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REVIEW ARTICLE
Infections associated with cantaloupe consumption: a public health concern

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SUMMARY

Fresh produce is an important part of a healthy diet and is consumed in greater quantity in the United States than ever before. Consumption of cantaloupe has recently been associated with several large outbreaks of infections in North America, highlighting the need for a better understanding of practices and processes that may contribute to contamination. We reviewed all cantaloupe-associated outbreaks that were reported to the Centers for Disease Control and Prevention (CDC) and published in the literature. Twenty-three outbreaks occurred between 1984 and 2002; 1434 people became ill, 42 were hospitalized, and two died in these outbreaks. Aetiological agents in the outbreaks included five serotypes of *Salmonella enterica*, *Campylobacter jejuni*, *Escherichia coli* O157:H7, and norovirus. We reviewed processes contributing to cantaloupe contamination, conditions affecting survival and growth of bacterial pathogens on melons, and potential methods for sanitization. For maximum safety, industry, federal, and international partners must collaborate to ensure that appropriate interventions are in place to minimize the risk of contamination and prevent the growth of pathogens during cantaloupe production, processing, storage, and preparation.

INTRODUCTION

Fresh produce has been implicated in outbreaks of foodborne illness in the United States with increased frequency in the past two decades [1–5]. Several factors may be contributing to this trend. Produce is now available all year round as a result of global marketing and trade, and international travel and restaurant dining may enhance the likelihood of consumer exposure to contaminated produce [3, 6–8]. In addition, fresh fruits and vegetables have been promoted to consumers as an important part of a healthy lifestyle. Numerous campaigns have highlighted the nutritional value of produce, resulting in an increase in *per capita* consumption.

Cantaloupe (*Cucumis melo* var. *reticulatus*) is among the fresh fruits that are being consumed in larger quantities in recent years. The annual US *per capita* consumption of cantaloupe increased from 5·8 lb in 1980 to 11·3 lb in 2002 [9]. Recently, several large outbreaks of *Salmonella enterica* serotype Poona infections were associated with consuming cantaloupes, highlighting the need for enhancing cantaloupe safety and resulting in importation restrictions for implicated producers [10, 11]. We reviewed the Centers for Disease Control and Prevention (CDC) reports of outbreaks of foodborne infections from 50 states and four territories, as well as the global literature, to summarize information on cantaloupe-associated outbreaks, including aetiological agents,

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possible sources of contamination, conditions affecting survival and growth of pathogens on melons, and procedures for pathogen reduction or elimination.

METHODS

We searched PubMed for all outbreaks that reported cantaloupe or muskmelon as the vehicle of infection because muskmelon is the common name for cantaloupe in some regions of the United States. Outbreaks that implicated cantaloupe or muskmelon in addition to another food item were included in the analysis; however, outbreaks that implicated honeydew or casaba melons alone were not included.

We defined an outbreak as two or more epidemiologically linked cases of illness. Not all outbreak-associated cases had laboratory-confirmed infection. Investigators identified food vehicles that were statistically significantly associated with illness or that yielded the aetiological agent when cultured. Aetiological agents were identified by laboratory confirmation from two or more case-patients in each outbreak.

Data sources included the CDC foodborne outbreak surveillance system, which collected reports of foodborne outbreaks from 50 US states and four territories between 1973 and 2003, and outbreak reports from the literature. The CDC foodborne outbreak surveillance data collection form was modified in 1998 to capture demographic information, such as gender and age of case patients, thus providing additional data for the 1998–2003 period. We searched PubMed with the key words 'cantaloupe' or 'melon' in combination with 'epidemiology', 'outbreak', or 'illness'. Bibliographies of resulting articles were also searched.

We also reviewed the scientific literature for cantaloupe and produce microbiological studies. PubMed search terms included 'cantaloupe' or 'produce' in combination with 'microbiology'. Additionally, bibliographies and personal files were reviewed. We assumed findings from studies involving non-melon produce could also have relevance to melons.

RESULTS

We identified 25 outbreaks associated with consumption of cantaloupes reported to the CDC foodborne outbreak surveillance system between 1973 and 2003 (Table 1). Three additional outbreaks were discovered in a search of the literature (outbreaks 2, 9, 13 in Table 1). Each outbreak identified raw cantaloupe as the vehicle of infection. Muskmelon was not implicated in any outbreak. In 14 outbreaks, food items in addition to cantaloupe were implicated as vehicles. In all, 1615 people were reported ill (some reports included only the lower limit of the number ill), 57 were hospitalized, and two died.

