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Outbreaks Associated with Cantaloupe, Watermelon, and Honeydew in the United States, 1973–2011

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Abstract

Fresh fruits and vegetables are an important part of a healthy diet. Melons have been associated with enteric infections. We reviewed outbreaks reported to the Centers for Disease Control and Prevention's Foodborne Disease Outbreak Surveillance System during 1973–2011 in which the implicated food was a single melon type. We also reviewed published literature and records obtained from investigating agencies. During 1973–2011, 34 outbreaks caused by a single melon type were reported, resulting in 3602 illnesses, 322 hospitalizations, 46 deaths, and 3 fetal losses. Cantaloupes accounted for 19 outbreaks (56%), followed by watermelons (13, 38%) and honeydew (2, 6%). Melon-associated outbreaks increased from 0.5 outbreaks per year during 1973–1991 to 1.3 during 1992–2011. *Salmonella* was the most common etiology reported (19, 56%), followed by norovirus (5, 15%). Among 13 outbreaks with information available, melons imported from Mexico and Central America were implicated in 9 outbreaks (69%) and domestically grown melons were implicated in 4 outbreaks (31%). The point of contamination was known for 20 outbreaks; contamination occurred most commonly during growth, harvesting, processing, or packaging (13, 65%). Preventive measures focused on reducing bacterial contamination of melons both domestically and internationally could decrease the number and severity of melon-associated outbreaks.

Introduction

Consumption of fresh produce in the United States has increased over the last 40 years (United States General Accounting Office, 2002). Global trade has allowed American consumers to expect year-round availability of fresh fruits and vegetables (Pollack, 2001). In addition, initiatives to combat chronic diseases have brought awareness of the nutritional value of fresh produce as part of a healthy diet (United States General Accounting Office, 2002). At the same time, an increasing number of foodborne disease outbreaks have been

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associated with fresh produce (Lynch *et al.*, 2009). Between 1973 and 1987, fresh produce caused only 2% of reported foodborne disease outbreaks (Sivapalasingam *et al.*, 2004), but by 2009–2010 fresh produce was implicated in 23% (CDC, 2013b).

Melons are frequently implicated in produce-associated outbreaks (Sivapalasingam *et al.*, 2004). For example, recurrent outbreaks of *Salmonella enterica* serotype Poona infections associated with Mexican cantaloupes occurred annually from 2000 to 2002, resulting in importation restrictions for implicated producers (CDC, 2002). More recently, the possible severity of outbreaks caused by contaminated melons was underscored by the 2011 outbreak of *Listeria monocytogenes* infections caused by contaminated cantaloupes; it was the deadliest foodborne outbreak in the United States since the 1920s (CDC, 2011b). To better understand the frequency and characteristics of melon-associated outbreaks, we examined data reported to the Centers for Disease Control and Prevention's (CDC) Food-borne Disease Outbreak Surveillance System (FDOSS).

Materials and Methods

State, local, territorial, and tribal health departments voluntarily submit reports of foodborne disease outbreaks to FDOSS. We defined melon-associated outbreaks as the occurrence of similar illnesses in ≥ 2 persons resulting from consumption of a melon, including cantaloupe (or musk-melon), watermelon, or honeydew. We defined multistate outbreaks as those where illnesses linked to ingestion of melons occurred in more than one state. For this analysis, we defined precut melons as fresh whole melons that were sliced or cut, with or without washing, before use by the consumer or retail establishment (Fleming *et al.*, 2005).

We analyzed outbreak frequency, size, month and year, geographic location, case demographics (i.e., sex and age group), number of hospitalizations and deaths, etiologies (confirmed and suspected), location of food preparation, and type of melon reported. We analyzed the points of melon contamination (production or point of service) as well as their origin (imported or domestic). We defined contamination at the point of service as contamination caused by either an implicated foodworker or cross-contamination with other foods. We assumed that if a food-worker was implicated as the source, contamination occurred during food preparation at the point of service. We defined contamination that occurred during production as contamination that occurred during growth, harvesting, processing, or packaging before the point of service. We categorized reported locations of food preparation into six groups: restaurant, private home, grocery store, institution (e.g., camp, school, and day care), other, and multiple locations (i.e., more than one location reported). We corrected missing or incompletely reported data by reviewing published literature and by contacting the agencies that conducted the investigation.

