

Addressing Mycotoxin Exposure across Village Food Systems in Rural India

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Fungal toxins (mycotoxins) accumulate in a range of food commodities and are implicated in numerous human and livestock diseases, such as cancer, cirrhosis, immunological deficiencies, and others. Additionally, a growing body of evidence suggests that these toxins play a role in adverse child growth and development, which can have lasting impacts on the health and productivity of affected individuals and their communities.

Studies from across India have demonstrated that mycotoxins of public health and economic relevance are widespread. In the Indian context, these toxins are associated with a broad range of crops, particularly, groundnuts, maize, rice, sorghum/millet, wheat, chiles, and others.

Unlike in highly developed commercial contexts, in which grain products are extensively scrutinized for quality, smallholder-dominated food systems—such as those in India—often lack the capacity to ensure that products entering the market or pantry are sufficiently free of harmful environmental toxins. To adequately combat the mycotoxin burden in India’s rapidly developing agriculture sector, village food systems must be reinforced with the resources necessary to meet regulatory and societal needs.

Mycotoxins in village food systems: A complex problem

The bulk of global mycotoxins research in smallholder food systems has focused on sub-Saharan Africa, where the major staple foods (such as maize and groundnuts) are highly susceptible to mycotoxin accumulation, specifically, aflatoxin, a class of potent carcinogenic toxins produced

by *Aspergillus flavus* and related fungi. In this context, the level of mycotoxin exposure can be quite high, sometimes resulting in public health crises. Because these outbreaks are often linked to the abundance of maize and groundnuts in these food systems, the source of toxins is clear, and the crops targeted for intervention are straightforward.

In India, however, maize and groundnuts play a relatively small part in most diets, and the major staples on the subcontinent (rice, wheat, pulses, sorghum, millets, etc.) generally accumulate toxins at lower levels. The resulting toxin burden is perhaps more moderate than in African communities, but the dispersion of contamination across a greater diversity of products in the food system poses a substantial challenge for risk assessment and intervention (Figure 1).

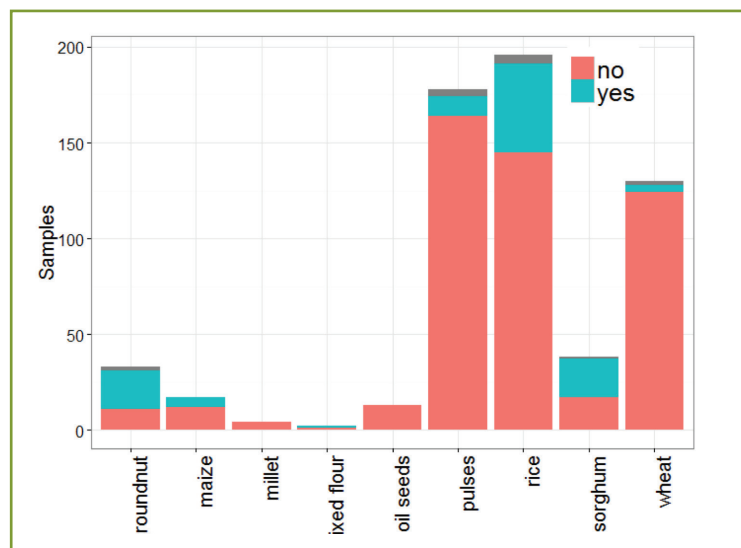


Figure 1. Proportion of household-derived food samples that were contaminated with aflatoxin B1 (> 1 ppb) across a diverse range of commodities. Source: TCI grain surveys.

Although the level of contamination found in Indian food systems is relatively low, our evidence suggests that there may be prolonged exposure to low or moderate doses of toxins in Indian communities, as a result of daily intake of rice, groundnuts, sorghum, and other less susceptible grains that are common in local diets. The health implications of prolonged low-dose exposure in humans are not known, but it is possible (as evidenced in livestock feeding studies and other mammalian systems) that such exposure can lead to adverse nutritional and immunological outcomes and chronic disease.

The Tata-Cornell Institute for Agriculture and Nutrition's (TCI's) 2016 preliminary survey of mycotoxin risk in four districts across four states—Maharajganj (Uttar Pradesh), Munger (Bihar), Kandhamal (Odisha), and Mahabubnagar (Telangana)—shed light on the dynamic nature of mycotoxin risk in India (Figure 2). The survey process engaged respondents in questionnaire-guided interviews, focus group discussions, and participatory resource-mapping exercises, with the objective of identifying key determinants of mycotoxin exposure.

In addition to the survey, we collected food samples from each site to be analyzed for aflatoxin B1 contamination in a laboratory. Samples were

drawn from several nodes of the food system (namely households, marketplaces, and the Public Distribution System [PDS] ration shops) to determine whether the frequency or amount of contamination varied across different food sources.