Seven serotypes of *S. enterica* (Berta, Chester, Muenchen, Oranienburg, Poona, Saphra, and an unknown serotype from Group E1) accounted for 11 (39%) of the outbreaks, an estimated 956 (59%) of the cases, 52 (91%) of the hospitalizations, and two deaths. Norovirus caused an additional seven (25%) outbreaks, and *Campylobacter jejuni* and *Escherichia coli* O157:H7 each caused one (4%) outbreak. No aetiological agent was determined in eight (29%) of the outbreaks, although the carbamate pesticide, Aldicarb, was suspected in one [12].

Analysis of 1998–2003 data revealed that more females than males developed illness. Most cases occurred in adults, with only 10% of case-patients being <19 years old and none aged <1 year. Case-patients resided in the United States and Canada. No outbreaks from other geographic areas were identified (Table 1).

Of the 28 outbreaks, 19 (68%) were reported between 1994 and 2003, the final decade of the 30-year surveillance period. To evaluate the effect of changes in surveillance, we examined the proportion of outbreaks associated with cantaloupe before and after 1998. Of foodborne outbreaks with a known vehicle, cantaloupe was implicated in 12 (0·25%) of the 4770 that occurred between 1973 and 1997, and 16 (0·34%) of the 4721 that occurred between 1998 and 2003. At least one outbreak occurred in each calendar month, while outbreaks of salmonella infections occurred in December (2), February (1), March (1), April (2), May (3), June (1), and September (1) (Fig. 1).

Seventeen (61%) of the 28 outbreaks were associated with cantaloupe prepared in a restaurant or by a caterer. Four (14%) additional outbreaks were associated with cantaloupe prepared in a grocery store. Results of environmental investigations were reported irregularly and inconsistently. Findings included contaminated preparation equipment, poor food-handler hygiene, ill food handlers, and temperature abuse. Four of the seven outbreaks caused by norovirus were reported to involve ill food handlers.

Table 1. *Cantaloupe-associated outbreaks in the United States and Canada, 1973–2003*

Outbreak number	Year	Onset month	Location	Aetiological agent	Additional vehicles implicated	Attack rate (%)	Illnesses (n)	Hospitalizations (n)	Deaths (n)	Ref.*
1	1984	6	PA	Unknown		63	12	n.a.	0	
2	1985	7	CA	Unknown		n.a.	77	n.a.	n.a.	[12]
3	1985	8	WI	*Campylobacter jejuni*		6	16	2	0	
4	1989	5	MO	Unknown	Honeydew and pineapple	46	101	3	0	
5	1989	12	30 US states	*Salmonella* Chester		n.a.	245	n.a.	n.a.	[13]
6	1991	5	23 US states and 4 Canadian provinces	*Salmonella* Poona		n.a.	>400	7	0	[14]
7	1991	6	MN	Unknown		n.a.	21	0	0	
8	1993	1	MN	Unknown	Honeydew	49	140	0	0	
9	1993	8	OR	*E. coli* O157:H7		n.a.	24	n.a.	n.a.	[15, 16]
10	1995	10	WI	Unknown	Ice cream	92	24	0	0	
11	1995	11	IL	Unknown	Watermelon	13	27	0	0	
12	1997	2	CA	*Salmonella* Saphra		n.a.	24	6	0	[17]
13	1998	5	Ontario	*Salmonella* Oranienburg		n.a.	20	n.a.	n.a.	[18]
14	1999	6	IA	Norovirus	Honeydew, watermelon	79	61	n.a.	n.a.	
15	1999	9	MN	Norovirus		n.a.	5	0	0	
16	2000	4	5 US states (CA, CO, NM, OR, WA)	*Salmonella* Poona		n.a.	47	11	0	[19]
17	2000	6	MN	Norovirus	Turkey sandwich	n.a.	33	0	0	
18	2000	12	AK	Norovirus	Turkey	n.a.	20	n.a.	n.a.	
19	2001	1	KS	Norovirus	Honeydew, pineapple	n.a.	36	0	0	
20	2001	3	MN	Norovirus	Pineapple	n.a.	42	0	0	
21	2001	4	5 US states (AZ, CA, NV, OR, WA)	*Salmonella* Poona		n.a.	50	9	2	[19]
22	2001	6	CA	*Salmonella* Poona	Honeydew, watermelon	n.a.	23	4	0	
23	2001	6	WA	Unknown	Pineapple	80	4	0	0	
24	2001	12	OR	*Salmonella* Group E1		n.a.	2	0	0	
25	2002	3	10 US states and 4 Canadian provinces	*Salmonella* Poona		n.a.	58	n.a.	n.a.	[19]
26	2002	9	WA	*Salmonella* Berta	Watermelon, grapes	n.a.	29	n.a.	n.a.	
27	2003	5	9 US states (CT, MA, MI, MO, NH, NM, NY, OH, VA)	*Salmonella* Muenchen	Honeydew	n.a.	58	15	0	
28	2003	8	FL	Norovirus	Pineapple, banana	n.a.	16	n.a.	n.a.	
Total							1615	57	2	