We used food availability, consumption, and supply data on fresh melons from 1973 to 2010 from the United States Department of Agriculture's Economic Research Service (USDA, 2012) and from CDC's FoodNet Population Survey (CDC, 2007) to estimate melon consumption to determine whether changes in consumption were correlated with changes in outbreak frequency using the Pearson correlation test. We analyzed data using SAS Version

9.3 (SAS Institute, Cary, NC) and Microsoft Access 2010 and Microsoft Excel 2010 (Microsoft, Redmond, WA).

Results

During 1973–2011, 34 outbreaks caused by the consumption of cantaloupes, watermelons, or honeydews were reported, resulting in 3602 illnesses, 322 hospitalizations, 46 deaths, and 3 fetal losses (Table 1). Outbreak reports specifying more than 1 type of melon (12 outbreaks), in which the melon type was unspecified (8), or in which melons and other fruits were reported (e.g., fruit salad, 43), were excluded from analysis. Cantaloupes were the most commonly reported melon type (19 outbreaks, 56%), followed by watermelons (13, 38%) and honeydews (2, 6%). Outbreaks occurred in 45 states; California reported the most (16), followed by Colorado (11), Oregon (11), and Washington (10).

The frequency of melon-associated outbreaks increased from 0.5 outbreaks per year during 1973–1991 to 1.3 per year during 1992–2011 (Fig. 1). During the study period (1973–2011), the per capita consumption of watermelons (14 lb/y) was greater than that of cantaloupes (9 lb/y) or honeydews (2 lb/y) (Fig. 1). More recently, the per capita consumption of cantaloupes decreased from 11.1 lb in 2000 to 8.5 lb in 2010, while the per capita consumption of watermelons increased, from 13.8 lb in 2000 to 15.4 lb in 2010. Changes in consumption were weakly correlated with changes in the number of outbreaks caused by any type of melon ($r = 0.35$ for watermelon, $r = -0.15$ cantaloupe).

More illnesses in these outbreaks involved women than men (cantaloupes: 61% women; watermelons: 67%; honeydews: 58%). In outbreaks attributed to cantaloupes, 68% of illnesses were among persons aged > 50 years old, compared with 54% in outbreaks caused by honeydews and 19% in outbreaks caused by watermelons. Outbreaks caused by watermelons more commonly affected young children (1–4 years old: 42%) than outbreaks caused by cantaloupes (3%) and honeydews (5%).

Outbreaks were most often caused by *Salmonella* (19 outbreaks, 56%), followed by norovirus (5 outbreaks, 15%) (Table 2). The etiology was confirmed in all but one outbreak in which norovirus was suspected. Of the 12 *Salmonella enterica* serotypes reported, the two most common were Poona and Javiana. Their frequency varied by melon type; Poona was always associated with cantaloupes (four of four Poona outbreaks) and Javiana most commonly with watermelons (three of four Javiana outbreaks).

The location of preparation was reported for 29 outbreaks (85%) (Table 2). Among the 17 (59%) with a single preparation location, restaurant or deli (6 outbreaks, 35%), grocery store (4, 24%), and private home (3, 18%) were most commonly reported.

Among 20 outbreaks (59%) with available contamination information, melons were contaminated during production in 13 (65%) and at the point of service in 7 (35%). Among 22 outbreaks with information available, precutting of melons was reported as contributing to contamination for 17 (77%). Among 13 outbreaks attributed to contamination during production, 9 outbreaks (69%) involved imported melons and 4 outbreaks (31%) involved domestically grown melons. Among the outbreaks caused by imported melons, 8 (88%)

were caused by cantaloupes and 1 (13%) by honeydews. The annual occurrence of outbreaks caused by melons from domestic and imported sources varied, but followed production patterns (Fig. 2a). Melon-associated outbreaks occurred most often during June–August (50%) (Fig. 2b). Outbreaks associated with melons contaminated during production and imported (n = 9) were only reported during winter months; outbreaks associated with melons contaminated during production and domestically grown (n = 4) were only reported during summer months.

