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Mini Review

Cantaloupe -A Food safety concern: Mini-Review

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Introduction

Historically, the United States has positioned itself as one of the leading producers and consumers of melons in the world with a 2020 production value of over $295 million (excluding watermelons). It has been estimated that on average the per capita consumption of melons in the U.S. is about 24 pounds each year [1]. Increased consumer awareness of healthy diets, sensory attributes of melons, enhanced year-round availability, marketing techniques and improved cultivars contribute to explaining the higher demand for melon consumption [2]. As consumption of cantaloupes increases, the likelihood of associated illnesses and outbreaks caused by microorganisms increases too. As an example, in the past two decades, melon consumption has been linked to several multistate foodborne outbreaks. Cantaloupes, as well as other fresh produce, can potentially become contaminated with foodborne pathogens and cause disease because it is consumed in their raw state without any processing step that can inactivate or remove hazardous microorganisms [3].

Outbreaks associated with cantaloupe consumption

Between July and October 2011, the CDC received 147 reports of listeriosis infections, which led to 33 known fatalities. Among the ill patients, 134 reported the consumption of cantaloupe within the same month [4,5]. Likewise, between 2011 and 2021, there were ten *S. enterica* outbreaks connected to melons (Table 1), accounting for 39.1% of all *S. enterica* outbreaks connected to fruits. Nine of these outbreaks linked to melon used cantaloupe and the other involved a different type of melon [6].

Pre-harvest conditions promoting bacterial attachment to cantaloupe

The main pre-harvest contamination events are the transmission and attachment of human pathogens from environmental sources to the surface of the cantaloupe. In the field cantaloupes usually grow on the ground, therefore, pre-harvest contamination is frequently caused by soil, improperly composted manure, irrigation water, dust, insects, wild animals, and improper human handling [8,12].

Table 1: Multistate foodborne outbreaks of bacterial infection in the U.S. from 2011 to 2021 were associated with melons.

Year	Total of states	Bacteria Associated	Aetiological agent	Illnesses	Hospitalizations	Death	References
2011	10	*Salmonella* Panama	Cantaloupe	20	3	0	[7]
	NA	*Salmonella* Uganda	Cantaloupe	25	4	0	[8]
	28	*L. monocytogenes*	Cantaloupe	147	143	33	[4]
2012	24	*Salmonella* Typhimurium	Cantaloupe	228	94	3	[9]
		Salmonella Newport	Cantaloupe	33			
		Salmonella Newport	Cantaloupe	24	5	0	[8]
	NA	*Salmonella* Typhimurium	Cantaloupe	14	1	0	[8]
2014	NA	*Salmonella* Baildon	Cantaloupe	20	6	0	[8]
2016	NA	*Salmonella* Minnesota	Cantaloupe	10	3	0	[8]
2017	2	*Salmonella* Newport	Melon	24	6	0	[8]
2018	9	*Salmonella* Adelaide	Pre-Cut Melon	77	36	0	[10]
2019	10	*Salmonella* Carrau	Pre-Cut Melon	137	38	0	[11]

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Furthermore, temperature, relative humidity and contact time are environmental variables that affect bacterial attachment and biofilm formation [13,14]. Biofilm formation begins once bacterial cells are attached to fruit surfaces, which is a common method adopted by bacteria to protect themselves from environmental stress [15-18]. A significant element impacting the effectiveness of post-harvest treatments is bacterial attachment. For example, Ukuku and Fett [19], found that the efficacy of chemical treatments on detachment or inactivation of pathogenic bacteria from cantaloupe surfaces depends on the location of the organisms on the rinds, application time, and treatment. Additionally, the netting that naturally covers the cantaloupe rinds promotes attachment and harbors microorganisms from the soil or irrigation water [20]. Different studies have suggested that contamination and possible internalization of foodborne bacterial pathogens within preharvest fresh produce; cantaloupes are part of this group [14,21-23]

