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Ground Turmeric as a Source of Lead Exposure in the United States

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Financially motivated adulteration of spices is a long-standing and important public health problem worldwide.[1] For example, in 1994, ground paprika adulterated with lead oxide resulted in the poisoning and hospitalization of >50 people in Hungary.[2] Today, adulteration of turmeric with lead chromate, which is vibrant yellow, is a concern in India and Bangladesh. In this commentary, we summarize a growing body of evidence indicating that turmeric containing excessive concentrations of lead is available for purchase in US grocery stores and that childhood lead-poisoning cases attributable to consumption of contaminated turmeric have occurred in the United States. We hypothesize that turmeric is being intentionally adulterated with lead to enhance its weight, color, or both. Additionally, we review current regulations on spice safety and provide recommendations for consumers, public health professionals, and government agencies charged with ensuring the safety of the US food supply.

Evidence of Turmeric Contamination With Lead in the United States

Case Reports

In 2010, a report in *Pediatrics* detailed the case of a 12-month-old boy who was referred to the Pediatric Environmental Health Center at Boston Children's Hospital with a blood lead level of 28 μg/dL,[3] which exceeded the Centers for Disease Control and Prevention's reference level of 5 μg/dL.[4] After conducting a detailed investigation of the child's home, the Massachusetts Department of Public Health determined that daily consumption of several lead-contaminated spices, including turmeric, was the primary pathway of exposure.[3] Between 2010 and 2014, five other cases of childhood lead poisoning attributable to culinary spice consumption were reported in the United States. The cases were geographically diverse, and all were documented by departments of public health (Arizona,[5] California,[6] Colorado,[7] Connecticut,[8] and New York[9]).

Product Recalls

In the past several years, 13 brands of lead-contaminated turmeric have been recalled, all voluntarily. In 2011, companies based in Missouri and California initiated recalls of Archer Farms[10] and Spice Hunter[11] ground turmeric sold at stores nationwide because of excessive lead levels. Later that year, an online distributor recalled a powder-based dietary turmeric supplement (Dr Clark brand), which had been sold throughout the United States, Canada, Japan, Korea, and the United Kingdom.[12] These recalls were followed by the voluntary recall of Pran ground turmeric in 2013 by 4 companies based in New York,[13,14] Texas,[15] and Michigan.[16] Samples collected from these states had lead concentrations of 28-42 ppm, 53 ppm, and 48 ppm, respectively.[13-16] After these recalls, the US Food and Drug Administration (FDA) issued an import alert, which allows ports to detain future shipments from specific importers, targeting turmeric from Pran (Bangladesh), Visakarega Trading (India), and IndoVedic Nutrients (India).[17] In August 2016, seven brands of turmeric distributed by Gel Spice Inc were recalled because of elevated lead levels.[18-20] The recalled turmeric had been distributed throughout the United States, including at a farmers market in Georgia. Coincidentally, 5 brands of curry powder—of which turmeric is a key ingredient—amounting to 337 000 pounds were recalled by the Florida-based Oriental Packing Company because of lead contamination.[21] Most recently, 38 000 pounds of turmeric that were distributed to Florida and New York by Spices USA Inc were recalled because of elevated lead levels.[22]