There were 13 (38%) multistate outbreaks (Table 3). Of these, 11 (85%) were caused by cantaloupes, 1 (8%) by watermelon, and 1 (8%) by honeydew. The median number of states involved in multistate outbreaks was 10 (range: 5–30). Multistate outbreaks (median number of cases: 50 [range: 10–949]) were generally larger than single-state outbreaks (18 [range: 4–736]). Many multistate outbreaks (8, 62%) were caused by melons imported from Mexico and Central America (Table 3). Two multistate outbreaks were caused by domestically grown melons from Colorado and California. For most of the multistate outbreaks (10, 77%), the initial contamination occurred during production; for 3 (23%) the source of contamination could not be determined.

Discussion

The average annual number of outbreaks caused by melons in the United States increased during 1973–2011. Changes in melon consumption are unlikely to explain the observed increase in melon outbreaks; cantaloupe was the most common melon type reported in outbreaks, yet in recent years cantaloupe consumption has decreased. Several other explanations for the increase in melon-associated outbreaks are possible. Enhancements in outbreak detection, investigation, and reporting may have led to an increase in the number of reported outbreaks in recent years. In 1996, the national molecular subtyping network (PulseNet) was established to identify cases of enteric illnesses with similar bacterial strains and improve outbreak detection (Swaminathan *et al.*, 2001). National participation in PulseNet for *Salmonella* isolates was reached in 2001, and the number of *Salmonella* isolates subtyped increased almost ninefold between 2001 and 2012 (Peter Gerner-Smidt, CDC, personal communication). Increased PulseNet participation likely contributed to an increased number of multistate outbreaks detected, including those attributed to melons (CDC, 2013a). In addition, reporting of foodborne disease outbreaks transitioned from paper-based to electronic reporting in 1998, and the number of outbreaks reported doubled (CDC, 2006). The increase in melon-associated outbreaks may in part be a result of these enhancements in detection and reporting. These changes have also been noted for other food commodities (CDC, 2013b).

Cantaloupes accounted for more than half of outbreaks attributed to melons; this is likely due in part to differences in the physical attributes of cantaloupe compared with other melon types. Cantaloupes have rough, netted surfaces that make them more difficult to clean. Surface irregularities such as roughness, crevices, and pits increase bacterial adherence and reduce the ability of washing treatments to remove bacterial cells (Frank *et al.*, 1990; Austin *et al.*, 1995). Once present on the surface of a cantaloupe, specifically on and within the ridges and corky tissues of the netting, pathogens cannot be completely eliminated by

washing (Parnell *et al.*, 2005). In comparison, watermelons and honeydews have smoother surfaces that are more amenable to pathogen removal by washing; also, efforts to reduce microbial contamination on the rind have been shown to be more effective with honeydews than cantaloupes (Ukuku, 2004). In addition, biofilms readily form on cantaloupe rinds and are resistant to antimicrobial agents (Annous *et al.*, 2005). Precut melons were implicated in many of these outbreaks. During the 1990s, changes in retail marketing made melons more widely available to consumers as precut, convenience products (Boriss *et al.*, 2006). In 2003, melons, including fruit salads and melon mixes, accounted for 65% of precut products (Mayen *et al.*, 2003). Precutting melons leads to additional opportunities for contamination and pathogen amplification. Slicing into a melon can transfer pathogens from the surface to the edible flesh (Patil *et al.*, 2013), or may lead to cross-contamination of other melons. Bacterial pathogens grow rapidly on the edible flesh of cut melons held at room temperatures (Golden *et al.*, 1993; Ukuku *et al.*, 2012).

The initial source of contamination in most outbreaks, particularly those that were multistate, was during production. Because melons are grown on the ground, their surfaces can become contaminated with dirt, chemicals, animal excreta, and bacteria. The most common *Salmonella* serotypes implicated in outbreaks, Poona and Javiana, have been associated with reptilian reservoirs (Jackson *et al.*, 2013). In a recent outbreak investigation, cultures of samples of cantaloupe collected from the fields yielded *Salmonella* (FDA, 2012a). Poor sanitary practices in packing sheds and inadequate monitoring of chlorinated wash water have also contributed to contamination (Castillo *et al.*, 2004). Improper cooling and cold storage practices and equipment that is difficult to clean may lead to contamination of melons (FDA, 2011). Although the cantaloupe industry took actions in 2005 to address contamination during production (Fleming *et al.*, 2005), it is unknown how widely they were implemented. The Food and Drug Administration (FDA) continues to urge cantaloupe production facilities to review their practices in the context of current food safety guidance documents developed by FDA (FDA, 2009), industry trade organizations, and academic institutions to address common risk factors for contamination in their operations (FDA, 2013). Given the difficulty in removing pathogens during food preparation and the fact that melons are usually consumed raw, efforts should focus on the prevention of microbial contamination at all steps from production to distribution.