Post-harvest contamination of cantaloupes

Cantaloupes can become contaminated during harvesting, washing, packing, and storage. If cantaloupes are pre-cut, once the protective epidermal barrier of the rind has been damaged or intentionally cut, the likelihood of foodborne pathogen growth and/or survival may be enhanced [14,24]. Once cantaloupes have been peeled or cut, more nutrients and water will be available for contamination and proliferation of undesirable microorganisms. For example, several studies have shown greater proliferation of human pathogenic bacteria such as *Listeria*, *Salmonella*, *E. coli* O157:H7, and *Staphylococcus* in pre-cut as compared with intact commodities[14,25-27]. Similar results were obtained after applying commercially available sanitizers to different melon rinds. It was found that pathogenic bacteria were recovered on pre-cut cantaloupe and melon juice [28,29].

Rind structure and bacterial attachment to cantaloupe rind

In general, intact fresh produce have a protective outer barrier that reduces the likelihood of contamination with human pathogenic bacteria, as compared with cut produce surfaces. Most undamaged product surfaces' protective outer barrier may limit gas, moisture, and nutrient absorption and exchange [14,30,31]. The rind of melon is typically covered by a thick cuticle, a waxy specialized barrier that covers the outer surface of the fruit. This structure protects the fruit rind epidermis from water loss and creates a natural resistance to external compounds and microorganisms that can affect the quality and safety of the produce [32]. In the case of melons, another structure is formed on the surface of the fruit rind throughout development. In the early stage of melon development, fissures appear vertically in the equatorial region. During ripening, fissures continue developing horizontally and interconnect with the vertical fissures. Periderm tissues with waxy suberized cell wall layers mend these cracks or spontaneous wounds ("net") [33]. Human pathogenic bacteria can attach to the cantaloupe melon's surface using the meshwork of lenticular netting, which works as protection during washing procedures and sanitizer application. As a result of maturation, the fissures start to open and expand, and waxy cutin depositions occur to protect the nonfunctional cells, leaving the lenticels exposed. Foodborne bacterial pathogens attached to the then disrupted tissue promote greater infiltration to the cantaloupe mesocarp [34,35].

The attachment and biofilm formation of human pathogenic bacteria to cantaloupe rinds is highly influenced by charge and hydrophobicity. For example, in a comparative study among *Salmonella, Listeria,* and *E. coli*, Ukuku and Fett [36] determined the influence of the hydrophobic nature of bacteria and the interaction with the hydrophobic nature of intact cantaloupe rinds to promote attachment and biofilm formation. They also found that *Salmonella* bound the strongest to the surface of the melon, as compared with the other bacteria genera. Melon rinds in their intact form are hydrophobic in nature, likewise, *Salmonella* is highly hydrophobic on their surface. Furthermore, *Salmonella* production of extracellular carbohydrate polymer cellulose and other appendages, such as cellulose, flagella, and curli have been found as the main components for biofilm formation [37]. Finally, studies have demonstrated that foodborne pathogens are transferred to the mesocarp during the pealing and cutting of cantaloupes that have been previously washed with commercially available postharvest sanitizers [28,38-40].

Conclusion

This mini-review contains a summary of the multistate foodborne outbreaks of bacterial infection in the U.S. associated with melon consumption, from 2011 to 2021. These data highlight the importance of research on potential routes of contamination of melons in the field, during harvesting, and postharvest conditions. Furthermore, this review presents numerous studies that investigated foodborne pathogens' growth and/or survival on intact cantaloupe surfaces under the different stages of production. Additionally, the review emphasized the interaction between bacteria and rind surface, and how the rind netting works as a protective barrier against commercially available sanitizers, reducing their efficacy to remove pathogenic bacteria, becoming a food safety concern. The food industry will be helped in determining the danger of human pathogenic bacteria contamination by identifying these elements that affect the growth and/or improved survival of foodborne pathogens on intact cantaloupe surfaces by adopting best agricultural practices or implementing specific handling, transporting, and storing conditions for this specific commodity.

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