Food source as a determinant of risk

To link mycotoxin risk in household-derived samples with particular nodes of local food value chains, we collected information about how each food item was procured by the household. In Uttar Pradesh (UP) and Bihar, subsistence agriculture was widely practiced. In contrast, villages in Mahabubnagar had a cash crop-based smallholder economy, where households were reliant on the marketplace for much of their food needs. In Odisha, households were also more reliant on marketplace-derived food items than in UP and Bihar, but this was largely due to lower agricultural productivity. Therefore, marketplace-derived samples were nearly equal in abundance to those produced on respondents' own farms. Food items procured through the PDS, a subsidy program of the Government of India, were prevalent in each location to varying degrees.

Although we did not observe any statistically significant relationships between commodity source and mycotoxin contamination, the preliminary survey brought to light several valuable insights regarding the risk associated with the various origins of food commodities. For example, it is notable that the items procured through the PDS were rarely contaminated with detectable aflatoxins. This is likely attributable to the regulatory scrutiny underpinning this system, and also to the smaller quantities/shorter storage times associated with subsidized grain rations. Similarly, we found that marketplace-derived samples were often less toxic than homegrown produce. This is consistent with the minimal toxin loads of samples collected directly from marketplace vendors. The

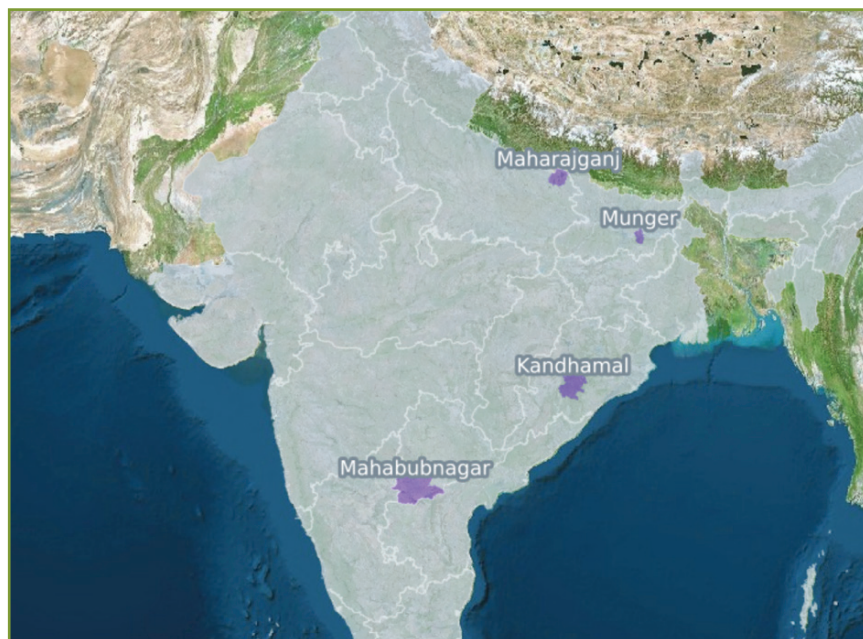


Figure 2. Districts where TCI's 2016 preliminary survey of mycotoxin risk was conducted.

relatively high toxin burden of homegrown grain suggests a lack of local capacity to distinguish and eliminate potentially toxic grain.

Interestingly, among only samples taken from household storage, there was no observable difference between the three origin categories (homegrown, marketplace, PDS), suggesting that the bulk of mycotoxin accumulation across these diverse food systems is occurring in the storage environment.



Food vendors at a marketplace in Mahabubnagar District, Telangana. Photo credit: Author

Storage practices as a determinant of risk

It is widely known that grain storage conditions influence the growth of toxin-producing fungi, and thereby, the magnitude of postharvest toxin deposition. In order to understand the dynamics of storage-associated risks in the context of the Indian village, we set out to observe common food storage and handling practices across the survey locations. Commodities kept in smaller quantities in the household (i.e., groundnuts, pulses, millets, oil seeds) were commonly kept in tin or plastic boxes. Because of the tight seal and solid composition, these containers are resistant to pests and molds, as long as the contents remain sufficiently dry.

In most cases, staple grains such as rice and sorghum were stored in sacks—likely attributable to the larger quantities in which these commodities are acquired. Sacks are

highly variable with respect to their ability to deter pests and toxigenic molds, because of the diversity of fabrics used to construct them. Jute sacks, which were not common in the survey locations, are vulnerable to numerous insect pests that can alter the storage microclimate and promote fungal colonization. Most sacks observed in our preliminary work were made of tough polypropylene, making them relatively more resistant to spoilage.

Traditional methods for storing food commodities were being practiced in all study sites. Such methods included mud- or dung-plastered bamboo silos, clay pots, and storage under cover of silage/fodder. The mud- and dung-plastered structures were a particularly popular means of storing rice, wheat, and maize. Clay pots were used to store groundnuts and rice. The “under fodder” method was used to store wheat in the Maharajanj District sites.

Traditional storage methods are a complicated issue to tackle. Despite their cultural value, they are often very vulnerable to spoilage by pests and molds. Some of the storage containers observed in our preliminary survey were important multigenerational fixtures in the household. Customary storage containers are not inherently less effective for preserving food, but rather they are often in disrepair, insufficiently engineered, or improperly managed due to lack of directed support.