After melons have been transported to the point of service, they can be cross-contaminated by a foodworker (CDC, 2008b) using improperly cleaned work surfaces and cutting utensils or by another food; bacterial contamination can also be amplified by improper storage (CDC, 1979). For example, an outbreak in a restaurant in 2000 was attributed to watermelons cross-contaminated with *Escherichia coli* O157:H7 by raw meat products on food preparation surfaces (CDC, Foodborne Disease Outbreak Surveillance System (unpublished data) 2013). Efforts to intervene at the point of service should continue. Current recommendations for preparing fresh produce both at retail and at home include thorough washing under running water before cutting and storage at temperatures of 40°F or below. In addition, for firm produce, such as melons, scrubbing with a clean produce brush is recommended (Fleming *et al.*, 2005). While scrubbing a melon with a produce brush has been shown to significantly reduce contamination on the rind (Parnell *et al.*, 2005), it is not

known whether this practice decreases the transfer of the organism to the edible part of the melon. In addition, when melons are scrubbed in water, contamination may spread from a localized region on the rind to surrounding areas (Parnell *et al.*, 2005). Understanding the most likely source of melons during a particular period can be useful for rapid outbreak investigation and identification of implicated foods. The source of melons implicated in these outbreaks was reflected in known distribution patterns for domestic and imported melons. For example, although most outbreaks were reported during the summer months, when the consumption of melons is also the highest (CDC, 2007), outbreaks caused by imported melons only occurred during December–April, coinciding with the months during which most of the United States melon supply is sourced from foreign locales, particularly Latin American countries, including Mexico and Central America (Boriss *et al.*, 2006). In addition to being more common in the winter months, outbreaks caused by imported melons were often geographically widespread. Through import alerts and laboratory-based monitoring systems for imported cantaloupes, FDA and the Mexican government have reduced the number of outbreaks in the United States caused by *Salmonella* and attributed to Mexican cantaloupes (FDA, 2012b); since 2005, none have been reported. However, outbreaks continue to be associated with imported cantaloupes from Central America.

The findings in this report are subject to limitations. The number of outbreaks caused by melons is likely underestimated. Because melons, like other produce items, have a limited shelf life, the implicated melon might be consumed or discarded before an outbreak investigation begins. In addition, because cantaloupe, watermelon, and honeydew are often consumed together (e.g., fruit salad) or alongside other foods, it can be difficult to implicate a specific type of melon. Even when a single melon type is suspected, poor labeling and comingling of melons during repacking and distribution can make traceback difficult. Finally, the source of melon contamination was unknown for one third of outbreaks; many of these outbreaks occurred during the summer months with either inconclusive or no information on traceback reported.

Conclusions

Preventive measures focused on reducing contamination of melons by bacterial pathogens during production on domestic and international farms and in packinghouses and processing facilities could decrease the number and severity of melon-associated outbreaks. Retail establishments should review policies related to sick leave for ill foodworkers, practices to improve proper storage of melons, especially precut melons, and methods to reduce cross-contamination during food preparation and storage. In addition, populations at high risk for severe complications of infections caused by enteric pathogens, including the young, old, and immunocompromised, or those preparing their meals, should be targeted for food safety education.

