Journal of Food Protection, Vol. 69, No. 1, 2006, Pages 233–237

General Interest

Recalls of Spices Due to Bacterial Contamination Monitored by the U.S. Food and Drug Administration: The Predominance of Salmonellae

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MS 05-288: Received 13 June 2005/Accepted 4 October 2005

ABSTRACT

From 1980 to 2000, the annual per capita consumption of spices in the United States increased by 60% (from 1.0 to 1.6 kg per person per year). Although spices are known to harbor various molds, fungi, and bacteria, relatively few reports have documented this group of foods as the cause of human illness. In recent years, however, the U.S. Food and Drug Administration (FDA) has noted an increased number of recalls of dried spices due to bacterial contamination. Accordingly, we reviewed spice recalls that took place in the United States from fiscal years 1970 to 2003. During the study period, the FDA monitored 21 recalls involving 12 spice types contaminated with bacterial pathogens; in all but one instance, the recalled spices contained *Salmonella.* Paprika was the spice most often involved in the recalls. A wide variety of countries were the source of the recalled spices. Using data from the Centers for Disease Control and Prevention National *Salmonella* Surveillance System, we were unable to discern any increases in the reported incidence of laboratory-confirmed salmonellosis in states that received spices contaminated with selected rare *Salmonella* serotypes. A variety of effective methods exist to disinfect spices, procedures that have attained increased importance given the frequent use of spices in ready-to-eat foods and the potential for contaminated spices to cause widespread outbreaks.

Foodborne illnesses impose a major burden on public health in the United States, accounting for an estimated 76 million episodes of illness each year at a cost of approximately $5 billion to $6 billion in direct medical expenses and lost productivity *(11, 15).* Norovirus, along with other viruses, may cause as much as two thirds of the foodborne diseases of known etiology; bacterial agents, however, are believed to account for approximately 30% of the foodborne illnesses *(11)* and cause infections of greater morbidity and mortality than those due to viruses. *Campylobacter* and *Salmonella* are the leading causes of bacterial foodborne illness. An estimated 95% of the salmonellosis cases result from the ingestion of contaminated foods and beverages *(11).*

Although spices are sometimes known to harbor various molds *(5),* fungi *(7, 9),* and bacteria *(12, 13),* relatively few reports have documented spices as the cause of human illness *(6, 10).* In 1993, contaminated potato chips seasoned with paprika imported from South America were responsible for more than 1,000 cases of salmonellosis in Germany *(10)*; a variety of serotypes were recovered from both patients and paprika-containing foods. A decade earlier (i.e., 1981 to 1982) in Norway, black pepper imported from Brazil via Germany caused an outbreak, with 126 culture-confirmed cases of *Salmonella* Oranienburg infection *(6).*

In its regulatory role of monitoring foods under recall, the Center for Food Safety and Applied Nutrition (CFSAN) of the U.S. Food and Drug Administration (FDA) has noted an increase in recent years in the number of recalls of dried spices due to bacterial contamination. For example, whereas only two such recalls occurred during the 1990s, 16 recalls were monitored from fiscal year 2000 through the first quarter of 2004. We reviewed CFSAN records from 1 October 1969 to 31 December 2003 to determine the types of spices recalled for bacterial contamination, the countries of origin of the spices, and the bacterial pathogens responsible for the recalls. Because *Salmonella* accounted for all but one of these recalls, we reviewed serotype-specific human *Salmonella* surveillance data maintained by the Centers for Disease Control and Prevention (CDC) to determine whether any of the spices had caused a discernible increase in laboratory-confirmed *Salmonella* infections reported to the CDC before and immediately following the recall. We summarize our findings in this article.

MATERIALS AND METHODS

We defined a ‘‘spice’’ as any aromatic vegetable substance in whole, broken, or ground form whose function in food is primarily for seasoning, rather than for nutritional value, and from which no portion of any volatile oil or other flavoring principle

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has been removed *(1)*. A complete list of spices is provided in the FDA *Code of Federal Regulations*, chapter 21, §182.10. Consistent with this definition of spice, we excluded onions, garlic, and celery, because these substances traditionally have been regarded as "foods."

To determine the number of spice recalls due to bacterial contamination, as monitored by the FDA, we reviewed recall records at CFSAN from 1 October 1969 to 31 December 2003. We recorded the following information: product; container size; name and address of manufacturer; name of recalling firm; dates, distribution pattern, and volume of product entered into commerce; and bacterial pathogens recovered from the product.