* Other than outbreaks 2, 9, and 13, all outbreaks were identified in the CDC foodborne outbreak surveillance database.

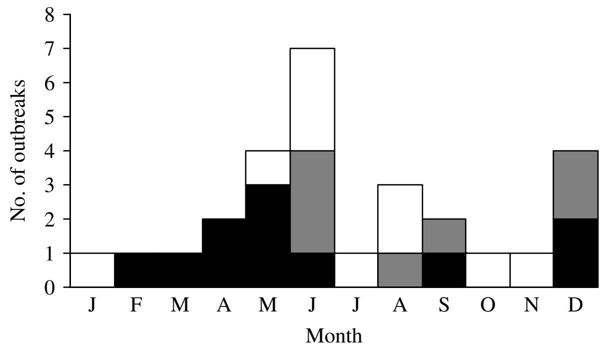

Fig. 1. Number of cantaloupe-associated outbreaks, by aetiology and month. □, Other; ▪, norovirus; ■, salmonella.

Information about the locations at which cantaloupes were grown was not recorded for most outbreaks.

DISCUSSION

Sources of contamination

Cantaloupes may become contaminated before harvest, during harvesting, packing, and storage, and during processing or preparation of cut products (Table 2).

Preharvest environment

Soil and soil amendments such as improperly composted manure, contaminated irrigation water, wild and domestic animals, and farm workers are potential vehicles of contamination of preharvest melons [8, 28, 29]. Microorganisms capable of causing human diseases can survive in soil for protracted durations. *Listeria monocytogenes* can survive in soil for at least 8 weeks [30], salmonella and *E. coli* O157:H7 can survive up to 23 weeks, and viruses can live for 3 weeks [31–33]. These pathogens may also be introduced by infected or colonized wild animals, such as reptiles, birds, and rodents, eating fruit and defecating directly in fields [29], and further distributed by insects [34] and perhaps nematodes [35]. Poor field-worker hygiene could also contribute to surface contamination [29, 36]. In addition, the netting that naturally covers the surface of cantaloupe rinds (Fig. 2) may facilitate attachment and survival of microorganisms from the soil or irrigation water [37]. Evidence suggests that some preharvest fruits and vegetables may become internally contaminated with enteric pathogens through unknown mechanisms [28, 38, 39]; this may also occur in melons.

Whole melon handling and storage

Although the aim of post-harvest washing is largely to remove soil and clean the melons, it may also contribute to contamination. In packing houses, fresh produce can harbour microorganisms at populations of 10^4–10^6 c.f.u./g [19, 40, 41]. For apples and tomatoes, a negative temperature differential (i.e. the temperature of the wash water is lower than the temperature of the fruit) has been shown to enhance infiltration of microorganisms into subsurface tissue of the fruit [42, 43]. Similarly, if cantaloupes are submerged in cooler water or hydrocooled, hydrostatic pressure differences may facilitate infiltration of salmonella into the rind surface of some varieties [21]. Enteric microorganisms have been found in wash and hydrocooler water at several cantaloupe harvesting locations and packing facilities [37]. This problem may be further complicated by regional practices and environmental conditions. For example, many growers in the Western United States have adopted best management practices for cantaloupe that avoid exposing the product to water [37]. However, in some regions, there may be a greater need for washing and/or fungicide application to clean cantaloupes and maintain the quality of the product.

