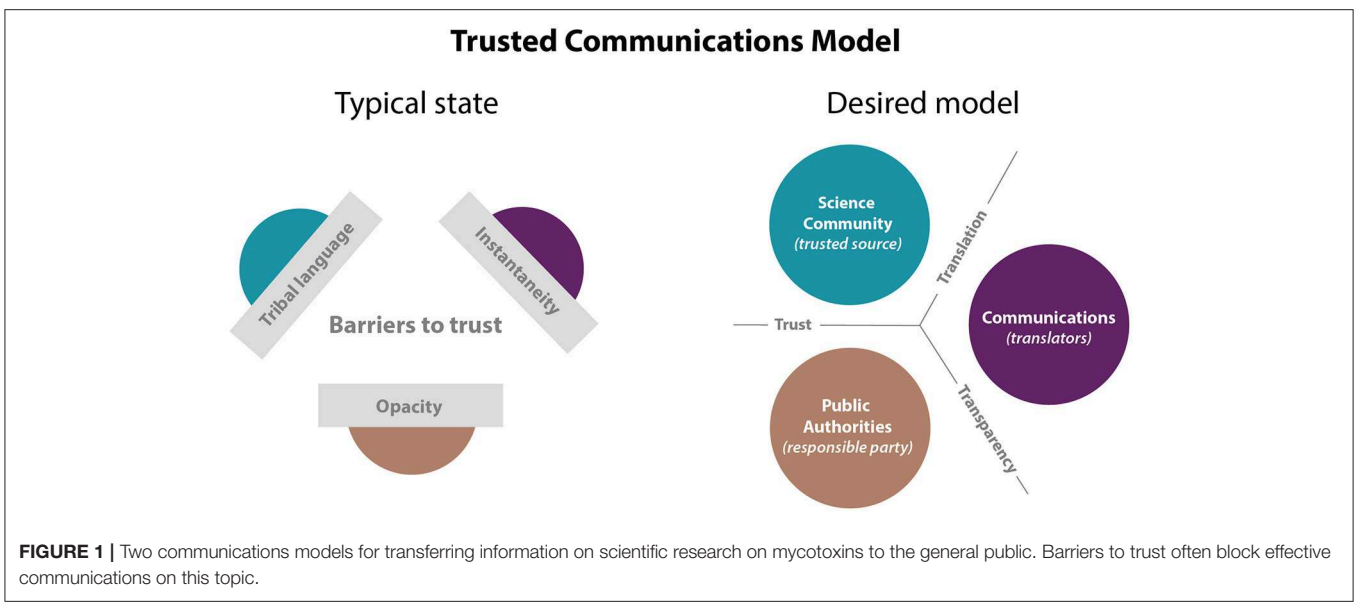

FIGURE 1 | Two communications models for transferring information on scientific research on mycotoxins to the general public. Barriers to trust often block effective communications on this topic.

