

International Investigation of Lead and Chromium Contamination in Imported Apple Puree

Abstract In October 2023, the Food and Drug Administration (FDA) was notified about four children in North Carolina who had high blood lead levels that were associated with consumption of apple cinnamon fruit puree from pouches. FDA and the Centers for Disease Control and Prevention (CDC), along with state and local partners, launched an international investigation into the source of lead contamination. FDA received 90 consumer complaints from 32 states, while CDC identified 556 cases of high blood lead levels with a variety of symptoms in 44 states. Novel laboratory methods were developed to identify the specific contaminant: lead chromate. Testing of products produced in Ecuador found lead concentrations 100- to 600-times above the FDA action level. The traceback investigation identified a cinnamon processor as the likely source of the contaminant. The investigation found that the lead and chromium in the apple cinnamon fruit puree pouches were likely due to lead chromate found in the ground cinnamon. The investigation led to the recall of these apple puree products and enhanced surveillance of cinnamon. The findings highlight the potential for children to be exposed to toxic elements from nontraditional sources and could help inform blood lead investigations in children.

Keywords: lead, food adulteration, chemical hazards, childhood lead poisoning, food safety, economically motivated adulteration, outbreak investigation

Introduction

Lead chromate (PbCrO_4), which is used to enhance the weight or appearance of food, rarely has been identified as a food contaminant in the U.S., although it has been identified as an economic adulterant in spices elsewhere in the world (American Spice Trade Association, 2025; Lopez et al., 2022). Consumption of lead chromate can cause lead poisoning and chromium exposure, which can affect multiple organ systems (National Center for Biotechnology Information,

2026b; Woolf & Woolf, 2005) and is of particular concern for pediatric populations.

In October 2023, the North Carolina Department of Health and Human Services (NCDHHS) and the North Carolina Department of Agriculture & Consumer Services (NCDA&CS) notified the Food and Drug Administration (FDA) of an investigation involving four children with high blood lead levels (BLLs) (Napier et al., 2024). The children, ages 1 to 3 years, were from three unrelated households and had two consecu-

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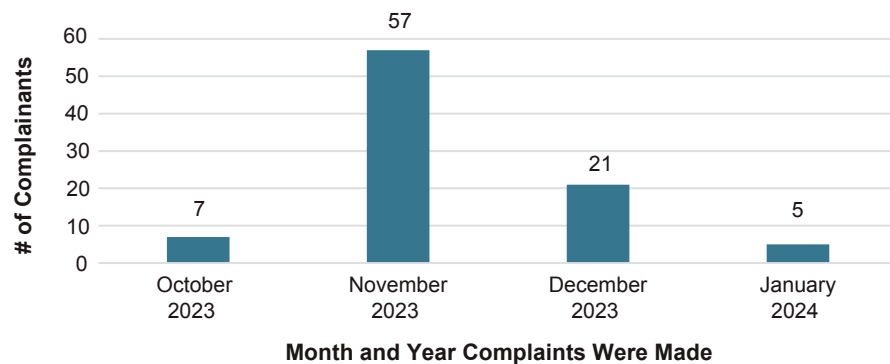
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FIGURE 1

Distribution of Complainants Meeting the Case Definition of the Food and Drug Administration, October 2023–January 2024 (n = 90)



tive BLLs >5 µg/dL (reference level: <3.5 µg/dL) reported to NCDHHS between June and August 2023 (LeBlanc et al., 2024).

These results triggered home investigations to identify sources of the exposure. The NCDHHS investigation identified one brand of apple cinnamon fruit puree pouches as a potential shared exposure, and laboratory analyses measured extremely high lead concentrations in the product across multiple manufacturing lots (1.9–5.2 mg/kg [ppm]). Recently, FDA published guidance for industry that includes an action level of 0.01 ppm (10 ppb) for lead in processed fruits intended for consumption by infants and young children <2 years (Food and Drug Administration [FDA], 2025c).

In this article, we describe an investigation conducted by FDA in collaboration with the Centers for Disease Control and Prevention (CDC) and state, local, and international partners, which determined that cinnamon intended for the manufacturing of these fruit puree pouches contained lead chromate. This incident highlights the unique challenges present when investigating chemical hazards, especially when the food products are imported, in food intended for vulnerable populations.

