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Invited review: Hispanic-style cheeses and their association with *Listeria monocytogenes*

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ABSTRACT

The rise in consumption of Hispanic-style cheeses (HSC), due in large part to the increasing Hispanic population in the United States, has not been met with advances in food safety sufficient to prevent the numerous outbreaks and recalls due to *Listeria monocytogenes*. Hispanic-style cheeses are typically high moisture and have low salt content and low acidity from being subjected to little to no ripening. These conditions necessitate refrigeration to maintain safety and quality, as the majority of traditional extrinsic preservation methods are either ineffective or disrupt the mild sensory attributes of HSC. Unfortunately, the cold-growth of *L. monocytogenes* presents significant problems from post-pasteurization contamination or insufficient pasteurization. In this review, we discuss the factors affecting listerial contamination and growth in HSC, and present current knowledge of *L. monocytogenes* incidence in manufacturing settings and commercial prevalence. Furthermore, we differentiate HSC types by processing methods to aid with interpretation of works involving nonstandardized varieties and, finally, summarize research on intervention methods for eliminating listerial contaminants in HSC.

Key words: Mexican-style cheese, *Listeria monocytogenes*, food safety, antimicrobials

INTRODUCTION

Across the world, cheeses are consumed in numerous styles and broadly acknowledged for their nutritional value. About one-third of the milk produced in United States is used for cheese production, which is reflected in the broad variety of cheese varieties made in the United States, including American types, Italian types, Muenster, Swiss, and Hispanic-style cheeses (HSC; USDA-NASS, 2015). Hispanic-style cheeses

in particular, a category of cheeses referring to those originally developed and manufactured in Mexico and Latin America (Van Hekken et al., 2007), have been increasing in popularity among US consumers over the last 2 decades (Hnosko et al., 2009), which is reflected in the rise in both production and consumption. The HSC have shown an increase in production of 271% and increase in per capita consumption of 188% compared with that in 1996, a growth rate at least 3.5-fold higher than observed for Italian type cheeses, the largest cheese group produced and consumed in the United States (USDA-NASS, 1997, 2016; USDA-ERS, 2015). This trend is likely driven in large part by the growing Hispanic population in the United States, which increased 93.7% between 1996 and 2014, representing an estimated 17% (55 million persons) of the US population (US Census Bureau, 1997, 2015). However, the appreciation for HSC is not limited to Hispanic or Latin populations; the remarkable potential for its consumption by non-Hispanic consumers in the United States has been previously suggested (Clark et al., 2001).

The rise of consumption and production of HSC is expected to continue in the years to come, which has increased the need for proper awareness of the microbial safety concerns of this group of cheeses. It is well known that nonripened cheeses, such as fresh HSC, are prone to foodborne pathogen contamination, notably with *Listeria monocytogenes*. However, most HSC safety research has focused on Queso Fresco, leaving other commercially available varieties unaddressed (Torres-Llanez et al., 2006). Combined with the lack of identity standards for HSC in the United States, this has made it difficult to assess the listeriosis risks of other varieties and there has been no comprehensive assessment of *L. monocytogenes*-associated food safety risk between varieties of HSC.

This is unfortunate, considering the severity of listeriosis and its effect on public health. Infections by *L. monocytogenes* can develop into serious complications, including pneumonia, bacteremia, meningitis, or uterine infections that may result in miscarriage or stillbirth. Although listeriosis is rare, its high fatality rate among young, elderly, pregnant, or otherwise immunocompro-

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mised individuals has led the United States to declare *L. monocytogenes* 1 of 3 zero-tolerance microorganisms in ready-to-eat foods such as HSC. *Listeria* constitutes the greatest source of disease burden in dairy foods, with costs due to medical expenses, productivity loss, and mortality estimated to be between \$60 million and \$2 billion annually (Batz et al., 2012). The majority of dairy-associated listeriosis cases have been linked to HSC and soft-ripened cheeses (Batz et al., 2011). Costs borne by the dairy industry from recalls and outbreaks are unknown; however, individual outbreaks of pathogens in other foods have each been estimated to trigger hundreds of millions of dollars in nonmedical economic losses as well (Hussain and Dawson, 2013).