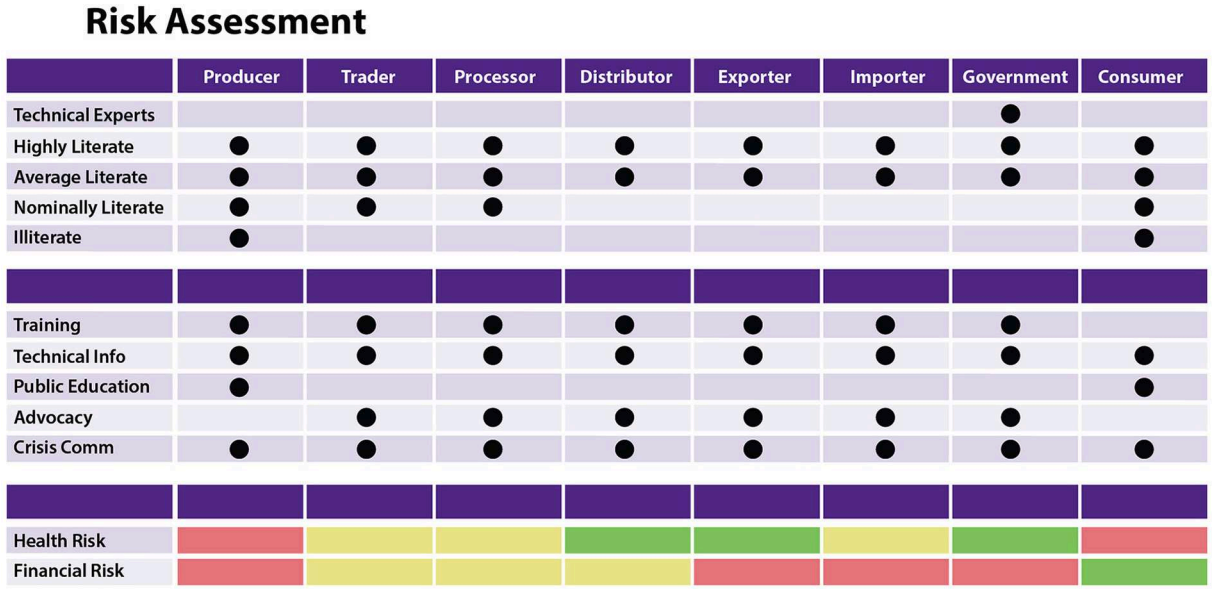

FIGURE 2 | Types of education/training on mycotoxins needed by food value chain stakeholders. The top portion of the figure subdivides different stakeholders by their general literacy and expertise in mycotoxins. Likely classes in each stakeholder group are denoted by a bullet (•). The middle portion of the figure denotes types of information and communications generally needed within a stakeholder group. The bottom portion of the figure denotes risks faced by various stakeholders based on their location in the value chain. These risks are denoted with green for low, yellow for intermediate and red for high.

communicators develop the trust and transparency necessary to responsibly translate research findings for use by the general public.

Once technical scientific results are published, there needs to be a way to talk about them and to responsibly let people know of the potential consequences. Broader distribution of such information is generally considered a prudent step, but determining who bears the responsibility for such distribution generally is not. Most scientists, for example, stop at the publication of results in a technical journal. The crucial next step of translating the scientific results into a language that can be widely understood by the general public or those working in the value chain is left, often by default, to institutional public relations staff who have little or no understanding of the scientific results.

Compounding the common disconnect between science and public relations is the often unspoken problem of ownership of the problem. Government entities and non-governmental organizations (NGOs) may have key roles in helping to ensure a safe food supply. Companies and distributors have clear financial risks. The medical community must address health issues arising from a populace exposed to mycotoxins. For example, at a recent strategic planning conference on mycotoxin issues in Nepal, the participating individuals were much more concerned about the potential health hazards posed by mycotoxins to them and to their families than they were the potential financial problems. Health, agriculture and trade sectors must work together to own the problem and to manage mycotoxin contamination and communication issues. Without clearly defined roles and responsibilities for all three sectors prior to a crisis situation, management of the crisis ranges from difficult to nearly impossible and damage to reputations, health and finances all but certain. Thus, before plans for crisis management can be put in place, it is essential to understand the target audiences and the implications of the health and financial risks that these audiences may be trying to manage.

TARGET GROUP CONSIDERATIONS

Effective communications create bridges of trusted communications between stakeholders. There are many stakeholders in the value chain for a food or feed that might be contaminated with mycotoxins (**Figure 2**). The major risks for these stakeholders usually are either health or financial, but these risks are not distributed uniformly across the value chain or its participants, which means that the actions and messages needed vary as well.

The variation in types of risk by stakeholder group demonstrates the need for a matrixed targeted communications plan to communicate scientific findings. The level of technical understanding and literacy is not consistent between, or even within, significant audiences, with the lowest levels of literacy often found amongst those with the greatest health risk. Communication challenges can be directly related to the regressive nature of this problem. The population closest to the problem, e.g., producers, may have the greatest exposure to the health and financial risks posed by mycotoxins. This population commonly is located in a rural area where communications channels are the least robust.

