RESEARCH ARTICLE

ROBERT A. LYNCH, MPH PHD ■ DANIEL T. BOATRIGHT, PHD
SAMUEL K. MOSS

Lead-Contaminated Imported Tamarind Candy and Children's Blood Lead Levels

SYNOPSIS

In 1999, an investigation implicated tamarind candy as the potential source of lead exposure for a child with a significantly elevated blood lead level (BLL). The Oklahoma City-County Health Department tested two types of tamarind suckers and their packaging for lead content. More than 50% of the tested suckers exceeded the US Food and Drug Administration (FDA) Level of Concern for lead in this type of product. The authors calculated that a child consuming one-quarter to one-half of either of the two types of suckers in a day would exceed the maximum FDA Provisional Tolerable Intake for lead.

High lead concentrations in the two types of wrappers suggested leaching as a potential source of contamination.

The authors used the Environmental Protection Agency's Integrated Exposure Uptake Biokinetic (IEUBK) model to predict the effects of consumption of contaminated tamarind suckers on population BLLs. The IEUBK model predicted that consumption of either type of sucker at a rate of one per day would result in dramatic increases in mean BLLs for children ages 6–84 months in Oklahoma and in the percentage of children with elevated BLLs (≥10 micrograms per deciliter [μg/dL]).

The authors conclude that consumption of these products represents a potential public health threat. In addition, a history of lead contamination in imported tamarind products suggests that import control measures may not be completely effective in preventing additional lead exposure.

The authors are with the Department of Occupational and Environmental Health, College of Public Health, University of Oklahoma Health Sciences Center. Dr. Lynch is an Assistant Professor, Dr. Boatright is an Associate Professor, and Mr. Moss is a Graduate Research Assistant.

Address correspondence to:
Dr. Lynch, Dept. of Occupational and Environmental Health, College of Public Health, Univ. of Oklahoma Health Sciences Ctr., 801 NE 13th St., Oklahoma City, OK 73104; tel. 405-271-2070; fax 405-271-1971; e-mail <robert-lunch@ouhsc.edu>.

Imported food and food-related products present specific challenges for protecting public health. The large size of shipments, the many different routes of entry, the variety of foods imported, and the large number of potential contaminants make effective interdiction of contaminated foods difficult. Additionally, many products are brought into the country by travelers, especially US residents traveling back and forth regularly to their countries of origin. Although federal agencies regularly prohibit various food products from being distributed or remove them from distribution because of contaminants ranging from filth (for example, insect parts, rodent hairs) to toxic metals and pesticide residues, it is impossible to screen all foods for all contaminants. Given these factors, it should not be surprising that some contaminated foods reach the US consumer.

Chemical contamination of imported foods can occur during growth, processing, transportation, or packaging of the product. Pesticides (some of which may be banned in this country) may be directly applied to foods during growth, processing, or storage, or foods may be contaminated by the equipment or the environment in which they are processed or stored. Finally, packaging materials have been shown to cause food contamination; materials such as lead may leach into food products from print dyes.[1–3]

Lead in food. Contaminated soil, dust, and paint are the most common sources of exposure to lead; however, other sources, although less widely known, may contribute significantly in individual cases or in small populations.[4] For example, pottery glazes have been identified as the source of elevated blood lead levels (BLLs) in several cases, and the Food and Drug Administration (FDA) has established specific standards for these products.[5] Imported foods contaminated with lead have included tamarind products,[1] food coloring (lozeena) from Iraq,[6] prune juice concentrate from France,[7] duck eggs from Taiwan,[8] and raisins from Turkey.[9]

The most alarming example of unintentional exposure to lead comes from the use of folk remedies with very high levels of lead such as Alarcon, Azarcon, Coral, Greta, Liga, Maria Luisa, and Rueda (Greta, for example, is composed of approximately 99% lead oxide).[10]

The FDA's Level of Concern for lead in imported food varies; for example, it has been set at 0.25 milligrams per kilogram (mg/kg) for raisins and 0.50 mg/kg for tamarind candy.[9,11] The FDA has also set a Provisional Total Tolerable Intake for lead of 6 micrograms (μg) per day for children younger than 6 years of age.[11] The acceptable concentration for food contact surfaces has been set by the FDA at 7 mg/kg12; however, for certain materials, such as ceramicware, the standard has been set at ≤3 mg/kg.[5]