Methods

Initial Detection and Investigation

On notification from North Carolina authorities, the FDA Office of Coordinated Outbreak Response, Evaluation, and Emergency Preparedness (CORE+EP) initiated its process

for foodborne incident response, coordinating activities among public health partners (Seelman et al., 2021; Viazis et al., 2024).

Case and Adverse Event Identification

FDA and CDC collected epidemiological information independently, using the same case definition: BLL ≥ 3.5 µg/dL measured in a person within 3 months of consuming a pureed fruit pouch. Unlike outbreaks of foodborne illnesses genetically linked to a pathogen, lead exposure in an individual can result from several sources. No established method exists to link lead exposure in an individual to a specific source, which can make establishing a causal relationship difficult.

CDC conducted nationwide case-finding in collaboration with state partners to identify high BLLs associated with the consumption of apple cinnamon fruit puree pouches. A detailed account of the case-finding was previously reported (Troeschel et al., 2025). As a brief summary, from November 21, 2023, to April 12, 2024, CDC identified 566 cases in 44 states, Puerto Rico, and the District of Columbia that met the CDC case definition. Cases were further classified as suspect, probable, or confirmed based on the type of laboratory blood test conducted (capillary versus venous) and the results of a home assessment to identify any other possible sources of lead exposure. Approximately 96% of cases occurred among children <6 years. The median within-person maximum venous BLL was 7.2 µg/dL (range: 3.5–39.3 µg/dL). Symptoms were reported among 20% of cases and included

gastrointestinal, developmental, and behavioral symptoms (Troeschel et al., 2025). Individuals with lower relative levels of lead poisoning might not have exhibited symptoms.

FDA used self-reported information from healthcare professionals, consumers, and state partners who filed reports through FDA Consumer Complaint Coordinators or to the FDA Human Foods Complaint System as an initial step in identifying individuals who might have been affected (FDA, 2025d). To be included in FDA's complainant count, a person must have had a laboratory test after ingestion of a product from Manufacturer A (deidentified manufacturer). FDA used a broader complainant definition by neither differentiating between testing methods nor requiring a follow-up assessment.

Product Traceback

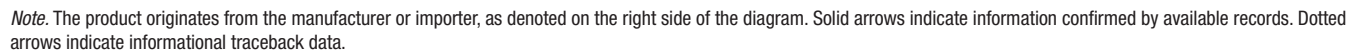
A traceback investigation was conducted by FDA and state food programs as previously described (Irvin et al., 2021). Briefly, the brand of fruit puree pouch that was reported in initial complaints was traced through the supply chain. Once the manufacturer of the fruit puree pouch was identified, traceback was conducted on individual ingredients to their respective sources.

Product Testing

FDA laboratories analyzed samples of the fruit puree and cinnamon from Manufacturer A using a multi-laboratory validated toxic element method with inductively coupled plasma mass spectrometry (ICP-MS) detection of lead and chromium (Gray & Cunningham, 2019). The FDA National Forensic Chemistry Center (NFCC) developed a de novo laboratory method to test cinnamon by preconcentrating the suspected particles and analyzing them with Raman microspectroscopy along with ICP-MS analysis.

Four state laboratories analyzed samples of the fruit puree produced by Manufacturer A and distributed domestically through Importers A and B, using the FDA laboratory method for detection of lead and chromium, while a fifth state laboratory used a U.S. Environmental Protection Agency (1996) method for determination of lead. FDA reviewed the analytical packages from the five states, including the initial reports from NCDHHS, and supported the analytical findings from these states.