A mud-lined traditional grain storage structure. Photo credit: Author

Communication and knowledge sharing

TCI's preliminary survey indicated that access to agricultural and nutrition information in some form was high. Across the survey locations, 63–97% of respondents reported some access to nutrition information (UP and Bihar had the lowest rates), and > 90% of respondents reported having at least some access to information about agricultural practices. Most commonly, respondents reported Anganwadi workers¹, clinicians/doctors, print and electronic media, and family as major sources of information about nutrition and health. Commonly reported sources of agricultural information included Village Agricultural Workers (VAW), block-level agricultural extension, NGO extension/field schools, and agricultural input dealers.

These findings suggest that there are existing, viable, and trusted routes by which capacity-building information about mycotoxin management can be conveyed to village communities. Indeed, we observed that stakeholders are generally receptive to ideas and eager to seize opportunities for innovation and improvement. The most trusted sources of both agricultural and nutrition information were often those that involved interpersonal engagement with local sources of expertise, such as farmer-to-farmer communication, Anganwadi workers, and VAWS.

The way forward: Policy recommendations to promote safe village food systems

Recommendation 1: Expand capacity for local monitoring and prevention. Despite marked agriculture sectoral growth, much of the food that circulates in India's smallholder food systems is not subject to any regulatory or quality control measures. It is, therefore, important that communities are empowered to endogenously assess risk factors associated with mycotoxin exposure and take actions to prevent toxin-associated food losses and public health outcomes. Awareness of the issue is a critical first step toward mycotoxin management at the community

level. Programs intended to inform producers and consumers about the signs and symptoms of mycotoxin contamination would provide a sound foundation for limiting the mycotoxin burden of the food system. Furthermore, enabling local buyers and traders to make quality-informed judgments prior to marketing local grains could incentivize parties across the value chain to think critically about food quality, resulting in eventual systemic improvements in how risks are perceived and acted upon.

Recommendation 2: Enhance awareness of and adherence to food quality standards across the food value chain. The Indian government has delineated regulatory guidelines for reduction or elimination of harmful mycotoxins in food, but there is widespread insufficiency in how these guidelines are used and enforced to ensure food safety at the local level. In smallholder (especially, subsistence-based) agricultural economies, food producers and consumers rarely have access to the knowledge and technology required to distinguish between "safe" and "unsafe" food. It is in all smallholder farmers' interests to retain as much of their yields as possible, and there are many hurdles to convincing farmers to part with even a fraction of their valuable harvest. However, there is an urgent need to reconsider the tradeoffs between yield and the fitness of said yield for human consumption. Efforts to incentivize production of "clean" food that meets regulatory standards should be nurtured. If farmers have access to the necessary information and are held accountable for the quality of their product, there is potential for reducing the endogenous community's mycotoxin burden.

Recommendation 3: Promote enhanced storage practices. Our study has confirmed that a wide range of storage practices is used across Indian village food systems. Because diverse storage circumstances differ in their propensity to harbor mycotoxins, there is reason to believe that substantial gains in food safety can be achieved through concerted improvements to storage practices and infrastructure. Replacing

¹ Government workers who are engaged with maternal and child nutrition at the village level.

or upgrading vulnerable storage containers in favor of safe, hermetically sealed options has the potential to reduce fungal growth and mycotoxin accumulation. Moreover, emphasis on best practices, such as drying, sorting, and natural additives, can have a substantial protective effect. Even if the toxin burden is high, it may not always be practical nor morally sound to replace customary containers with conventional options that are unfamiliar and bereft of sentimental value. Storage upgrades and replacements are part of a broader need for enhanced resilience and uptake of best practices.

Recommendation 4: Enable access to reliable extension services for postharvest grain management. We believe that enhancements to extension at the macro-level should be accompanied by the social support necessary to facilitate comfortable, enriching knowledge sharing in the long term. In our preliminary survey work, it was evident that agricultural extension services, if present at all, provided no support to farmers beyond harvest time—leaving a substantial portion of the value chain underserved. Efforts to curb postharvest mycotoxin contamination should therefore focus on access to information that promotes good practices and provision of resources (educational, etc.) that can enable proper maintenance and management of storage environments—traditional and otherwise.

Recommendation 5: Leverage local knowledge and uplift impoverished communities. While adherence to regulatory standards at the local level may substantially reduce the amount of mycotoxins that enter the food system, it is important to consider that regulations are meaningless (and thus more difficult to enforce) to stakeholders, unless their value is locally understood. There is a sizable economic incentive to produce high quality foods, but this frames quality as a purely economic parameter and not one that influences the nutrition and safety of foods consumed within the household. Our survey indicated that > 95% of respondents have some understanding of what constitutes a healthy and nutritious diet. This suggests that there is already a concept of public health in Indian village communities, which can be expanded upon to include information about food safety (and mycotoxin contamination, specifically) through outreach and education. Perhaps, the most powerful tool for combatting chronic mycotoxin exposure in village communities is locally relevant, pro-poor outreach and capacity building designed to relieve poverty from the ground up. Promoting good practices, rewarding good governance, and seizing local opportunities for social and economic gains can build resilience in smallholder communities, in effect, improving access to safe and nutritious foods.

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