Chapter 16
The Effects of Probiotic Cultures on Quality Characteristics of Ice Cream

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ABSTRACT
The manufacturing design and probiotic strain that are used in ice cream production affect sensorial, nutritional, and physicochemical properties of ice cream. Therefore, it is possible to produce better quality products or to develop existing methods by considering the effects of probiotic cultures on these properties of ice cream. The International Dairy Federation has recommended that probiotic products contain at least 10^7 CFU/g of viable probiotic strain before consumption, so that the therapeutic value of a probiotic product can be associated with the viability of these bacteria. The nutritional value of probiotic ice cream is related not only to the dietary components it contains, but also to the maintaining of the viability and the activity of the probiotic bacteria. This chapter provides information on the viability of probiotic strains during ice cream processing and storage. Furthermore, the effects of probiotic cultures on sensory and physicochemical properties of ice cream are also discussed.

INTRODUCTION
Ice cream is a dairy product with a complex physicochemical system which is obtained by freezing a pasteurized mix prepared with fat, milk solid nonfat, sugar, stabilizers and emulsifiers, sometimes aroma and color substances, and fresh or dried egg yolk. Ice cream definition contains plain ice cream, nonfat, reduced-fat, low-fat, fruit added, and probiotic ice creams. As a result of its beneficial composition, ice cream can be described as a dairy dessert which is fondly consumed and which is used by manufacturers to deliver probiotics. Ice cream is an ideal vehicle for probiotic bacteria thanks to milk proteins, lactose, lipids, and other contents in its composition (Cruz, Antunes, Sousa, Faria, & Saad, 2009). Also, DOI: 10.4018/978-1-5225-5363-2.ch016
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it has a higher pH value, compared to other fermented foods, which is another important advantage for probiotic bacteria.

The World Health Organization has defined probiotics as viable microorganisms which provide health benefits when they are consumed in sufficient amount (FAO/WHO, 2001). The International Dairy Federation has reported that probiotics products should have at least $10^7$ CFU/g of viable cell in order to be beneficial to consumer health (Champagne, Gardner, & Roy, 2005). Viability and metabolic activity of probiotics are associated with food composition, processing, and storage conditions. In addition, probiotics influence the sensory and physicochemical properties of foods. Thus, it is necessary to assess the effects of probiotics on the quality characteristics of ice cream and determine the factors that affect the viability of probiotics from ice cream production to consumption. The aim of this chapter is to give an overview of how probiotics have an impact on the characteristics of ice cream and of which factors affect the survivability of probiotics in the ice cream matrix.

BACKGROUND

The demand of functional foods has increased rapidly, as consumers have more awareness of the health effects of foods. Probiotic dairy products are an important part of the functional food industry. Among the dairy products containing live culture, probiotic ice creams have attracted great interest in recent studies (Arslan et al., 2016; Cruxen et al., 2017; Yilmaz-Ersan, Ozcan, Akpinar-Bayizit, Turan, & Taskin, 2017). Ice cream ensures suitable conditions for the growth of probiotic bacteria in large counts and their viability over storage time. Several studies have informed that ice cream is appropriate to deliver probiotics in the diet (Da Silva, De Fátima Bezerra, Dos Santos, & Correia, 2015; Hekmat & McMahon, 1992). An ice cream matrix is a complex system consisting of fat globules, nutritional compounds, ice crystals, and air cells. However, probiotics, depending on their characteristics, cannot maintain viability in the ice cream due to oxidative, mechanical, cold, and osmotic stresses. In this context, studies focused on the viability of probiotic bacteria during ice cream production and storage (Arslan et al., 2016; Magarinos, Selaive, Costa, Flores, & Pizarro, 2007; Mohammadi, Mortazavian, Khosrokhavar, & Da Cruz, 2011; Nousia, Androulakis, & Fletouris, 2011). In addition, another focus of studies has been how probiotic cultures which are used in production affect the characteristics of ice creams.

*Lactobacillus* and *Bifidobacterium* species are the most commonly used probiotic bacteria in the manufacturing of probiotic ice creams. In probiotic ice cream formulations, appropriate cultures should be selected for maintain their viability in freezing and storage conditions. Probiotic strain characteristics, freezing, storage temperature and time, composition of ice cream, and packaging material have significant effects on the viability of cultures in the ice cream matrix. These factors will be discussed in detail in the following section. Homayouni, Azizi, Ehsani, Yarmand, and Razavi (2008) mentioned that *Bifidobacterium lactis* (Bb-12) and *Lactobacillus casei* (Le01) showed better resistance to ice cream conditions compared to other probiotics. However, the viability and growth of probiotic bacteria can be optimized with different production techniques and formulations. The probiotic cultures which are utilized in ice cream production are shown in Table 1.

Overall, the production of probiotic ice cream is carried out with four different techniques. Probiotics are inoculated at a concentration of about $10^8$-$10^9$ CFU/g of bacterial cells for each technique (Abghari, Sheikh-Zeinoddin, & Soleimanian-Zad, 2011; Arslan et al., 2016; Mohammadi et al., 2011). The common steps of these techniques consist of preparation of ingredients (e.g., milk, sweeteners, milk powder,