Traceback Diagram for High Lead and Chromium Levels in Apple Cinnamon Puree Pouches, 2023 and 2024 Investigations



Initial Investigation and Public Notification

Adverse Event Identification

Product Traceback

Product Testing

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TABLE 1

Samples Collected by State Agencies and FDA During the Investigation of Apple Cinnamon Puree Pouches, 2023 and 2024

Collecting Agency	Firm	Product Description	Lead (ppm)	Chromium (ppm)	Magnitude Above Lead Action Level (FDA, 2025c)
FDA	Distributor E	Cinnamon powder	5,110	1,200	N/A
FDA			2,270	531	N/A
FDA	Manufacturer A	Apple cinnamon fruit puree pouches	2.18 2.23	0.59	218–223x
MDH			6.01 5.85	1.53	585–601x
MDH			6.12 5.93	1.57	593–612x
MDH			6.35 6.15	1.71	615–635x
MDH *			6.43 5.55	1.41	555–643x
NCDHHS			1.9	N/A	190x
NCDHHS			1.9	N/A	190x
NCDHHS			2.3	N/A	230x
NCDHHS			2.5	N/A	250x
NCDHHS			2.9	N/A	290x
NCDHHS			3.0	N/A	300x
NCDHHS			3.1	N/A	310x
NCDHHS			5.2	N/A	520x
NCDHHS			5.2	N/A	520x
NCDA&CS *			2.16	N/A	216x
NCDA&CS *			2.41	N/A	241x
NCDA&CS *			2.45	N/A	245x
NCDA&CS *			2.49	N/A	249x
NCDA&CS *			2.53	N/A	253x
NCDA&CS *			3.19	N/A	319x
PDA *			1.44	N/A	144x
VDCLS			3.29	0.81	329x
VDCLS			2.40	0.64	240x

* State sample results reviewed by the FDA Human Foods Program for use in regulatory actions.

Note. Results for the apple cinnamon fruit puree pouches are reported to two decimal places with the exception of results from NCDHHS. The method used by NCDHHS for analysis of the fruit puree pouches produced results with a resolution to one decimal place. FDA = Food and Drug Administration; MDH = Maryland Department of Health; N/A = not applicable; NCDA&CS = North Carolina Department of Agriculture and Consumer Services; NCDHHS = North Carolina Department of Health and Human Services; PDA = Pennsylvania Department of Agriculture; VDCLS = Virginia Division of Consolidated Laboratory Services.

tions throughout the state. Findings from NCDA&CS were consistent with the extremely high concentration of lead reported by NCDHHS (Table 1). After a recall of the pouches was initiated, additional testing was conducted

to assess the extent of the contamination. Samples included other lots of apple cinnamon fruit puree pouches produced by Manufacturer A, other brands of apple cinnamon fruit puree pouches produced by Manufacturer A,

other fruit purees produced by Manufacturer A, and other cinnamon-flavored fruit puree pouches produced by other manufacturers.

Testing of the apple cinnamon fruit puree pouches and cinnamon collected at Manu-

facturer A revealed that the cinnamon—intended as an ingredient for the manufacturing of the apple cinnamon fruit puree pouches—was the source of the lead contamination. Additionally, lead chromate was present in the sampled cinnamon, which is indicative of economic adulteration.

FDA mobilized staff and coordinated with state partners, supported by the FDA Laboratory Flexible Funding Model (LFFM) grant program, which comprises a series of cooperative agreements to support public health laboratory infrastructure (FDA, 2025b). These grant-supported state partners collected samples at retail establishments across the U.S. to assess contaminant levels and determine the scope of contamination in fruit puree products.

The state partners collected and analyzed 102 samples of fruit puree produced by Manufacturer A, including 22 samples of apple cinnamon fruit puree pouches. Further, FDA collected and analyzed 33 samples of fruit puree products produced by Manufacturer A, including 1 sample of an apple cinnamon fruit puree pouch. The analysis showed that all apple cinnamon fruit puree pouch products produced by Manufacturer A had high lead levels.

Products from Manufacturer A that did not contain cinnamon and cinnamon products from other manufacturers were not found to have actionable lead levels. FDA and state laboratory results, supported by FDA scientific review, detected lead levels between 1.44 and 6.43 ppm and chromium levels between 0.59 and 1.41 ppm in the apple cinnamon fruit puree pouches (Table 1). Lead levels were 144–643 times higher than the FDA action level of 10 ppb for lead in processed fruits that are intended for consumption by infants and young children (FDA, 2025c).