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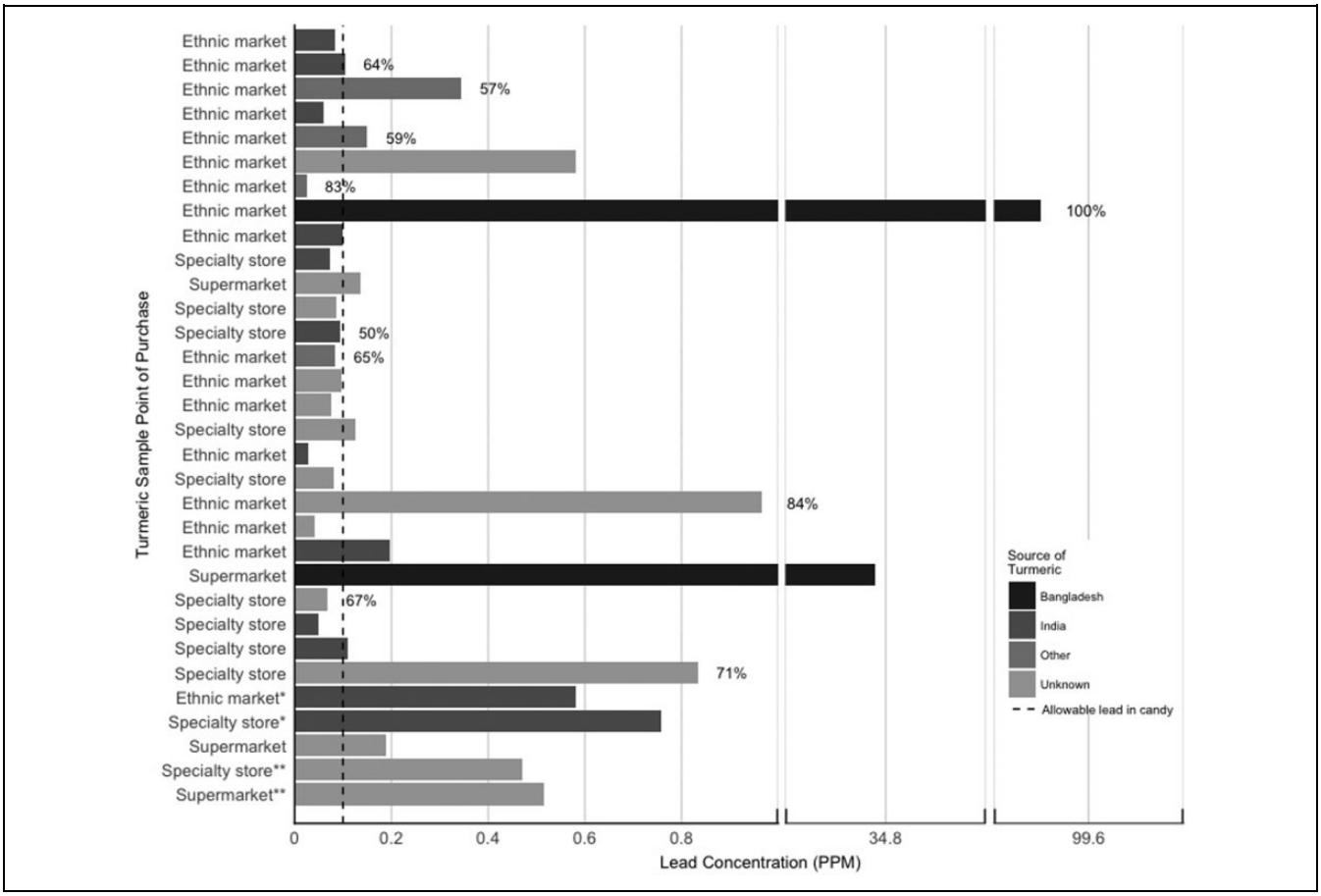

Figure. Lead concentration (ppm = 1000 × ng [lead] / g [turmeric]) in 32 turmeric samples purchased in the Boston metropolitan area, 2011 and 2012. The percentages indicate the estimated bioaccessibility (ie, fraction that can be absorbed by the human gastrointestinal tract) of 10 samples; not all samples were tested for bioaccessibility. Bioaccessibility was calculated following the formula outlined in the US Environmental Protection Agency Simple Bioaccessibility Extraction Test (SBET) protocol.[30] Asterisks indicate that 2 samples were the same brand.