Pathogens may survive and even grow on the surface of intact melons during shipment and storage (Table 3). *S.* Poona survives on intact cantaloupe rind for up to 14 days [23, 45] and grows in cantaloupe wounds [24, 46]. *E. coli* O157:H7 populations on intact cantaloupe rind can increase by two logs within 4 days at 25 °C [15]. Cantaloupes are also susceptible to post-harvest fungal rots, especially when stored unrefrigerated and at a high relative humidity [22]. Migration of *S.* Poona into the interior of the cantaloupe, followed by growth, is enhanced by co-infection with some species of moulds [24]. These observations point out the need to discard the entire melon when only a small area shows visual decay.

Cut melon processing

Barring a negative temperature differential between wash water and cantaloupes, and in the absence of mould growth, the physically intact rind comprises a natural barrier to infection. Even if the rind is contaminated, the edible cantaloupe flesh should remain free of enteric pathogens until the rind is breached [15, 25, 26]. The introduction of salmonella from the exterior surface to the internal flesh of cantaloupes and other fruits has been documented [22, 26, 51, 52].

Table 2. *Risk factors for produce contamination*

Location	Exposure	Ref.
Preharvest environment	Soil	[6, 13, 14, 20]
	Animals (rodents, birds, insects, reptiles)	[6, 13, 14, 20]
	Manure	[6, 13]
	Irrigation water	[6, 13, 14, 20]
	Water used in pesticide application	[6]
Whole-melon processing	Wash water temperature cooler than melon temperature (may lead to internalization of microorganisms)	[21]
	Contaminated hydro-cooler water (used in Rio Grande Valley and SE USA, and may contaminate melon surfaces)	[6, 20, 22]
	Rind wounding	[23, 24]
	Rind fungal rot	[23, 24]
	Workers' hands	[20]
	Conveyor belts/equipment	[6, 20]
Cut-melon processing	Cutting through contaminated rind	[22, 25, 26]
	Cutting with contaminated equipment or contaminated surfaces; ill food handler	[6]
	Temperature abuse	[6]
	Pooling cut fruit	[5, 27]

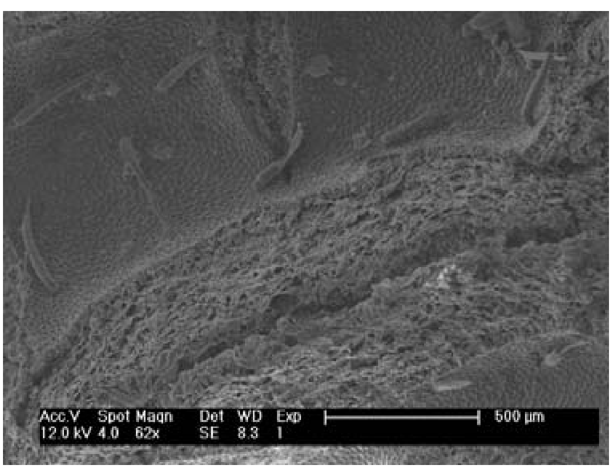

Fig. 2. Scanning electron micrograph of *Cucumis melo* var. *reticulatus* rind surface showing porous tissue structure (Courtesy of Janice Carr, CDC.).

Epidemiological and laboratory evidence in an outbreak of *E. coli* O157:H7 infections associated with cut cantaloupe suggested that contamination may occur not only by cutting through contaminated rinds but also by cutting with contaminated utensils [16].

Storage of cut cantaloupes at temperatures that are not adequately cool exacerbates the safety risk because juice released by cut tissues is a good growth medium for foodborne pathogens (Table 3). Cut melons are often displayed in grocery stores, farmers' markets, and salad bars on ice, but the surface of the pieces may be at a temperature close to ambient [53]. In much the same way that ground beef, representing a composite of meat from many carcasses, is more likely to internally harbour pathogens than would a single cut of steak, pooling cut melon pieces exacerbates the potential for contamination of larger quantities [5].

Mitigation of contamination

Several methods of reducing pathogens on intact and cut cantaloupes have been attempted with varying degrees of success (Table 4). Washing the rind surface of cantaloupes with water or sanitizers does not always substantially reduce microbial counts [8, 25, 37, 41, 62]. Treatment of melon flesh with food-safe sanitizers also does not eliminate bacteria. Sanitizers evaluated have included hydrogen peroxide, sodium hypochlorite (chlorine), and ethanol. These sanitizers are not effective in eliminating pathogens, in part because organic materials in melon tissues neutralize the bactericidal activity [6, 8]. Bacteriophages, gamma irradiation, and ultraviolet light treatment are possible alternatives to sanitizing melons but have not been sufficiently evaluated for their efficacy. Direct application of sanitizers to cut cantaloupe poses an additional concern. Reduction or elimination of microorganisms that would otherwise successfully compete with foodborne pathogens may lead to overgrowth of pathogens that might survive the treatment. Following treatment of endive with 10% hydrogen peroxide, for example, populations of *L. monocytogenes* actually increased [63].