FDA analyzed two batches of ground cinnamon collected from Manufacturer A and intended for manufacturing apple cinnamon fruit puree to be sold in pouches. Analysis revealed extreme levels of lead as high as 5,110 ppm, which is more than 2,000-fold higher than the limit in a proposed international standard for bark-derived spices (FDA, 2024c). FDA also detected extremely high levels of chromium at 1,200 ppm and 531 ppm in the two batches. Analysis of the food packaging materials showed the pouches were below the limit of detection for lead and chromium.

The detection of both lead and chromium in the cinnamon samples at a molar ratio (Pb:Cr) of 1:1 by ICP-MS analysis suggests the presence of lead chromate. ICP-MS alone, however, cannot identify lead chromate as a chemical compound. Using a method developed for this investigation, Raman microspectroscopy identified particles in the cinnamon as lead chromate based on spectral matches with a known standard (Kubachka et al., 2026). This method could not be applied to the apple cinnamon fruit puree to determine the forms of lead and/or chromium, as the concentrations of lead chromate particles in the finished product were below the detection limits of this method.

Regulatory Investigation and Compliance Actions

State agencies and local health departments, in coordination with FDA investigators, conducted more than 3,000 visits to retail stores nationwide to assess the effectiveness of the recall, which was the largest number of audit checks ever documented in the U.S. for a single recall. FDA, state, and local partners found the recall was ineffective at one national retailer due to its failure to adequately remove recalled product from store shelves. FDA worked with state officials and retailers, taking steps to remove contaminated products from the market (FDA, 2024c).

FDA partnered with Ecuadorian regulatory authorities for an on-site inspection at Manufacturer A. Although the firm was not processing food products at the time of the FDA inspection, investigators were able to conduct a facility inspection of the equipment and processes, sample products, collect records, and assess food safety procedures.

Processor A, the firm in Ecuador that is responsible for grinding cinnamon sticks into powder, is not regulated by FDA. Ecuadorian regulatory authorities conducted an independent inspection at Processor A and determined that the facility did not have the proper permits to operate under local law and also observed poor sanitation practices. Intact cinnamon sticks were sampled and analyzed by Ecuadorian authorities and found to be free of lead contamination. Processor A was believed to be the likely source of contamination due to the addition of lead chromate during or after grinding, based on ground cinnamon collected at Manufacturer A that was found to contain lead chromate.

Following FDA inspections of Manufacturer A and Importers A, B, and C, plus recall audit checks at retailers by FDA, state, and local partners, FDA issued warning letters noting violations of the Federal Food, Drug, and Cosmetic Act (FDA, 2024d, 2024e, 2024f, 2024g, 2024h). Additionally, FDA added the apple cinnamon fruit puree pouches from Manufacturer A and cinnamon from Distributor D onto Import Alert 99-42 “Detention Without Physical Examination of Foods Due to Heavy Metal (Toxic Element) Contamination” and cinnamon from Distributor D onto Import Alert 99-47 “Detention Without Physical Examination of Human Food Products That Appear to be Adulterated for Economic Gain” to prevent future product from entering U.S. commerce (FDA, 2024c).

Discussion

Lead chromate has been reported as an adulterant in spices such as turmeric in South Asia, the Middle East, and North Africa (Cowell et al., 2017; Forsyth et al., 2019; Moore et al., 2012). Foods marketed toward and consumed by infants and children, such as the fruit puree pouches implicated here, pose a potentially higher risk than contamination of products intended for adults—both due to children’s lower body mass and the potential for adverse developmental effects. Previous consumption surveys have reported that approximately one quarter (26%) of U.S. children consumed apple products in the 24 hours prior to a survey (Nicklas et al., 2015). FDA has published industry guidance establishing an action level of 10 ppb for lead in processed fruit products intended for consumption by infants and young children (FDA, 2025c).

Our investigation highlights many of the complexities present in a multinational food contamination response linked to toxic elements, such as the difficulty in establishing causality and the absence of standardized methods to identify specific contaminants in specific food matrices.