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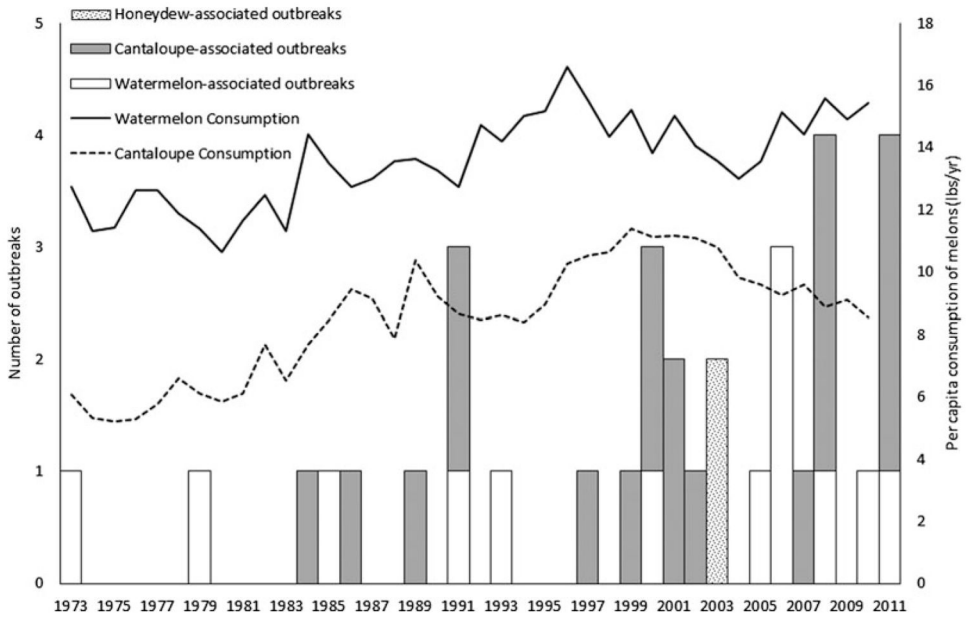

FIG. 1.

Number of outbreaks* by melon type and per capita consumption† in pounds per year (lbs/yr) of cantaloupes and watermelons, United States, 1973–2011. *Source: Centers for Disease Control and Prevention, Foodborne Disease Outbreak Surveillance System. †Source: U.S. Department of Agriculture, Economic Research Service.

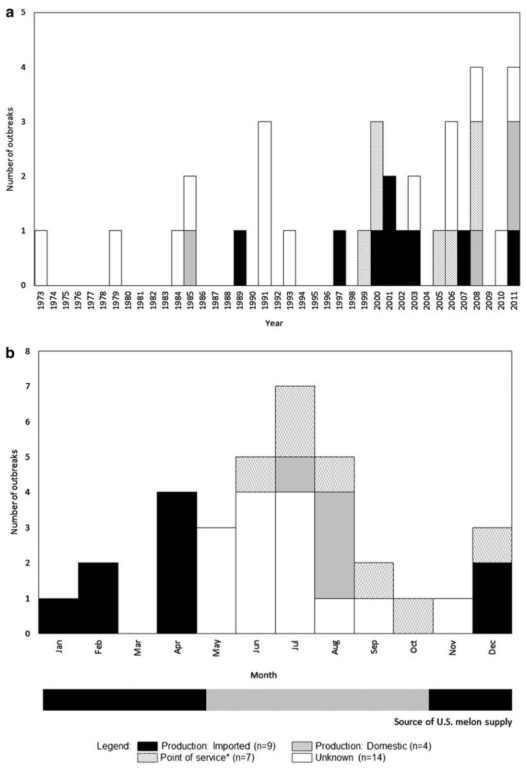

FIG. 2.

(a) Number of melon-associated outbreaks by contamination source and year—United States, 1973–2011. **(b)** Number of melon-associated outbreaks by contamination source and the usual source of the melon supply, and by month†—United States, 1973–2011. *Point of service includes five outbreaks, which were caused by implicated foodworkers and one outbreak caused by *E. coli* O157:H7-contaminated watermelons that were cross-contaminated by raw meat. †Source: U.S. Department of Agriculture, Economic Research Service.

Table 1

Melon-Associated Outbreaks, Illnesses, Hospitalizations, Deaths, and Fetal Losses—United States, 1973–2011

	Cantaloupe[a]		***Watermelon***		***Honeydew***		***All melons***
	n	***(%)***	**n**	***(%)***	**n**	***(%)***	**n**
Outbreaks	19	(56)	13	(38)	2	(6)	34
Illnesses	1012	(28)	2466	(68)	124	(3)	3602
Hospitalizations	215	(67)	91	(28)	16	(5)	322
Deaths	37	(80)	7	(15)	2	(4)	46
Fetal losses	1	(33)	2	(67)	0	(0)	3

[a]The high percentage of hospitalizations and deaths associated with cantaloupe is strongly influenced by a single 2011 *Listeria* outbreak (McCollum *et al.*, 2013) with 147 illnesses, 143 hospitalizations, 33 deaths, and 1 fetal loss.