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Table 3. *Observations of survival and growth of foodborne pathogens on melons*

Pathogen	Melon	Substrate	pH	Observation*	Ref.
Salmonella enterica	Cantaloupe	Slice/piece		Survived at 4 and 8 °C for 10 h, increased by 0·8 log c.f.u./g within 10 h at 20 °C and 2·2 log c.f.u./g within 10 h at 30 °C	[26]
			6·67	Increased *ca.* 0·8, 2·0, and 5·5 log c.f.u./g within 6, 12, and 24 h respectively at 23 °C	[44]
		Wounded rind	5·25–6·49	Survived for 22 days at 4 °C	[23]
			6·07	Penetration into tissue was enhanced by co-infection with mould	[24]
			5·90–6·88	Survived for 14 days at 4 °C, grew within 7 days at 21 °C	[45]
			5·84–6·70	Survived for 14 days at 4 °C, grew within 7 days at 20 °C	[23]
		Juice	6·78	Increased by 6·0 and 9·4 log c.f.u./ml within 24 and 48 h respectively at 20 °C	[46]
		Rind surface		Survived for 14 days at 4 °C	[45]
				Survived for 14 days at 20 °C	[23]
				Survived for 7 days at 4 °C	[47]
				Survived for 6 days at 4 and 20 °C	[26]
	Honeydew	Slice/piece	5·95	Increased *ca.* 08, 2·5, and 6·0 log c.f.u./g within 6, 12, and 24 h respectively at 23 °C	[44]
			5·80	Increased *ca.* 0·3 and 4·0 log c.f.u. at 10 and 20 °C respectively within 2 days	[48]
	Watermelon	Slice/piece	5·90	Increased *ca.* 1·2, 3·0, and 6·7 log c.f.u./g within 6, 12, and 24 h respectively at 23 °C	[44]
		Juice	5·53	Increased *ca.* 0·50, 1·17, and 5·50 log c.f.u./ml of 20 % juice within 4, 6, and 24 h respectively at 22 °C	[49]
Escherichia coli O157:H7	Cantaloupe	Slice/piece	7·01	Increased 3·8 log c.f.u./g within 28 h at 25 °C, survived at 5 °C for 34 h	[15]
		Rind surface		Increased within 4 days at 25 °C and high relative humidity	[15]
				Survived 7 days at 4 °C	[47]
	Watermelon	Slice/piece		Increased by 5·5 log c.f.u./g within 28 h at 25 °C, survived at 5 °C for 34 h	[15]
		Rind surface		Increased within 4 days at 25 °C and high relative humidity	[15]
Campylobacter jejuni	Watermelon	Slice/piece		Survived but did not grow at 25–29 °C for 6 h	[20]
Listeria monocytogenes	Cantaloupe	Slice/piece		Survived for 15 days at 4 °C, grew within 4 h at 8 or 20 °C, increased by *ca.* 1 log c.f.u./g within 10 h at 20 °C	[47]
		Pulp	5·87	Generation times of 7·12, 1·74, and 0·84 h at 10, 20 and 30 °C respectively	
		Rind surface		Survived for 15 days at 4 and 20 °C	[50]
	Watermelon	Slice/piece	5·50	Generation times of 13·0, 2·17, and 1·00 h at 10, 20 and 30 °C respectively	[25, 50]

* Hours or days noted for survival indicate that pathogens survived for at least these lengths of time.

CONCLUSIONS

Outbreaks of illness associated with cantaloupe consumption in the United States have not been rare in recent years. We identified no single microorganism or obvious mode of contamination that appeared to be the cause of this trend. Instead, cantaloupes are susceptible to contamination in multiple ways, including internalization of bacteria through intact or damaged rind tissue and contact with contaminated surfaces during processing or preparation. In addition, cantaloupes may become contaminated if