Lead Chromate Toxicity and Risk to Children

Lead toxicity in children primarily affects the central nervous system (U.S. Preventive Services Task Force, 2019). Children are more vulnerable to lead poisoning because their nervous systems are still developing, and they

TABLE 2

Public Health Alerts That Resulted From Post-Incident Surveillance of Cinnamon Toxic Element, 2023 and 2024

Public Health Alert	FDA Samples	State LFFM (FDA-Funded) Samples	State Samples	Total
March 6, 2024 (FDA, 2024a)	11	4	—	15 samples (6 brands)
July 25, 2024 (FDA, 2024b)	—	—	1	1 sample (1 brand)
July 30–November 1, 2024 (FDA, 2024d)	—	11	3	14 samples (11 brands)
Total				30 samples (13 brands)*

* Four brands had multiple high samples that resulted in more than one recall and/or advisory.

Note. FDA = Food and Drug Administration; LFFM = Laboratory Flexible Funding Model.

tend to absorb a higher fraction of ingested lead than do adults (LeBlanc et al., 2024). Although children who have been exposed to lead might have no visible acute symptoms, even low levels of lead have been associated with learning, behavioral, and cognitive deficits (Flannery et al., 2020; National Toxicology Program, 2026). A child who is exposed to large amounts of lead can develop acute lead poisoning, which presents with gastrointestinal, hematological, and neurological effects that include anemia, abdominal pain, weakness, and severe neurological sequelae such as seizures, encephalopathy, and coma (Flora et al., 2012).

Chromium exists in multiple oxidation states in nature. Most human exposures involve one of two types: chromium (III) (trivalent) or chromium (VI) (hexavalent), according to the National Center for Biotechnology Information (2026a). Chromium (III) is a trace element in the human diet, with an adequate intake estimated from 20 to 45 µg per day. Chromium (III) is less soluble and less toxic than is chromium (VI), which is the oxidation state present in lead chromate. Occupational exposure or oral ingestion of large quantities of chromium (VI) have been associated with both acute and chronic physical effects, although these effects have not previously been documented from exposure in food (Zhang et al., 2024). Acute adverse effects reported with oral chromium (III) are limited to rare case reports involving high-dose ingestion of chromium picolinate

dietary supplements, which resulted in acute kidney injury, liver injury, and dermatitis (Cerulli et al., 1998).

Public Messaging and Mitigation Activities

Given the known health risks of lead, FDA, CDC, and state and local health departments have existing programs intended to detect and reduce lead exposure, particularly among children. These programs include the “Closer to Zero” initiative of FDA (2025a). At the time of this event, the Childhood Lead Poisoning Prevention Program (CLPPP) of CDC funded 62 state and local childhood lead programs for testing, reporting, surveillance, linkages to care, and interventions through a cooperative agreement, which provided an instant response partnership framework and preestablished lines of communication (CDC, 2024).

When notified of this incident by North Carolina state partners, FDA, CDC, and state and local partners coordinated communication efforts to amplify recommendations for the public and promote product recall information. Communication efforts included public-facing webpages, targeted outreach to healthcare professionals, responses for journalists at major media outlets, and social media posts. Initial complexities were identified and collaboratively resolved across the agencies to ensure unified communications. Complaint and case data—reported by FDA and CDC, respectively—varied, as did

the case information received by the states. The varying case information was due to differences in data collection and management across local, state, and federal agencies. Through effective coordination and communication between agencies, however, a streamlined data collection and reporting process was established.

Ongoing Surveillance and Mitigation Activities

After the investigation was completed, FDA initiated a targeted analysis for lead and chromium in retail ground cinnamon products. FDA collected and tested 75 samples from retail locations between December 2023 and March 2024. FDA also worked with state partners (who were supported by FDA laboratory grant funding) to increase surveillance of ground cinnamon that was for sale. A total of 14 state partners collected 120 samples of ground cinnamon at retail locations between December 2023 and June 2024. Separate from this coordinated effort, state partners conducted surveillance of spices between March and April 2024 in response to the March 2024 FDA advisory on cinnamon (FDA, 2024b).