Table 2

Characteristics of Melon-Associated Outbreaks by Melon Type—United States, 1973–2011

	Cantaloupe		***Watermelon***		***Honeydew***		***All melons***	
	n	***(%)***	**n**	***(%)***	**n**	***(%)***	**n**	***(%)***
Etiology (no. with information)	19 outbreaks		13 outbreaks		2 outbreaks		34 outbreaks	
Salmonella[a]	11	(58)	7	(54)	1	(50)	19	(56)
Norovirus[b]	3	(16)	2	(15)	0	(0)	5	(15)
Unknown	2	(11)	1	(8)	0	(0)	3	(9)
Campylobacter jejuni	1	(5)	1	(8)	0	(0)	2	(6)
Shiga toxin–producing *Escherichia coli*	1	(5)	1	(8)	0	(0)	2	(6)
Aldicarb (pesticide)	0	(0)	1	(8)	0	(0)	1	(3)
Listeria monocytogenes	1	(5)	0	(0)	0	(0)	1	(3)
Shigella sonnei	0	(0)	0	(0)	1	(50)	1	(3)
Locations of food preparation (no. with information)	17 outbreaks		10 outbreaks		2 outbreaks		29 outbreaks	
Multiple locations[c]	9	(53)	2	(20)	1	(50)	12	(41)
Restaurant	3	(18)	2	(20)	1	(50)	6	(21)
Grocery store	2	(12)	2	(20)	0	(0)	4	(14)
Private home	2	(12)	1	(10)	0	(0)	3	(10)
Institution	0	(0)	2	(20)	0	(0)	2	(7)
Catered event or picnic	1	(6)	1	(10)	0	(0)	2	(7)
Point of contamination (no. with information)	19 outbreaks		13 outbreaks		2 outbreaks		34 outbreaks	
Unknown	6	(32)	7	(54)	1	(50)	14	(41)
Production	10	(52)	2	(15)	1	(50)	13	(38)
Point of service	3	(16)	4	(31)	0	(0)	7	(21)

[a] Serotypes were Poona (four outbreaks), Javiana (four), Newport (two), and Chester, Oranienburg, Saphra, Litchfield, Saintpaul, Typhimurium, Panama, Uganda, and Anatum (one each).

[b] All laboratory-confirmed except one suspected norovirus outbreak.

[c] Food served at more than one location.

Table 3

Multistate Melon-Associated Outbreaks—United States, 1973–2011

Year	Melon type	Domestic cases	Month	Etiology	Source of melon	Initial point of contamination[a]	Public health action	Reference
1985	Watermelon	949[b]	July	Aldicarb (pesticide)	California (probable)	Production	Embargo	(CDC, 1986)
1989	Cantaloupe	295	December	*Salmonella* Chester	Mexico, Guatemala	Production		(Ries *et al.*, 1990)
1991	Cantaloupe	143[b]	May	*Salmonella* Poona	Texas, Mexico (probable)	Unknown		(CDC, 1991)
2000	Cantaloupe	46	April	*Salmonella* Poona[c]	Mexico	Production		(CDC, 2002)
2001	Cantaloupe	50	April	*Salmonella* Poona[c]	Mexico	Production	Embargo, recall	(CDC, 2002)
2001	Cantaloupe	35	April	*Salmonella* Anatum[c]	Mexico (probable)	Production		
2002	Cantaloupe	26[b]	April	*Salmonella* Poona[c]	Mexico	Production	Recall, import alert	(CDC, 2002)
2003	Honeydew	68	January	*Salmonella* Newport	Central America	Production		
2007	Cantaloupe	53[b]	December	*Salmonella* Litchfield	Honduras	Production	Recall, import alert	(CDC, 2008a)
2008	Cantaloupe	10	November	*Salmonella* Javiana	Unknown	Unknown		
2011	Cantaloupe	20	February	*Salmonella* Panama	Guatemala	Production	Recall	(CDC, 2011a)
2011	Cantaloupe	25	June	*Salmonella* Uganda	Unknown	Unknown		
2011	Cantaloupe	146	August	*Listeria monocytogenes*	Colorado	Production	Recall	(CDC, 2011b)

[a] Production includes growth, harvesting, processing, and packaging before the point of service.

[b] Additional cases in Canada.

[c] Outbreaks were all traced to same distributor.