Table 4. *Efficacy of treatments to decontaminate cantaloupes*

Location	Agent	Temp. (°C)	Duration (min)	Results
Rind	Water	Ambient	Up to 5	Alone, does not substantially reduce cantaloupe surface microbial counts [27, 54]. Melons inoculated with 4 log c.f.u. *Pantoea agglomerans*/cm² and scrubbed with a brush for 1 min show 75–85 % reduction in bacterial counts [54]
	Water	97	1	Decreased surface salmonella by 3·3 log c.f.u./cm² 3 days after inoculation with 10^8 c.f.u./ml. Eliminated surface salmonella if initial inoculum was 1·9 log c.f.u./cm². Cut pieces from melons of either treatment batch contained salmonella detectable only after enrichment [51]
	Water	76	2–3	Reduced *S.* Poona by >5 log c.f.u./cm² [55]
	Hand soap with 0·5 % tricolsan	Ambient	1	Melons inoculated with 4 log c.f.u. *Pantoea agglomerans*/cm², rubbed with 3·5 ml soap, then rinsed in tepid tap water for 1 min show 80 % reduction in bacterial counts [54]
	Chlorine (200 μg/ml)	Ambient	2	Reduced salmonella by 2·0–3·1 log c.f.u./cm² when melons were continuously agitated or rubbed during treatment [56]
	Chlorine (1000 μg/ml)	Ambient	Up to 5	1–2·6 log reduction of salmonella on cantaloupe rind [26, 41]
	Chlorine (2000 μg/ml)	Ambient	3	Reduced salmonella by *ca.* 3 log c.f.u./ml. *E. coli* O157:H7 was reduced from *ca.* 3 log c.f.u./ml to non-detectable level [8]
	H_2O_2 (1 %)	Ambient	3	Reduced *E. coli* O157:H7 and salmonella populations by *ca.* 2–3 log c.f.u./ml [8]
	H_2O_2 (1 %)	Ambient	Up to 30	Ineffective in killing *E. coli* 766 (ATCC 9637; similar to *S.* Poona) [57]
	H_2O_2 (2·5 %)	Ambient	5	Decreased surface salmonella by 2·3 log c.f.u./cm² from an initial inoculum of *ca.* 4·4 log c.f.u./cm² [27]
	H_2O_2 (2·5 %)	Ambient	5	3-log reduction in microbial counts up to 24 h after treatment at 4 and 20 °C [26, 54]
	H_2O_2 (5 %)	Ambient	2	Reduced salmonella by 2·0–3·4 log c.f.u./cm² when melons were continuously agitated during treatment [56]
Rind/ pieces	H_2O_2 (5 %)	70	1	Decreased surface salmonella by 3·8 log c.f.u./cm² 3 days after inoculation with 10^8 c.f.u./ml. Eliminated surface salmonella if initial inoculum was 1·9 log c.f.u./cm². Cut pieces from melons of either treatment batch contained salmonella detectable only after enrichment [51]
	Ethanol (70 %)	Ambient	2	Increased subsequent attachment of *L. monocytogenes* compared to unwashed or water-washed melons [25]
	Serial treatments	Ambient	4	Melons inoculated with 4 log c.f.u. *Pantoea agglomerans*/cm², scrubbed in 1 % antibacterial hand soap solution for 1 min, scrubbed in tepid water for 1 min, immersed in 150 μg/ml sodium hypochlorite for 20 s, and rinsed in running water for 2 min, show 90 % reduction in bacterial counts [54]
Pieces	H_2O_2 (5 %)	Ambient	n.a.	Non-significant trend toward lower bacterial populations than on unwashed melon cubes [6, 41]
	H_2O_2 (5 %)	50	1	Non-significant trend toward lower bacterial populations than on unwashed melon cubes [6, 41]
	Chlorine (2000 μg/ml)	Ambient	2	Decreased salmonella on cubes by <1 log c.f.u./g [6]
	Nisin (50 μg/ml), EDTA (0·02 M), sodium lactate (2 %), potassium sorbate (200 μg/ml)	Ambient	5	Combination of nisin and EDTA, sodium lactate, or potassium sorbate reduced salmonella by 2–3 log c.f.u./cm² of rind and up to 1·4 log c.f.u./g of pieces [58]
	Ethanol (70 %)	Ambient	2	Decreased salmonella by <log c.f.u./g [6]
	Bacteriophages			Decreased *S.* Enteritidis on cut honeydew by 3·5 log c.f.u./g during storage for 120 h at 5 °C [48]
	Gamma irradiation			Greatly reduces populations of vegetative bacterial cells and spores, yeasts, moulds, viruses, and parasites on produce [59]
	Ultraviolet light			Has been used to decontaminate beef, fish, and poultry [60, 61]

they are grown, harvested, or packed in areas where hygienic practices are less than adequate. Effective methods for decontaminating whole and cut melons have not been identified. Efforts to reduce cantaloupe-associated illness are needed by growers, processors, and food preparers.