To address potential problems with mycotoxin contaminations, communicators must survey the available channels of communications and develop plans based on the

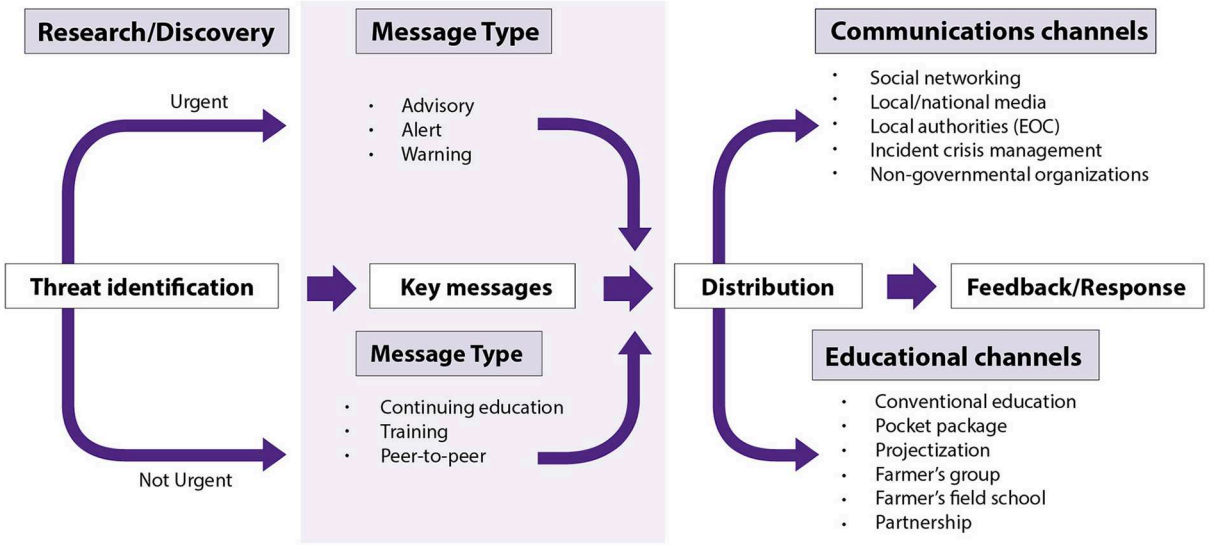

FIGURE 3 | Time-sensitive and time-agnostic paths for communicating about food safety (or other) threats from scientists to the general public.

reality on the ground. "One-size-fits-all" approaches to crisis communications are inadequate for the needs of scientists, the stakeholders along the value chain, and the general public. The time to build trust, establish linkages, identify communication channels and develop plans is prior to when scientists discover a potential threat. Not having a crisis communications plan in place can be a very different crisis all of its own.

Another layer of complexity stems from the dual health and financial threats mycotoxins bring. Health threats, especially if contamination levels are sufficiently high, can include death of humans and domesticated animals that consume the contaminated food and can generate panic-driven headlines and social media posts that quickly go viral. Chronic exposure to sub-acute levels of mycotoxins results in very different health threats. For example, long-term consumption of maize contaminated with non-lethal levels of aflatoxins and fumonisins can lead to cancer, reduced immune system function, birth defects in newborns, and stunted development of children under the age of five (Kumar et al., 2016; Kamle et al., 2019). Milk often is promoted as a food to improve health and nutrition of children in developing countries. Contamination of milk with aflatoxin M_1 can have health effects similar to those resulting from consuming cereals contaminated with sub-acute levels of other aflatoxins, with respect to carcinogenicity and immunotoxigenicity, however, the amount of aflatoxin M_1 required to have a particular impact usually is larger than the amount of aflatoxin B_1 required for the same impact (Neal et al., 1998; Marchese et al., 2018). However, reports of contamination of cereals are viewed differently than are reports of contamination of milk. When milk is found to be contaminated then questions are raised about the health of children and carefully crafted nutrition programs of which milk often is a critical component with the dairy industry in the region sometimes taking dramatic financial losses. Mismanagement of communications here can lead to massive financial damage and to loss of credibility for quite unrelated programs and the entities that promote them.