Surveillance in India, Bangladesh, and the United States

A 2014 study published by researchers at Harvard University reported lead concentrations of up to 483 ppm in turmeric samples collected from 18 households in rural Bangladesh,[23] where the allowable level of lead in turmeric is 2.5 ppm.[24] Furthermore, several international media outlets have cited evidence that adulteration of turmeric with lead chromate is an ongoing problem. For example, the *Times of India* reported that during a raid by the Indian Food and Drug Authority in 2010, inspectors discovered >100 bags of raw turmeric contaminated with lead chromate at a spice-manufacturing plant.[25] Similarly, a major Bangladeshi newspaper purchased turmeric from local markets in 2014 and found lead concentrations of up to 55 ppm in packaged powder samples and 182 ppm in dry turmeric roots that had been boiled and polished but not ground.[26] When the newspaper interviewed a local turmeric grower, he reported that "traders use the artificial color [lead chromate] to hide the marks of pest attacks and other spots on raw turmeric. It is used during boiling and polishing to make the spice look brighter to attract big buyers, including spice processing firms."[26] Most turmeric sold in the United States is imported from India and Bangladesh.[27]

In 2011 and 2012, we purchased samples of turmeric from mainstream grocery stores, specialty stores, and ethnic markets throughout greater Boston. We analyzed 32 samples using inductively coupled plasma-mass spectrometry and found detectable levels of lead in all of the samples, with a median concentration of 0.11 ppm (range, 0.03-99.50 ppm; Figure). The FDA has published several recommended maximum levels of lead; however, the FDA has not established guidelines for lead levels in spices.[28] Without such a guideline, we evaluated our results against the FDA's maximum allowable level of lead in candy (0.1 ppm), which we concluded was the best available comparison food, despite differences in candy composition, consumption habits, and packaging. We found that concentrations in 16 of the 32 samples exceeded the FDA's allowable level of lead in candy, with 2 samples (34.78 and 99.50 ppm) exceeding the level by 2 orders of magnitude. These were the only samples

imported from Bangladesh. Lead is generally insoluble in soil and poorly absorbed by plants.[29] Therefore, although detection of low lead levels in most of our samples may reflect uptake from soil during growth, it is unlikely that agricultural fields were the source of the excessive concentrations that we detected.

Lead exists in several chemical forms, which along with the source of exposure (eg, ground spice, paint, soil) may influence the degree to which it is absorbed into the body. A measure of potential absorption, or gastrointestinal solubility, is bioaccessibility. To determine whether lead in turmeric powder can be readily absorbed by the human gastrointestinal tract, we measured bioaccessibility using the US Environmental Protection Agency's simple bioaccessibility extraction test.[30] We found that bioaccessibility ranged from 50% to 100% (mean, 70%). The sample with the highest concentration of lead was also the most bioaccessible; however, we did not find a correlation between lead concentration and bioaccessibility. We found greater lead bioaccessibility than that found by a 2010 study in Boston (mean, 49%)[3] that examined a mixture of spices or by a 2014 study in Bangladesh (mean, 43%)[23] that examined only turmeric. Interestingly, the Boston-based study determined that lead oxide was the primary lead form present, whereas the Bangladesh-based study detected levels of chromium in 3 samples (maximum, 235 ppm).

Turmeric Consumption in the United States

Concern for turmeric as a source of lead is heightened by its increased use in the United States. In 2014, approximately 12 million pounds of turmeric were imported, and per capita import rates increased 89% during the past 50 years, from 9 g in 1966 to 17 g in 2014.[31] This increase likely reflects the growing diversity of the US population and the promotion of spices as healthy, flavor-enhancing alternatives to salt.[32] Turmeric is used as a natural food-coloring agent for many foods, including cheeses, cereals, mustard, ice cream, and margarine[33]; as the demand for natural food additives rises,[34] we expect its use in these products to increase. For example, in 2015 Kraft replaced synthetic colorants in its macaroni and cheese with turmeric and other spices.[35] This upward trend in turmeric use suggests that exposure might be increasing for the US population, especially among Asian families, whose food culture often involves the use of large quantities of spice to prepare traditional meals. In addition to its culinary use, turmeric is being explored for medicinal use by research institutions and pharmaceutical companies because of its antioxidant, anti-inflammatory, and anticancer properties.[36] Likewise, turmeric-based dietary supplements and beverages are widely sold in nutrition and grocery store chains; between 2013 and 2014, the most recent years for which data are available, turmeric was the best-selling herbal ingredient at independent and chain natural product retail stores across the United States.[37]