Recalled spices could involve imported or domestically produced spices. To gauge the volume of spices imported from 1 October 2002 to 30 September 2003 (fiscal year 2003, the most recent year for which data were available), we reviewed the Operational and Administrative System for Import Support (OASIS) of the FDA, an automated system for tracking imports that captures, among other variables, the type of product imported, the country of origin of the product, the name of the product manufacturer, the name of the shipper, and the name of the consignee *(16)*. Because the quantity of each product imported is an optional data element within OASIS, we gauged the volume of spices imported during fiscal year 2003 using two approaches: (i) from data entered into OASIS, we tallied the weights of imported spices (this data field, however, was only approximately 90% complete for spice transactions) and (ii) we summed the number of data lines within OASIS that were dedicated to spice imports (so-called spice-lines), each spice-line capturing a unique manufacturer–consignee transaction. We also determined the number of instances in which spices had been refused entry into the United States, the reasons for these refusals, and the refusal rates by country. Possible reasons for spice refusals included microbiological contamination, filth or unapproved pesticides, labeling issues, foreign objects, and incorrect product identity. For OASIS data mining, we identified spices using industry codes 28A and 28B (industry code 28 is "Spices, Flavors, and Salts").

Finally, to assess whether there may have been reported illnesses in the United States stemming from the consumption of contaminated spices, we examined recalls that met the following conditions: (i) some portion of the contaminated lot had been marketed to consumers (as opposed to recalls in which the complete lot had been retrieved before reaching the consumer level) and (ii) contamination had involved infrequently reported *Salmonella* serotypes, defined in this study as serotypes for which fewer than 200 laboratory-confirmed infections had been reported per year, on average, to the CDC National *Salmonella* Surveillance System from 1992 to 2002. For the recalls that met these conditions, we compared the number of laboratory-confirmed infections reported for each spice-associated *Salmonella* serotype during the 12- and 18-month period before each spice had been marketed with the number of laboratory-confirmed infections reported during the 12- and 18-month period after each spice was marketed.

RESULTS

During the study period, the FDA monitored 21 recalls involving 12 spice types contaminated with bacterial pathogens (Table 1). In all but one instance, the recalled spices contained *Salmonella*. The exception was a recall of bay leaves contaminated with *Listeria monocytogenes*. Information about *Salmonella* serotypes was available for 10 recalls as follows: Senftenberg (two recalls), Ohio, Haifa, Bispebjerg, Salford, Gaminara, Karlshamn, Onderstepoort, and Derby. Although five of these recalls transpired during the preceding 30 years (one each in 1971, 1983, 1989, 1995, and 1996), the remaining 16 (76%) occurred during fiscal years 2001 to 2004. The country of origin of the spice was known for 15 recalls: 12 involved imported spices (India [three recalls], Spain [three recalls], Turkey [two recalls], and one recall each from Egypt, Jamaica, Mexico, and Taiwan), and the remaining three involved domestically produced spices (two recalls due to *Salmonella* and one recall due to *L. monocytogenes*). Contamination of the spices was discovered by authorities in state health or agricultural departments in 12 recall instances and by the FDA in 6 recall situations (no information was available in this regard for the remaining three recalls).

TABLE 1. *Spice recalls due to bacterial contamination monitored by the U.S. Food and Drug Administration, 1 October 1969 to 31 December 2003*

Spice	No. of recalls
Basil leaves	1
Bay leaves	1[a]
Black pepper (ground)	1
Cerase spice	1
Cumin (ground)	2
Oregano (ground)	3
Paprika	4
Red pepper (powder)	1
Sage (ground)	2
Sesame seeds	3[b]
Thyme (ground)	2[c]
Total	21

[a] Contaminated with *Listeria monocytogenes*, all other products listed in table contaminated with *Salmonella*.
[b] Two of the three recalls involved the same bulk lot of sesame seeds (one recall involved plain sesame seeds, and the other recall involved green seasonings that contained sesame seeds); the third recall entailed "Sesame seed Anjoli," a product that consisted of almondlike seeds often used in oriental cuisine as a garnish, as an hors d'oeuvre, or as a salad ingredient.
[c] One product was a combination of ground thyme and poultry seasonings.

The volume of the contaminated product introduced into commerce before the recalls varied greatly, ranging from 26 kg in one episode to 15,876 kg in the largest episode (median, 864 kg). To our knowledge, in all instances but one, the contaminated spices were available for purchase by consumers; the exception involved a shipment of oregano contaminated with *Salmonella* Bispebjerg that went only to restaurants. For three recall events, contaminated spices were distributed to only one state, whereas in the remaining events, contaminated products were shipped to multiple states, territories, or nations. Although the domestic recall effort was successful in retrieving much or, in some recalls, all of the contaminated spices, insufficient records were available to quantify the amounts that were not retrieved.