In some cases financial risks may dominate. Ochratoxin A exemplifies this scenario. This toxin is found in a variety of plant products, including raisins, nuts, coffee, tea, spices, cacao, and dried fruits (Petzinger and Ziegler, 2000). These foods are not a major part of most diets in less-developed countries, so the apparent health risk of long-term consumption is less-well understood (Malir et al., 2016). International quarantine regulations, however, bar these commodities, if they are contaminated, from international markets and can hand staggering financial losses to stakeholders all along the value chain that produces and markets a contaminated product. Each of these commodities has a different value chain and requires a different, targeted approach for effective communications, as well as scientific results that are unique to the commodity and its production chain.

TIME-SENSITIVE AND TIME-AGNOSTIC COMMUNICATIONS

During the threat identification phase of a potential mycotoxin issue, it is important to distinguish between time sensitive and time agnostic information. Financial and health concerns may drive this distinction, as both bring risk.

For a time-sensitive, and particularly an acute crisis, situation involving public health, the message modality follows a traditional crisis communications pattern (**Figure 3**). A hierarchy of messages is prepared with various levels of immediacy and clearly defined actions. Communications channels are chosen for their timeliness, reach, and accuracy. National and local authorities may establish emergency operations centers and create centralized sources of information to be tapped as necessary. The communicators' role is to create tailored

messages for each audience and to manage their distribution. The communicators must have access to research findings and scientists as the messages are created. No matter how much care is taken, rumors and inaccurate information will spread rapidly, assisted by the non-curated world of social media. Feedback loops are essential to collect questions and to identify inaccurate information that requires immediate response. Pre-established relationships between government officials, scientists, and communicators are essential for managing the information flow. Once a crisis hits, there is no time to establish the relationships required for the information to flow.

Another important consideration is how and when scientists and communicators can work together. Face-to-face is not always possible in a crisis, and some methods, e.g., video conferencing, require access to broadband internet service. Typical communications tools, e.g., e-mail, often are inadequate in a crisis due to their asynchronous nature and queuing characteristics. We have learned this lesson firsthand while conducting practice drills for messaging about a potential crisis associated with Foot and Mouth Disease, which will be a major focus of the National Bio- and Agro-Defense Facility (NBAF) soon to open in Manhattan, Kansas. Efforts to communicate foundered unless communications went through a central center to which all participants were connected in real-time (and preferably all located physically at the same location). Knowing which tools to use when, developing messages targeted to that format, and then practicing the skills are all crucial readiness activities.

Not all communications need be time-sensitive crisis-type communications. Threat identification does not always lead to a crisis, if scientists, communicators and authorities have been working together to transmit information in a time-agnostic manner through established educational channels (**Figure 3**). In such cases, the scientific results are circulated through continuing education, extension networks and peer-to-peer channels. These efforts can involve many players—government entities, NGOs and external partners, such as United States Agency for International Development (USAID) and other donors—although the best practices used by all should be similar. Again, established trusted relationships between scientists and communicators are needed to develop messages and craft strategies. Clear delineation of the channels to the target audience(s) is important and may be time-consuming to ensure that all essential stakeholders are effectively engaged. At this stage, educating educators becomes an important part of the process as well, and an additional set of trusted relationships must be developed. Fortunately, such relationships often already exist at most US Land Grant universities, which have both explicit research and outreach missions. Feedback loops and follow-up responses are still needed, however, to get accurate, timely information to those who need it most. Word-of-mouth through formal and informal networks remains one of the most effective communications channels in developing countries. Feeding trusted, accurate information to that channel requires forethought, planning and careful consideration of the various stakeholders and differences in their capacity to receive and share the information provided to them.