Spice Safety Regulations

The Bangladesh Standards and Testing Institution, the Bureau of Indian Standards, and the Indian Agricultural Produce Grading and Marking Act state that turmeric must be free from lead chromate and other artificial coloring matter. The allowable level of lead in turmeric powder is 2.5 ppm,[24] 10 ppm,[38] and 2.5 ppm,[33] according to these 3 agencies, respectively. Unlike agencies in Bangladesh and India, the FDA has not established a recommended maximum level for heavy metals (eg, lead, chromium) in spices in the United States.[39,40] However, several existing regulatory tools have been conferred by the Federal Food, Drug and Cosmetics Act and the Food Safety Modernization Act for preventing contaminated spices from reaching consumers in the United States.[40,41] Specifically, the FDA has the authority to (1) inspect domestic and foreign manufacturing, packing, and storage facilities; (2) test products at spice facilities and ports where spices are imported; and (3) detain shipments or deny entry of products from international facilities that refuse access to FDA or third-party inspectors. Additionally, the FDA can issue import alerts.

Recommendations

In December 2016, the FDA issued an import alert (#28-13) after inspectors from the New York State Department of Agriculture and Markets detected high concentrations of lead in ground turmeric during routine sampling.[17] We support this alert and encourage the use of portable, fast, inexpensive, and reliable heavy metal screening tools, such as x-ray fluorescence instruments, at major ports.[42] In addition to general surveillance, the FDA has the authority to issue targeted field assignments to better understand particular food safety problems. We recommend that the FDA conduct a targeted field assignment focused on lead contamination of turmeric. We further support recent initiatives by the FDA to improve spice safety, including its development of the International Food Protection Training Institute, which is focused on teaching international colleagues about vulnerabilities in food production pathways.[41] We recommend that strategies for preventing and detecting lead contamination be incorporated into the programs developed by this institute.

By law, food production and manufacturing facilities must "identify hazards reasonably likely to occur" and "establish preventive controls for such hazards."[41] We recommend that spice facilities that repackage, store, and distribute turmeric in the United States incorporate lead-specific screening approaches as a component of their hazard analysis plans. Finally, although we support the FDA's risk profile on pathogens and spices, we note that this risk analysis pertains only to microbial pathogens (ie, salmonella) and filth (ie, rodent hair).[39] Given the potential for lead poisoning attributable to turmeric consumption, we recommend that this risk analysis be extended to include heavy metals and that a maximum allowable level of lead in spices be established.

At the local level, clinicians and public health officials should be aware of the potential for exposure to excessive levels of lead from consumption of processed turmeric. Public health agencies should consider adding turmeric and possibly other spices to guidance documents and protocols used during investigation and clinical management of lead-poisoning cases. Our recommendations for consumers are limited. If lead chromate is being used as an adulterant to polish turmeric roots before they are ground, it is plausible that the use of whole, unpeeled turmeric roots might avoid exposure to lead. Unfortunately, fresh turmeric is not available for purchase in many geographic regions.

Public Health Implications

The case reports, product recalls, and surveillance data reviewed in this commentary provide insight on a nontraditional source of lead exposure in the United States and potentially globally. Removal of lead from paint and gasoline and the reductions in blood lead levels that followed was one of the most important environmental health achievements of the past quarter-century. However, as we have observed, evidence exists that turmeric contamination with lead is a problem in India and Bangladesh, which are major global exporters of the spice. Future research investigating both lead and chromium would contribute to a better understanding of the pathways by which turmeric is contaminated with lead. Finally, government agencies tasked with maintaining the safety of the food supply should prioritize the development of policies aimed at preventing the distribution of contaminated turmeric throughout US commerce.

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