TYPES OF HISPANIC-STYLE CHEESES

Hispanic-style cheeses comprise a large and diverse group, albeit generally unstandardized. At least 30 different varieties are recognized in countries such as Mexico (Villegas de Gante, 2004). Currently there are 63 HSC-producing plants in the United States (USDA-NASS, 2015), manufacturing varieties including, but not limited to, Queso Fresco, Cotija, Oaxaca, Panela, Chihuahua, Queso Blanco, Asadero, Añejo, Manchego, Adobera, and Ranchero (CMAB, 2016). The HSC show considerable variation in shape, size, texture, moisture, and flavor due to differences in cheesemaking procedures such as curd setting methods, pressing, and ripening (Villegas de Gante, 2004). For further information on characteristics and production aspects of artisan cheeses most commonly produced in Mexico, see González-Córdova et al. (2016). Generally, HSC are characterized by their high moisture and are consumed shortly after manufacture. To help better understand the subtleties differentiating them, Figure 1 delineates several major processing steps that result in 11 select HSC types. The diversity among HSC allows for several ways to classify them but, for practical purposes, these cheeses can be divided into 2 main groups according to their degree of ripening: fresh and aged.

Fresh Hispanic-Style Cheeses

Most of the HSC are fresh (unripened), generally characterized by being soft, high moisture, having a mild fresh milk flavor, and being ready for consumption immediately after manufacture (e.g., Queso Fresco, Queso Blanco, Panela, and Ranchero). Moreover, *pasta filata* varieties (e.g., Oaxaca, Asadero, and Adobera), which involve kneading or stretching the curds much like mozzarella, are also considered fresh cheeses. As with all cheeses, HSC undergo varied manufacturing processes that differentiate styles and that may or may

not include a light “cook” step, curd milling, kneading, or pressing. Distinctive characteristics and manufacturing properties of these cheeses are summarized in Table 1.

Aged Hispanic-Style Cheeses

Aged HSC are hard or semi-hard cheeses subjected to ripening, leading to some degree of biochemical transformation of the curd, which affects numerous sensory characteristics. The degree of ripening of aged HSC is usually less than 1 mo, matching the preference of Hispanic consumers. Further description of distinguishing characteristics of prototypical aged HSC are outlined in Table 2. Aging of these cheeses, although less extensive than that of other aged varieties, may contribute to fewer food safety concerns than with fresh HSC, due to decreases in moisture content and pH.

FOOD SAFETY

Several steps can influence pathogen contamination, survival, or growth during manufacture of HSC. The source and microbial quality of milk, adjustment of fat content, milk homogenization, pasteurization, use of starter cultures, coagulation, extensive curd manipulation, hand stirring, salting, whey removal, milling, molding, and storage conditions may all contribute to increase the probabilities of cheese contamination (Ryser, 2007; Fernandez Escartin, 2008).

Traditionally, consumer preferences in Hispanic populations have led to a large proportion of HSC being made from raw milk (Villegas de Gante, 2004; Torres-Vitela et al., 2012), which may contain pathogens such as *Salmonella*, *Escherichia coli*, and *Listeria monocytogenes* (FDA, 2015). Consumption of raw-milk fresh cheeses constitutes a significant public health threat, evidenced by the number of outbreaks and recalls due to foodborne pathogen contamination.

Foodborne outbreaks caused by consumption of various cheeses have been tied to *Salmonella* spp., *Staphylococcus aureus*, *E. coli* O157:H7, and *L. monocytogenes* (Gould et al., 2014). It is recognized that HSC provide favorable conditions to support the growth or survival of several foodborne pathogens, including *Campylobacter* spp., *E. coli* O157:H7, *Salmonella* spp., and *L. monocytogenes*, and their consumption has even caused illness due to norovirus infection. However, with the exception of *L. monocytogenes*, HSC consumption represents no more than 0.02 to 0.5% of the outbreaks due to these pathogens (CDC, 2015a). However, about 1 of every 5 listeriosis outbreaks have been traced to HSC (CDC, 2015a), highlighting the fact that such fresh cheeses support *L. monocytogenes* growth to high levels, as

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