Data from OASIS indicated that 278×10^9 kg of spic-

TABLE 2. *Country of origin of spices imported by the United States, by weight and spice-lines, for fiscal year 2003*

Weight		Spice-lines[a]	
Nation	Amt (10^9 kg)	Nation	No. of spice-lines
China	237.5	Mexico	21,081
Honduras	20.9	Canada	19,898
Mexico	11.0	India	9,374
Lebanon	3.3	United States	8,986[b]
Peru	1.3	China	6,431
India	1.0	Colombia	6,218
Chile	0.73	Israel	5,693
Spain	0.34	Indonesia	2,918
Morocco	0.32	Spain	2,386
Argentina	0.26	Peru	2,072

[a] A spice-line refers to a data line within the FDA's Operational and Administrative System for Import Support (OASIS) database and designates a unique manufacturer–consignee transaction.

[b] Represents exports of spices from the United States that are then returned as ''American Goods Returned'' because of specific problems.

es were imported by the United States from 129 nations during fiscal year 2003. Overall, there were 6,112 unique spice manufacturers in the 129 nations from which the United States imported spices; the three countries with the leading numbers of spice manufacturers were India (629 manufacturers), China (547), and Mexico (441). During fiscal year 2003, there were 9,911 unique spice consignees in the United States who purchased imported spices. Approximately 85% of the spices imported in fiscal year 2003 were produced in China, and the next four leading spice exporters to the United States—Honduras, Mexico, Lebanon, and Peru—contributed an additional 13% (Table 2). In fiscal year 2003, spice transactions within OASIS accounted for 2% of all lines assigned to food industry codes 02–50 (105,440 of 5,080,027 lines). As Table 2 illustrates, the ranking of countries from which the United States imported spices differed, depending on whether one assessed the rank by spice weight or spice-lines.

A relatively small percentage of spices was refused entry into the United States. Specifically, of the 105,440 spice-lines within OASIS, 258 spice-lines were coded as ''refusals'' (0.2%), and of these 258 spice-line refusals, 178 (69%) were refused because the manufacturer had a history of shipping *Salmonella*-contaminated spices. In 131 (74%) of these 178 refusals, the importer chose not to challenge the refusal; in 44 (25%) instances, *Salmonella* was shown to be present by laboratory analysis. In the remaining three (1%) instances, the spices were refused because of the presence of mold or filth. Although a total of 360 charges of all kinds were assigned to the 258 spice-line refusals, concern about *Salmonella* contamination accounted for 178 (49%) of the charges. Of the 10 countries that recorded the most spice-lines within OASIS (Table 2), the three with the greatest percentages of spice-line refusals that resulted from a concern about *Salmonella* contamination were India (0.9%), Spain (0.1%), and China (0.08%).

The time between the marketing of contaminated spices and the initiation of recalls varied from 1 to 18 months (Table 3). Using data from the National *Salmonella* Surveillance System, we found no indication of any increase in the number of laboratory-confirmed serotype-specific *Salmonella* infections in the 12 or 18 months after the distribution of contaminated spices in states where contaminated spices were distributed. In all, nine recalls were analyzed in this fashion.

DISCUSSION

Studies have shown that spices available at the retail level may contain a variety of bacteria and fungi *(9, 13)*. Some, however, harbor antiseptic and disinfectant components in their essential oils that may decrease the risk of

TABLE 3. *Recall of contaminated spices monitored by the U.S. Food and Drug Administration, 1 October 2000 to 31 December 2003, by product,* Salmonella *serotype, duration of spice on market, number of states receiving spice, and number of human infections with respective* Salmonella *serotype reported to the Centers for Disease Control Prevention before and after marketing of spice*

Recall fiscal year	Product	*Salmonella* serotype	Duration of spice on market (mo)	No. of states receiving spice	Human *Salmonella* isolations: Premarket[a]	Human *Salmonella* isolations: Postmarket[b]
2001	Paprika	Ohio	2.5	7	143	86
2002	Oregano	Bispebjerg	4	1	0	1
2002	Sesame seeds[c]	Senftenberg	2.7	13	225	175
2002	Basil leaves	Haifa	6.5	1	10	8
2003	Ground cumin	Onderstepoort	5	27	4	1[d]
2003	Paprika	Karlshamn	1	2	0	0[d]
2003	Ground sage	Gaminara	18	50	86	74
2003	Ground cumin	Salford	5.4	1	0	0
2004	Red pepper powder	Derby	3	3	221	84[d]

[a] Number of reports of laboratory-confirmed infections of respective *Salmonella* serotypes reported to the CDC's National *Salmonella* Surveillance System for the 18-month period preceding the initial spice marketing date for regions where spice was marketed.