Based on findings of high lead levels (2–20 ppm) in 30 surveillance samples, FDA issued three public health alerts and recommended voluntary recalls of product for 13 brands of ground cinnamon (FDA, 2024a, 2024b, 2025e) (Table 2). It is important to note that no adverse events have been reported related to ground cinnamon products from the ongoing sampling that was initiated after the investigation of the apple cinnamon fruit puree pouches, and the lead levels were significantly lower than those in the ground cinnamon used as an ingredient in the recalled apple cinnamon fruit puree pouches. FDA and state partners continue to monitor lead in ground cinnamon at multiple points in the supply chain and will continue to take appropriate actions.

Conclusion

This public health investigation highlights the complexity of identifying and mitigating a previously unrecognized threat to child health. While the risks to children from ingestion of lead are well characterized, acute toxicity from a food product in broad domestic distribution is rare. Our findings can inform the inclusion of examining nontradi-

tional sources of lead exposure when a childhood lead investigation does not immediately implicate more frequently noted exposures (e.g., paint, cosmetics, home remedies).

This incident would not have been detected without the routine surveillance and investigation of pediatric lead exposure at the state and local level that was supported by CDC's Childhood Lead Poisoning Prevention Program. Similarly, the capacity to rapidly assess the scope and severity of contamination was facilitated by state food

laboratories receiving support from the FDA Laboratory Flexible Funding Model grant program. Through the cooperative efforts of multiple public health agencies, the risks were mitigated and preventive efforts enhanced. ✨

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References

- American Spice Trade Association. (2025). *ASTA guidance levels for heavy metals in spices*. <https://astaspice.org/resources/asta-guidance-levels-for-heavy-metals-in-spices>
- Centers for Disease Control and Prevention. (2024). *About the Childhood Lead Poisoning Prevention Program*. <https://www.cdc.gov/lead-prevention/php/about-clppp/index.html>
- Cerulli, J., Grabe, D.W., Gauthier, I., Malone, M., & McGoldrick, M.D. (1998). Chromium picolinate toxicity. *Annals of Pharmacotherapy*, 32(4), 428–431. <https://doi.org/10.1345/aph.17327>
- Cowell, W., Ireland, T., Vorhees, D., & Heiger-Bernays, W. (2017). Ground turmeric as a source of lead exposure in the United States. *Public Health Reports*, 132(3), 289–293. <https://doi.org/10.1177/0033354917700109>
- Flannery, B.M., Dolan, L.C., Hoffman-Pennesi, D., Gavelek, A., Jones, O.E., Kanwal, R., Wolpert, B., Gensheimer, K., Dennis, S., & Fitzpatrick, S. (2020). U.S. Food and Drug Administration's interim reference levels for dietary lead exposure in children and women of childbearing age. *Regulatory Toxicology and Pharmacology*, 110, Article 104516. <https://doi.org/10.1016/j.yrtph.2019.104516>
- Flora, G., Gupta, D., & Tiwari, A. (2012). Toxicity of lead: A review with recent updates. *Interdisciplinary Toxicology*, 5(2), 47–58. <https://doi.org/10.2478/v10102-012-0009-2>
- Food and Drug Administration. (2024a). *FDA alert concerning certain cinnamon products due to presence of elevated levels of lead*. <https://www.fda.gov/food/alerts-advisories-safety-information/fda-alert-concerning-certain-cinnamon-products-due-presence-elevated-levels-lead>
- Food and Drug Administration. (2024b). *FDA public health alert for additional ground cinnamon product due to presence of elevated levels of lead*. <https://www.fda.gov/food/alerts-advisories-safety-information/fda-public-health-alert-additional-ground-cinnamon-product-due-presence-elevated-levels-lead>
- Food and Drug Administration. (2024c). *Investigation of elevated lead & chromium levels: Cinnamon applesauce pouches* (November 2023). <https://www.fda.gov/food/outbreaks-foodborne-illness/investigation-elevated-lead-chromium-levels-cinnamon-apple-sauce-pouches-november-2023>
- Food and Drug Administration. (2024d). *Warning letter: Austrofood S.A.S. MARCS-CMS 679052—August 09, 2024*. <https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/warning-letters/austrofood-sas-679052-08092024>
- Food and Drug Administration. (2024e). *Warning letter: Caribbean Produce Exchange, LLC MARCS-CMS 679804—November 04, 2024*. <https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/warning-letters/caribbean-produce-exchange-llc-679804-11042024>
- Food and Drug Administration. (2024f). *Warning letter: Dollar Tree Inc. MARCS-CMS 674301—June 11, 2024*. <https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/warning-letters/dollar-tree-inc-674301-06112024>
- Food and Drug Administration. (2024g). *Warning letter: Purcell International MARCS-CMS 680631—November 05, 2024*. <https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/warning-letters/purcell-international-680631-11052024>
- Food and Drug Administration. (2024h). *Warning letter: WanaBana USA LLC MARCS-CMS 680548—November 04, 2024*. <https://www.fda.gov/inspections-compliance-enforcement-and-criminal-investigations/warning-letters/wanabana-usa-llc-680548-11042024>
- Food and Drug Administration. (2025a). *Closer to Zero: Reducing childhood exposure to contaminants from foods*. <https://www.fda.gov/food/environmental-contaminants-food/closer-zero-reducing-childhood-exposure-contaminants-foods>
- Food and Drug Administration. (2025b). *Grants & cooperative agreements (food): Laboratory Flexible Funding Model CAP*. <https://www.fda.gov/food/funding-opportunities-provided-office-domestic-partnerships/grants-cooperative-agreements-food>
- Food and Drug Administration. (2025c). *Guidance for industry: Action levels for lead in processed food intended for babies and young children*. <https://www.fda.gov/regulatory-information/search-fda-guidance-documents/guidance-industry-action-levels-lead-processed-food-intended-babies-and-young-children>