Table 1. Lead concentration, lead volume, and pH in two imported tamarind candy products

	Product #1 (n = 20 pieces)			Product #2 (n = 20 pieces)		
Variable	*Product*	*Stems*	*Wrappers*	*Product*	*Stems*	*Wrappers*
Lead concentration (mg/kg)						
Minimum	0.15	0.36	15,248	0.36	0.44	459
Mean	0.42	0.82	20,176	0.85	0.92	662
Median	0.36	0.74	19,143	0.64	0.92	576
Maximum	1.17	2.50	27,125	3.61	1.40	1135
Lead mass per sucker (mg)						
Minimum	0.0038	0.0005	24.1	0.009	0.0007	0.73
Mean	0.011	0.0012	31.88	0.021	0.0014	1.05
Median	0.009	0.0011	30.25	0.016	0.0014	0.91
Maximum	0.029	0.0038	42.86	0.091	0.0021	1.79
pH						
Minimum	2.2	—	—	2.2	—	—
Mean	2.4	—	—	2.3	—	—
Median	2.4	—	—	2.3	—	—
Maximum	2.6	—	—	2.5	—	—

Tamarind products. The pulp of the fruit from the tamarind tree (*Tamarindus indica*) is made into a variety of consumable goods, including drinks, preserves, sauces, and candy. These products are imported into the US from a number of Asian and Latin American countries. Tamarind products have frequently been the subject of FDA attention and have been involved in a number of import alerts. From October 1991 to July 1993, 179 different tamarind products from eight countries were detained because of contamination with filth.[13] Two FDA advisories specifically related to lead contamination of tamarind products have been issued: one concerning tamarind products packaged in ceramic containers and the other concerning tamarind suckers.[1,6,13]

Potential for exposure. Although the potential for adverse health effects due to the ingestion of lead-contaminated products is often demonstrated through investigation of individual incidents, the larger-scale public health effects are not well defined. Use of many products associated with lead exposure is largely confined to specific ethnic groups, especially recent immigrants who maintain specific cultural practices and have access to products from their country of origin. The potential for exposure in these groups is rarely understood due to the lack of data regarding lead levels in various products, and the extent of their use within communities.

LEAD-CONTAMINATED TAMARIND CANDY: OKLAHOMA, 1999

The present article describes an investigation of lead found in specific tamarind candy products and their packaging and the use of computer modeling to predict the effects of consumption of these products on population BLLs. Specifically, computer modeling was used to predict the geometric mean BLL for children consuming contaminated tamarind suckers and the percentage of children with elevated BLLs, by lead concentration and level of consumption of these products.

CASE INVESTIGATION

In January 1999, routine screening of high-risk children at a municipal hospital outpatient clinic revealed a child with a BLL of 35 µg/dL. (Children enrolled in Medicaid and/or receiving care at public clinics are screened in Oklahoma if they have specific risk factors—residence in an area with older housing or a sibling with an elevated BLL.) The Centers for Disease Control and Prevention (CDC) has set an action level for lead at ≥10 µg/dL; the action level is the level at which intervention is recommended. An assessment team from the Oklahoma City-County Health Department investigated the child's residence for potential sources of lead exposure. *In situ* paint and soil measurements were made with a Niton® Model XL-309 X-Ray Fluorescence (XRF) Lead Analyzer, and some areas of deteriorating lead-based paint were discovered. Soil and dust samples were collected and returned to the Health Department laboratory. All dust samples were found to be within Department of Housing and Urban Development (HUD) standards for lead; however, the concentration of lead in the dripline soil sample was above the HUD standard for building perimeter soil.