[b] Number of reports of laboratory-confirmed infections of respective *Salmonella* serotypes reported to the CDC's National *Salmonella* Surveillance System during the 18-month period following the initial distribution of spices to states receiving contaminated products.

[c] Includes sesame seeds (one recall) and green seasonings containing contaminated sesame seeds (one recall).

[d] Not full-time period because data available only through the end of 2003.

them causing illness *(5, 14)*. For example, one study demonstrated that cloves markedly inhibit the growth of *Salmonella* Mbandaka *(12)*, whereas three other spices—basil, oregano, and thyme—have been reported to show antimicrobial effects against *Shigella sonnei* and *Shigella flexneri* *(4)*. Nevertheless, under the right conditions, a variety of organisms recovered from spices have the potential to induce human illness, including aflatoxin-producing fungi (e.g., *Aspergillus* spp.), *Bacillus cereus*, *Clostridium perfringens*, *Escherichia coli*, and *Salmonella* *(5, 9, 10, 12, 13)*. Spices that have been shown to be contaminated with *Salmonella* include paprika *(5, 12, 13)*, black peppercorns *(12, 13)*, white peppercorns *(12)*, black pepper *(5)*, and fenugreek seeds *(12)*. The findings from the present study extend the list by including basil leaves, cerasse spice, cumin, oregano, red pepper powder, sage, sesame seeds, and thyme. Such contamination is significant, because spices are often added to foods that undergo no further heat treatment; as a result, the surviving pathogens have the potential to cross-contaminate other foods and to multiply to higher levels under favorable conditions.

Relatively little information exists concerning the prevalence of *Salmonella* in spices. An assessment of the microbiological quality of spices imported by Australia recovered *Salmonella* from 8.2% of black peppercorn samples, 1.5% of white peppercorn samples, and 7.1% of fenugreek seed samples *(12)*. When present, the quantity of *Salmonella* in spices has been reported to be low *(5, 10)*. For example, a quantitative analysis performed on a sample of paprika powder implicated in the national outbreak of multiple-serotype salmonellosis in Germany in 1993 yielded 2.5 *Salmonellae* per g *(10)*. A second count performed on the sample 8 months later detected a level of 0.7 *Salmonella* per g, which illustrates the ability of this pathogen to survive for prolonged periods in a dry vehicle. By comparison, levels of 0.04 to 0.45 *Salmonella* per g were found in the implicated paprika-seasoned potato chips, yielding a calculated infective dose of 4 to 45 culturable organisms per 100-g consumed portion, a finding that underscores the importance of preventing *Salmonella* contamination in ready-to-eat (RTE) foods.

It is likely that differences in spice-harvesting methods contribute to the microbial load of spices. For example, Pafumi *(12)* reported higher microbial counts (defined as counts of yeasts, molds, coliforms, *E. coli, B. cereus, C. perfringens,* and *Salmonella*) among samples of black peppercorns than among samples of white peppercorns. This finding was attributed to the harvesting of black pepper, which originates from green or unripe berries that are sun dried, whereas white berries are picked later and soaked in water to remove the outer skin before being sun dried, an additional step that may diminish bacterial counts *(12)*.

It is also likely that the multiple steps involved in the production and distribution of spices serve as potential points for *Salmonella* contamination. Furthermore, the finding that the United States imported spices from 6,112 manufacturers in 129 nations in a single year underscores the complexity of spice distribution. Contamination may occur, for example, following the contact of spices with animal or human feces, or with insects, during growing, harvest, storage, shipping, or packaging. For example, Christensen et al. *(7)* noted rodent droppings and insect excreta in a sample of peppercorns. On the other hand, in a microbiological survey of selected imported spices and associated fecal pellet specimens, Satchell et al. *(13)* observed no relationship between the enteric microflora of the spices and that of the fecal pellets recovered from the spices.