Although we report more than 1600 cases of illness associated with cantaloupe consumption in the United States and Canada during the past 30 years, the true burden of foodborne disease associated with cantaloupes is probably much greater. While most of the outbreaks we report (Table 1) were associated with cantaloupe prepared at commercial eating establishments, contamination can occur at any point along the supply chain. In addition, a large number of cantaloupe-related illnesses also probably occurred among clusters too small to be detected easily. Outbreaks also comprise a small proportion of all episodes of foodborne illness each year; thus, a large number of sporadic cases of illness associated with cantaloupe consumption probably occurred between 1973 and 2003 that are not included in our estimates [64]. Further, we restricted analysis to outbreaks which specifically named cantaloupe or muskmelon as a vehicle of infection; a number of additional outbreaks associated with fruit salad, which may contain cantaloupe, were excluded.

Since 1994, outbreaks of infections associated with cantaloupe consumption have been reported with increased frequency. Data from these outbreaks are consistent with other data suggesting an increase in outbreaks associated with consumption of fresh produce and outbreak reporting in general. Data also correspond to an increase in consumption of cantaloupes and raw produce, and increased availability of produce all year round from global distributors. It is possible that awareness about cantaloupes and other produce as potential vehicles of pathogens has increased among investigators in recent years. If this is so, the documented recent increase in the number of cantaloupe-associated outbreaks might be misleading; however, the total number of outbreaks associated with cantaloupes may have been greatly underestimated during the period 1973–2003.

In 1998, the US Food and Drug Administration (FDA) issued voluntary guidelines for good agricultural practices (GAPs) and good manufacturing practices (GMPs) for growing and packing fresh produce [65]. Several documents outlining pre- and post-harvest guidelines for microbiological safety of fresh and fresh-cut produce, including cantaloupes, have been published [40, 66–70]. These guidelines are directed, in part, toward reducing safety risks associated with cantaloupes.

We found that illness associated with consumption of cantaloupes occurred throughout the year. Because the US cantaloupe production season typically spans from May to October, outbreaks were probably associated with both domestic and imported cantaloupes. Both domestic and imported product samples have also yielded microbiological evidence of contamination in testing by regulatory agencies. In 1999, the FDA cultured eight different imported produce items and found that cantaloupe was the third most commonly contaminated item, with 7·3% of samples yielding salmonella or shigella [40]. In a similar survey of domestic produce in 2000, cantaloupe was the second most commonly contaminated item; 3·0% of cantaloupes yielded salmonella or shigella [71].

As a result of the 1999 FDA survey, seven Central American and Mexican firms were placed on detention without physical examination (DWPE), requiring importers to prove that their produce was not grown under conditions likely to lead to adulterated product [11, 19]. In response to continued findings of positive product samples, observations of irregularities during inspections, and additional outbreaks of salmonellosis associated with cantaloupes grown in Mexico, an Import Alert was issued to include all Mexican cantaloupe growers in October 2002 [10]. Firms that believe that their practices and conditions are adequate may submit information to FDA and request removal from the Import Alert; a number of firms have done this. Because complete outbreak data are not yet available for 2004–2005, it is unknown if these measures have affected the number of cantaloupe-associated illnesses. During future outbreak investigations, collecting information about cantaloupe source might greatly facilitate regulatory response.

What steps can consumers attempting to follow a healthy diet take to minimize the risk of illness associated with potentially contaminated cantaloupes? The FDA has recommended that consumers avoid produce with blemishes, wash hands with soap before handling melons, and scrub melons with a brush under cool tap water before consumption [40]. As with any food preparation, utensils, knives, and cutting boards should be cleaned in hot, soapy or chlorinated water before and after use, and should not be cross-contaminated with uncooked foods, particularly those of animal origin. Intact cantaloupes may be stored at room temperature, but cut products should be refrigerated within 2 h of preparation, or else discarded. Even with these precautions, some level of risk of illness associated with the consumption of cantaloupes remains. A successful strategy to improve the safety of melons will require education, regulation, cooperation, and commitment throughout the supply chain and at the industrial, national, and international levels.

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DECLARATION OF INTEREST

None.

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