At a follow-up visit, two Health Department staff members, the lead-based paint risk assessor and a pediatric nurse, instructed the child's father in ways to reduce risk, such as wet cleaning and encapsulating lead-based paint. The child was re-tested for blood lead in mid-April 1999; his BLL had risen to 48 µg/dL. The father told the Health Department nurse that all suggested control measures had been instituted, which was confirmed by the nurse. The two Health Department representatives and the Director of the State of Oklahoma Childhood Lead Poisoning Prevention Program re-interviewed the father, asking specifically about the use of ceramic cookware or folk remedies. He said that none of these were in use in the home; however, he noted that the child often ate imported tamarind suckers. The Health Department team visited the store where the family purchased tamarind candy and obtained samples of the product as described by the parent. An XRF measurement of one sucker revealed a lead concentration of 0.30 mg/cm^2. Based on this analysis, the candy was subjected to a quantitative analysis by Graphite Furnace Atomic Absorption Spectrophotometry (GFAAS) at the Health Department laboratory, which confirmed the presence of lead.

BLOOD LEAD LEVELS AMONG HISPANIC CHILDREN IN OKLAHOMA

Because the lead-poisoned child was from a Mexican American family, we reviewed the Oklahoma State Department of Health Lead Poisoning Database to determine whether Hispanic children had a higher risk than other children of elevated BLLs, defined as BLLs ≥10 μg/dL. Because of limitations of the database, we used Spanish surnames to identify Hispanic children.

Among children younger than 7 years old tested, 3.7% of Hispanic children statewide and 2.8% of Hispanic children in Oklahoma City had elevated BLLs, compared with 2.0% of non-Hispanic children statewide and 2.6% of non-Hispanic children in Oklahoma City. Within Oklahoma City, the south central area had the highest percentage of Hispanic children in the lead poisoning database; 6.1% of children tested in 1994–1999 in the six ZIP Codes constituting this area had elevated BLLs. Hispanic children made up 17% of the children with elevated BLLs for the state as a whole and 42% in Oklahoma City, although only 3.3% of the state population in 1990 was Hispanic.[14]

Based on these findings, we initiated a project to determine the extent of contamination in two types of tamarind suckers and to model the predicted effects on population BLLs of consumption of these products.

SAMPLING AND LABORATORY TESTING

Two of the present authors (RAL and DTB) visited several local stores, obtaining 10 packages each of two types of tamarind suckers for laboratory analysis. One type (Product #1) was identical to that eaten by the child, and the other (Product #2) was from the same manufacturer but with a slightly different formulation and name. Each candy was ball-shaped and wrapped around a hollow plastic stem. Each was individually wrapped, and they were packaged in sets of two.

The wrappers of both types of suckers were bright yellow with red labeling. Based on a review of the literature and a previous FDA import alert,[6] we suspected that contaminated wrappers could be the source of exposure; therefore, candy was tested from the following zones: adjacent to the wrapper, inside the sucker, and adjacent to the stem. The stem and wrapper were also analyzed for lead. Twenty individual suckers (seeds removed) were digested in certified trace metal grade nitric acid and processed by microwave digestion. The stems and wrappers were treated with 4% glacial acetic for 24 hours. All extracted material was analyzed by GFAAS. The pH of each sucker was measured using a Hanna Instruments Foodcare pH meter.

Laboratory findings. One-quarter (5/20) of the samples of Product #1 and 80% (16/20) of the samples of Product #2 exceeded the FDA Level of Concern for lead in tamarind candy of 0.5 mg/kg. (See Table 1.) Although it is not clear if packaging from these items qualify as food contact surfaces, the wrappers of both products contained lead concentrations higher than the FDA guideline for food product surfaces (7 mg/kg).

The lead concentrations in the stems of the suckers were similar for the two products and were below the FDA guideline for food contact surfaces; however, the wrappers from all products tested were above the guideline, with a mean concentration of 20,176 mg/kg for

Table 2. Predicted geometric mean BLLs for children ages 6–84 months in Oklahoma and predicted percentages of children ages 6–84 months with BLLs ≥10 μg/dL, by frequency of consumption of two imported tamarind candy products

	Predicted geometric mean BLL (μg/dL), assuming a background geometric mean BLL of 3.7 μg/dL				*Predicted percent of children with BLLs ≥10 μg/dL, assuming a background prevalence of BLLs ≥10 μg/dL of 1.6%*			
Product	*Minimum*	*Mean*	*Median*	*Maximum*	*Minimum*	*Mean*	*Median*	*Maximum*
Product #1								
One/day	4.3	5.3	7.9	5.1	3.6	9.3	25.1	8.0
One/week	3.8	3.9	4.5	3.9	1.8	2.3	3.9	2.1
Product #2								
One/day	5.1	6.8	14.6	5.9	8.0	18.4	76.7	13.1
One/week	3.9	4.2	5.6	4.0	1.5	3.0	11.3	2.2

BLL = blood lead level

Product #1 and a mean concentration of 662 mg/kg for Product #2. The low mean pH values for the two candies combined with the volume of lead present in the wrappers (mean of 31.88 mg for Product #1 and mean of 1.05 mg for Product #2) raises the prospect that leaching of lead from the packaging could have been the source of contamination.