Sixteen (76%) of the recalls occurred during the last 4 years of the study period, whereas the remaining five transpired over the preceding 30 years. The recent increase was largely due to enhanced surveillance efforts undertaken by the Florida Department of Agriculture and the FDA in response to the discovery of contaminated spices at a Florida firm in 2001. Four separate recalls of spices marketed by this firm took place in 2001 to 2002. Six additional recalls of spices that involved other Florida firms took place during the final 4 years of the study period. Thus, 10 of the 16 recalls that occurred from 2001 to the end of the study period involved Florida firms.

Using data from the National *Salmonella* Surveillance System, we were unable to discern any notable increases in the number of reported laboratory-confirmed cases of human salmonellosis caused by the rare serotypes recovered from contaminated spices. This was true regardless of the period for which the surveillance data were scrutinized (i.e., both before and after the marketing of the contaminated spices in the respective states). Ideally, efforts should be expended in the future to promptly determine the serotype of all *Salmonella* isolates recovered from marketed spices so that cases of human illness resulting from the consumption of such spices can be readily identified, and public health action can be undertaken.

Despite our inability to find a discernible increase in serotype-specific salmonellosis linked to contaminated spices, we cannot rule out the possibility that the contaminated spices resulted in human illness. Contaminated spices may have caused illness among persons who did not have a laboratory-confirmed infection reported to the CDC. For example, ill patients may not have sought medical care, or, if they did, a specimen may not have been collected. Furthermore, contaminated spices may have caused illness among persons with laboratory-confirmed infections that were reported to the CDC, but because there was no overall increase in the number of serotype-specific infections, no attribution of illness to spices was made. The use of more sensitive subtyping procedures, including molecular subtyping techniques such as pulsed-field gel electrophoresis, might have enabled the detection of such associations. Finally, it is possible that there were errors in the dates of spice distribution reported to the FDA, an occurrence that would have impeded our ability to detect increases in spice-associated infections.

On the other hand, if the contaminated spices resulted in no human illness, several explanations may be possible, including (i) the level of contamination may have been insufficient to allow the spices to serve as efficient vehicles of infection or (ii) contamination may have been uneven, such that even though one portion yielded the pathogen, the remaining fraction may have been devoid of *Salmonella*. Finally, at the consumer level, culinary practices often, but not always, call for spices to be added to recipes before cooking, a step that subjects bacteria to the inactivating effects of heat.

The finding by Lehmacher et al. *(10)* that a spice—paprika, in this instance—contaminated with low numbers of *Salmonella* led to a nationwide outbreak underscores the requirement that spices be pathogen free at the time of marketing. This is particularly true, given that spices are often added to RTE foods. A number of methods exist to reduce or eliminate pathogens from spices (e.g., the use ethylene oxide, heat treatment, or irradiation [UV, infrared, or gamma]). Ethylene oxide is highly diffusive; is simple to use; does not significantly alter either the aromatic or flavor components of spices (unlike heat treatment, which can destroy the aromatic and flavor components of spices as well as their color *(12)*); and is effective in destroying microorganisms *(18)*. However, the effect of ethylene oxide on spores is not as great as it is for vegetative cells *(12)*. The FDA has established a maximum tolerance of 50 ppm for residues of ethylene oxide in ground spices *(2)*. On the other hand, at least one study has suggested that irradiation represents the most effective and safe method of treatment of spices, and it is a process that yields no toxic by-products *(17)*. For the microbial disinfection of spices, the FDA has established that, when irradiation is used, the maximum dose should not exceed 30 kilogray (3 Mrad) *(3)*.

Recent trends suggest that the consumption of spices in the United States will continue to increase. From 1980 to 2000, for example, annual per capita consumption increased 60% (from approximately 1.0 to 1.6 kg per person per year) *(8)*. Importantly, the growth in spice imports varied by spice, with oregano—the leading spice in terms of quantity imported and dollar value of sales—increasing from approximately 2,800 tons in 1980 to just more than 6,200 tons in 2000, a 121% increase *(8)*. In descending rank, following oregano, were imports of basil, sage, laurel leaves, parsley, mint leaves, and thyme. In view of the potential for contaminated spices to cause widespread outbreaks, such as the outbreak that occurred in Germany in 1993, as well as the widespread use of spices in RTE foods, these figures highlight the need to maintain rigorous standards in spice production, distribution, and sales.

ACKNOWLEDGMENTS

The authors acknowledge Richard Bishop and Edward Reeves of the Biostatistics and Information Management Branch, Division of Bacterial and Mycotic Diseases, Centers for Disease Control and Prevention, for their efforts in maintaining the National *Salmonella* Surveillance System, and Linda Fabbri, Center for Food Safety and Applied Nutrition, Food and Drug Administration, for her assistance in reporting spice import data.

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