References

- Food and Drug Administration. (2025d). *Human Foods Complaint System (HFCS)*. <https://www.fda.gov/food/compliance-enforcement-food/cfsan-adverse-event-reporting-system-caers>
- Food and Drug Administration. (2025e). *More ground cinnamon products added to FDA public health alert due to presence of elevated levels of lead*. <https://www.fda.gov/food/alerts-advisories-safety-information/more-ground-cinnamon-products-added-fda-public-health-alert-due-presence-elevated-levels-lead>
- Forsyth, J.E., Nurunnahar, S., Islam, S.S., Baker, M., Yeasmin, D., Islam, M.S., Rahman, M., Fendorf, S., Ardoin, N.M., Winch, P.J., & Luby, S.P. (2019). Turmeric means “yellow” in Bengali: Lead chromate pigments added to turmeric threaten public health across Bangladesh. *Environmental Research*, 179(Pt. A), Article 108722. <https://doi.org/10.1016/j.envres.2019.108722>
- Gray, P.J., & Cunningham, W. (2019). Inductively coupled plasma collision cell quadrupole mass spectrometric determination of extractable arsenic, cadmium, chromium, lead, mercury, and other elements in food using microwave-assisted digestion: Results from an FDA interlaboratory study. *Journal of AOAC International*, 102(2), 590–604. <https://doi.org/10.5740/jaoacint.18-0129>
- Irvin, K., Viazis, S., Fields, A., Seelman, S., Blickenstaff, K., Gee, E., Wise, M.E., Marshall, K.E., Gieraltowski, L., & Harris, S. (2021). An overview of traceback investigations and three case studies of recent outbreaks of *Escherichia coli* O157:H7 infections linked to romaine lettuce. *Journal of Food Protection*, 84(8), 1340–1356. <https://doi.org/10.4315/jfp-21-112>
- Kubachka, K., Witkowski, M., & Hurt, D. (2026). Detection of lead (II) chromate in cinnamon. *Applied Spectroscopy Practica*, 4(1), 1–10. <https://doi.org/10.1177/27551857261425269>
- LeBlanc, T.T., Chang, A., Svendsen, E., & Allwood, P. (2024). Perspectives on childhood lead exposure prevention: Looking back and looking ahead. *Pediatrics*, 154(Suppl. 2), Article e2024067808C. <https://doi.org/10.1542/peds.2024-067808c>
- Lopez, A.M., Nicolini, C.M., Aeppli, M., Luby, S.P., Fendorf, S., & Forsyth, J.E. (2022). Assessing analytical methods for the rapid detection of lead adulteration in the global spice market. *Environmental Science & Technology*, 56(23), 16996–17006. <https://doi.org/10.1021/acs.est.2c03241>
- Moore, J.C., Spink, J., & Lipp, M. (2012). Development and application of a database of food ingredient fraud and economically motivated adulteration from 1980 to 2010. *Journal of Food Science*, 77(4), R118–R126. <https://doi.org/10.1111/j.1750-3841.2012.02657.x>
- Napier, M.D., Huneycutt, A., Moore, C., Goforth, C., Komlos, M., Bryant, V., Shone, S.M., Michael, L.D., & Norman, E.H. (2024). Childhood lead exposure linked to apple cinnamon fruit puree pouches—North Carolina, June 2023–January 2024. *Morbidity and Mortality Weekly Report*, 73(28), 622–627. <https://doi.org/10.15585/mmwr.mm7328a2>