In an effort to investigate the migration of lead in the wrapper to the candy, we attempted to differentiate sections of the candy based on proximity to the wrapper; however, these efforts were unsatisfactory. Due to the sticky nature of the product, it was difficult to consistently dissect and extract particular zones. A procedure for reducing the inherent potential sampling error was considered an important step prior to further investigation. In addition, a lower concentration of lead was found in the candy with the higher lead concentration in the wrapper, which indicated that the wrapper might not be the primary source of the lead. Both products had dried chile and other products as ingredients; these might have contributed significant quantities of the lead measured in the products. Other factors that could also have confounded the determination of the relationship between lead in the wrapper and lead in the candy were potential differences between the two products in the leachability of lead in the wrapper and in the actual location of the lead in the wrapper.

The average net weight of the suckers (seeds removed) was 25.138 g; therefore, a child eating slightly more than one-half (57%) of a Product #1 sucker or one-quarter (28%) of a Product #2 sucker on a daily basis would exceed the FDA Provisional Total Tolerable Intake for lead of 6 μg/day.

Modeling Population Effects

We used the Integrated Exposure/Uptake Biokinetic (IEUBK) model developed by the US Environmental Protection Agency (EPA) to evaluate the effects on a population of consuming these products. Common uses of this model are to predict population mean BLLs or the prevalence of elevated BLLs (≥10 μg/dL), or to assess the effects of lead intake from various media on children's BLLs.[15]

We used the IEUBK model to predict how consumption of the two tamarind products would affect BLLs and the prevalence of elevated BLLs among children ages 6–84 months in Oklahoma. The model requires assumptions about background levels of lead in air, water, diet, soil, and dust as well as about the bioavailability of lead in these media. For this analysis, we used default levels provided with the model. Given that consumption of the tamarind suckers was not part of a "background" dietary intake, we used the "alternate" exposure pathway for consumption of the suckers with bioavailability set to the recommended level of 50%. Since the actual background level of exposure was not known for many areas, including Oklahoma City, the use of default values made the data generalizable to a wider population.

Using the default values provided, the model predicted a background geometric mean blood level of 3.7 μg/dL for any population of children ages 6–84 months. Given mean blood levels of 3.8 μg/dl for children tested in Oklahoma and 3.4 μg/dL for children tested in Oklahoma City, the risk of overestimation using the default values was not viewed as problematic. In fact, the model predicted a prevalence of elevated BLLs of 1.6% among children ages 6–84 months, based on default values, which was less than the 3.8% prevalence in the Oklahoma database, suggesting that the risk for the Oklahoma population is underestimated when default values are used.

In order to assess the population effects of sucker consumption, we entered different potential lead consumption values, based on lead concentration and mass per sucker, into the IEUBK model (see Table 2). We calculated the effects on population BLLs of eating one sucker per day and one sucker per week for each of the two products. The effect of consuming candy was associated with increases in the population geometric mean BLL and the percentage of children with elevated BLLs at all levels of the data distribution. Consuming candy containing the mean concentration of lead at the rate of once per day was predicted to result in a 43% increase in the geometric mean BLL for children ages 6–84 months in Oklahoma for Product #1 and a 84% increase for Product #2, compared with a baseline BLL of 3.7 μg/dL. Once-per-week consumption was predicted to raise mean BLLs by 5% for Product #1 and 14% for Product #2.

The effects of candy consumption on the percentage of children with BLLs ≥10 μg/dL better illustrates the potential for harm from these products. Consuming candy containing the mean concentration of lead at the rate of once per day was predicted to result in a more than five-fold increase in the prevalence of BLLs ≥10 μg/dL for Product #1 and an 11-fold increase for Product #2, while once per week consumption was predicted to raise prevalence levels by 6% for Product #1 and 88% for Product #2.