DISCUSSION: WHERE DO WE GO FROM HERE?

A critical question is, "How do we get people together to talk about mycotoxins in ways that avoid a crisis situation?" We see two somewhat different approaches to answering this question. One uses existing, organic communications channels, the other creates a more formalized communications network and processes. Given the networks that exist in many developing countries, a hybrid approach may be the most practical, which consists of leveraging existing relationships into a more intentional, deliberate structure.

The first task is to identify who needs to be at the table and ascertain the motivation or incentive for them to participate. Scientists may be motivated by the need to demonstrate impact as part of a grant requirement. Government ministries may have statutory or regulatory obligations to fulfill. NGOs may have a mission or mandate. Communicators continuously seek credible sources and accurate information in a timely basis. A successful structure will involve and motivate all of the key players.

Starting with the scientists often is the easiest. Most scientists participate in networks with their colleagues that begin when individuals with mutual self-interests find each other and then mature into networks of scientists whose work is highly trusted across the network and readily shared among colleagues. A network of this type is needed as a foundational building block for any risk communications plan. These networks may have broad geographic, perhaps even global, membership. For time-sensitive communications, the foundational network must have members who reside primarily in the country or region of concern. For time-agnostic communications, the need for geographic proximity is less important, although members of the network still need to be meeting with each other on a regular basis.

With the scientists settled, the next task is to analyze the governmental and NGO structures to identify an institution that can convene scientists and communicators when a mycotoxin issue arises. Several entities may be involved, but one must be identified as the lead. The correct institution will foster relationships between the media outlets they depend on as trusted partners and the scientific community to accurately convey science-based information to the general public.

The final task is to identify the communicators and media outlets that are essential to reach the target audiences. Communicators often are not equipped to understand the language of science, or to properly interpret the level of risk involved. Some communicators have established networks of trusted sources that they rely on, but there is a "language barrier" separating published research results and conclusions from public information. The time to identify the right translators and bring them to the table to build trusted relationships is prior to a crisis.

A somewhat deliberate approach is to sponsor "network initiation" events, which bring scientists, government officials, and communicators together in a structured way to begin building relationships and establishing the trust needed for effective planning and crisis management. There are distinct phases this process will go through, beginning with relationship

building, communications planning and eventually, more formal exercises to build capacity. Each group plays a role in mentoring other groups and creating common language platforms.

Models already exist for this type of cooperation and there are established best practices that can be applied to planning. At Kansas State University, for example, we work closely with federal, state, and local agencies to develop and maintain crisis communications plans in preparation for the opening of the National Bio- and Agro-defense Facility. This Biosecurity Level IV facility begins full operations in 2021 and there already have been multiple training and planning exercises to prepare for potential threats to the food supply. Each time a workshop or exercise is held, new lessons are learned and incorporated into the plan. Meetings are held at regular intervals to refresh protocols and reinforce relationships. Scientists, public officials, and professional communicators all participate and bring their perspectives to the table. The regular meetings enable development of trusted communications under non-stress conditions and let formal networks evolve into the organic networks that respond most effectively to crisis situations.

In summary, talking about mycotoxins occurs at multiple levels that range from sophisticated experimental analyses to day-to-day conversations about what is for dinner this evening. This conversation typifies many food safety conversations, but the health stakes are high with consequences such as cancer, birth defects and death going far beyond the normal food safety fears of some form of abdominal distress. Mycotoxins as a food safety issue have existed for millennia, e.g., Schoental (1994) and Lee (2009), although their first formal chemical characterizations did not occur until the 1960s (Nesbitt et al., 1962). Scientists and communicators share joint responsibilities for informing the general public and the stakeholders along a commodity value chain of the risks that mycotoxins may pose and effective ways of dealing with them. In the end, the ultimate goal of building risk communications capabilities is to show impact from scientific research without fomenting a crisis.

DATA AVAILABILITY STATEMENT

The datasets generated for this study will not be made publicly available. There are no data sets to share for this Perspectives article.