- National Center for Biotechnology Information. (2026a). *PubChem compound summary for CID 23976, chromium*. <https://pubchem.ncbi.nlm.nih.gov/compound/23976>
- National Center for Biotechnology Information. (2026b). *PubChem compound summary for CID 24460, lead chromate*. <https://pubchem.ncbi.nlm.nih.gov/compound/Lead-Chromate>
- National Toxicology Program. (2026). *Health effects of low-level lead*. <https://ntp.niehs.nih.gov/go/36443>
- Nicklas, T.A., O’Neil, C.E., & Fulgoni, V.L., III. (2015). Consumption of various forms of apples is associated with a better nutrient intake and improved nutrient adequacy in diets of children: National Health and Nutrition Examination Survey 2003–2010. *Food & Nutrition Research*, 59, Article 25948. <https://doi.org/10.3402/fnr.v59.25948>
- Seelman, S., Viazis, S., Merriweather, S.P., Cloyd, T.C., Aldridge, M., & Irvin, K. (2021). Integrating the Food and Drug Administration Office of the Coordinated Outbreak Response and Evaluation Network’s foodborne illness outbreak surveillance and response activities with principles of the National Incident Management System. *Journal of Emergency Management*, 19(2), 131–141. <https://doi.org/10.5055/jem.0567>
- Troeschel, A.N., Buser, M.C., Winquist, A., Ruckart, P., Yeh, M., Kuai, D., Chang, A., Pennington, A.F., Rumph, J.T., Smith, M.R., Lara, M.V., Cataldo, N., Lewis, K., Arnold, K., Harris, S., Nicholas, D.C., Hughes, M., Wortmann, T., Norman, E., . . . Daniel, J. (2025). Investigation of lead and chromium exposure following consumption of contaminated cinnamon-containing applesauce—United States, November 2023–April 2024. *Morbidity and Mortality Weekly Report*, 74(14), 239–244. <https://doi.org/10.15585/mmwr.mm7414a2>
- U.S. Environmental Protection Agency. (1996). *EPA method 3050B: Acid digestion of sediments, sludges, and soils* (2nd rev.). <https://www.epa.gov/esam/epa-method-3050b-acid-digestion-sediments-sludges-and-soils>
- U.S. Preventive Services Task Force. (2019). Screening for elevated blood lead levels in children and pregnant women: U.S. Preventive Services Task Force recommendation statement. *JAMA*, 321(15), 1502–1509. <https://doi.org/10.1001/jama.2019.3326>
- Viazis, S., Carstens, C.K., Walerstein, L., Armstrong, M., Fields, A., Blessington, T., Hardy, C., Seelman, S., & Weed, B. (2024). The evolution of FDA CORE: Adaptive response to outbreak-related challenges. *Food Safety Magazine*.
- Woolf, A.D., & Woolf, N.T. (2005). Childhood lead poisoning in 2 families associated with spices used in food preparation. *Pediatrics*, 116(2), e314–e318. <https://doi.org/10.1542/peds.2004-2884>
- Zhang, J., Wang, R., Qu, G., Ma, J., Wang, Y., Zhang, D., Zhou, X., & Liu, L. (2024). Acute fatal chromium toxicity: A case report of electroplating water ingestion. *Legal Medicine*, 71, Article 102524. <https://doi.org/10.1016/j.legalmed.2024.102524>