Table 3. Predicted levels of consumption of two imported tamarind candy products required to raise the proportion of children ages 6–84 months with BLLs ≥10 μg/dL to selected percentages

	Predicted number of suckers eaten/day			
	Product #1		*Product #2*	
Percentage of children ages 6–84 months with BLLs ≥10 μg/dL	*Assuming background prevalence of 1.6%[a]*	*Without background*	*Assuming background prevalence of 1.6%[a]*	*Without background*
5	0.52	1.95	0.26	0.96
10	1.08	2.52	0.53	1.24
15	1.64	3.09	0.81	1.53
20	2.20	3.66	1.09	1.81
25	2.76	4.23	1.37	2.09

[a]Prevalence of children ages 6–84 months with BLLs ≥10 μg/dL

BLL = blood lead level

We also used the IEUBK model to predict the amounts of these products that would have to be eaten to raise the proportion of the population with elevated BLLs to specific levels, based on both a presumed background prevalence of elevated BLLs of 1.6% and no background exposure (Table 3). Although the size of the population that consumed these products and consumption rates were both unknown, the model demonstrated that consumption of either of these products at a rate of approximately one-half to one sucker per day would raise the percentage of children ages 6–84 months with elevated BLLs as much as 10%. Even without the presumed background levels, consumption of these products would significantly raise the number of children with elevated BLLs.

DISCUSSION

These data provided convincing evidence that the two products tested contained unacceptable levels of lead, with potentially serious consequences for children who consumed them. Therefore, they represented a potentially significant public health threat. It is difficult to imagine that public health goals of reducing the prevalence of children with elevated BLLs could be achieved if these or similar products were in regular use in any population. The IEUBK model predicted that consumption of even one sucker per day would result in significant increases in both the population geometric mean BLL and the prevalence of children with elevated BLLs.

The actual source of contamination has not been fully explained. The data showed that both wrappers and stems were contaminated; however, these data were inconclusive. Given the pH of the candy, leaching from the wrapper and stems seemed probable. In particular, there appeared to be a significant potential for exposure associated with handling or mouthing the wrapper of Product #1.

Despite the efforts of regulatory authorities, the importation and distribution of lead-contaminated products continues. The pathway through which the two products tested in this study entered this country, and ultimately the retail marketplace, is unknown, as is the volume of these products imported and sold. It is possible that these two products represent an isolated case; however, given the history of tamarind products, this seems unlikely. It should be emphasized that these products were are typically purchased at large supermarkets rather than small ethnically specific shops and that they are readily available in many areas of central Oklahoma, not just confined to specific city neighborhoods. Although these products are obviously directed toward Spanish-speaking consumers, their use by other ethnic groups whose food culture involves the consumption of tamarind products also poses a potential health threat.

The recurrence of this type of contamination is problematic. It is obvious that testing of all products entering the country for all toxic or potentially toxic constituents is impossible; however, tamarind products may warrant special attention due to a history of contamination. Portable X-ray fluorescence instruments are now readily available, and as demonstrated by the investigations reported here, can be effective in screening products or in confirming contamination by lead or other metals. The specific sources of contamination must be identified if effective prevention and regulatory strategies are to be implemented. The tamarind suckers could have become contaminated by contact with the wrapper and stem during the manufacturing process; however, it is possible that some or all of the contamination occurred at other stages of production or distribution.

The anticipated growth of the Hispanic population in the United States will likely be accompanied by a proportionate increase in importation of products to satisfy consumer demands. In addition, the implementation of the North American Free Trade Agreement will likely contribute to a less restricted flow of products across the border. At the same time, the language barrier can make communication of public health information difficult. Culturally sensitive interventions are needed to address the use of potentially contaminated products, while at the policy level, energy should be exerted to see that products imported are safe for their intended use.

Because not all countries have agencies as vigilant as the FDA or state and local public health agencies, it seems likely that with steadily increasing immigration, increasingly free trade, and a limited ability to identify potentially toxic imported foods, problems of the nature described here can be anticipated to increase. Interventional foodstuffs surveillance is difficult at best; therefore, effective collaboration between agencies at all levels is vital if the appropriate interventions are to be developed and implemented.

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