AUTHOR CONTRIBUTIONS

JL and JM wrote portions of the manuscript and edited all of the manuscript. JL prepared the final draft and submitted the manuscript. JM prepared the figures.

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REFERENCES

Becker, K. (2013). Ditch aflatoxin-contaminated pet food now – it can be deadly to your pets. *Healthy Pets Newsletter* 2013, 04-03. Available online at: healthypets.mercola.com/sites/healthypets/archive/2013/04/03/aflatoxin-contaminated-dog-food.aspx

Gizachew, D., Szonyi, B., Tegegne, A., Hanson, J., and Grace, D. (2015). Aflatoxin contamination of milk and dairy feeds in the Greater Addis Ababa milkshed, Ethiopia. *Food Control* 59, 773–779. doi: 10.1016/j.foodcont.2015.06.060

Kamle, M., Mahato, D. K., Devi, S., Lee, K. E., Kang, S. G., and Kumar, P. (2019). Fumonisins: impact on agriculture, food, and human health and their management strategies. *Toxins* 11:328. doi: 10.3390/toxins11060328

Kumar, P., Mahato, D. K., Kamle, M., Mohanta, T. K., and Kang, S. G. (2016). Aflatoxins: a global concern for food safety, human health and their management. *Front. Microbiol.* 7:2170. doi: 10.3389/fmicb.2016.02170

Lee, M. R. (2009). The history of ergot of rye (*Claviceps purpurea*) I: from antiquity to 1900. *J R Coll Phys.* 39:179–184. doi: 10.4997/JRCPE.2009.416

Malir, F., Ostry, V., Pfohl-Leszkowicz, A., Malir, J., and Toman, J. (2016). Ochratoxin A: 50 years of research. *Toxins* 8:191. doi: 10.3390/toxins8070191

Marchese, S., Polo, A., Ariano, A., Velotto, S., Costantini, S., and Severino, L. (2018). Aflatoxins B_1 and M_1: biological properties and their involvement in cancer development. *Toxins* 10:214. doi: 10.3390/toxins10060214

Neal, G. E., Eaton, D. L., Judah, D. J., and Verma, A. (1998). Metabolism and toxicity of aflatoxins M_1 and B_1 in human-derived *in vitro* systems. *Toxicol. Appl. Pharmacol.* 151, 152–158. doi: 10.1006/taap.1998.8440

Nesbitt, B. F., O'Kelly, J., Sargeant, K., and Sheridan, A. (1962). Toxic metabolites of *Aspergillus flavus*. *Nature* 195, 1062–1063. doi: 10.1038/1951062a0

Nyikal, J., Misore, A., Nzioka, C., Njuguna, C., Muchiri, E., Njau, J., et al. (2004). Outbreak of aflatoxin poisoning – Eastern and Central Provinces, Kenya, January-July 2004. *Morb. Mortal. Wkly. Rep.* 53, 790–793. Available online at: https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5334a4.htm (accessed December 02, 2019).

Petzinger, E., and Ziegler, K. (2000). Ochratoxin A from a toxicological perspective. *J. Vet. Pharmacol. Ther.* 23, 91–98. doi: 10.1046/j.1365-2885.2000.00244.x

Schoental, R. (1994). Mycotoxins in food and the plague of Athens. *J. Nutr. Med.* 4, 83–85. doi: 10.3109/13590849409034541

Szonyi, B., Gizachew, D., Tegenge, A., Hanson, J., and Grace, D. (2015). Aflatoxin contamination of milk and feeds in the greater Addis Ababa milk shed in Ethiopia. *ILRI Research Brief No. 46*. Available online at: www.core.ac.uk/download/pdf/132677303.pdf (accessed December 02, 2019).

World Health Organization (2018). *Aflatoxins*. Food Safety Digest Ref no.: WHO/NHM/FOS/RAM/18.1. Available online at: www.who.int/foodsafety/FSDigest_Aflatoxins_EN.pdf (accessed December 02, 2019).

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.