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Probiotic functional foods: Survival of probiotics during processing and storage

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ABSTRACT

Probiotic foods are reported to provide several health benefits, as they help in maintaining a good balance and composition of intestinal flora, and increase the resistance against invasion of pathogens. The demand of probiotic functional foods is growing rapidly due to increased awareness of consumers about the impact of food on health. Development of foods with adequate doses of probiotics at the time of consumption is a challenge, because several factors during processing and storage affect the viability of probiotic organisms. The presence of probiotics in food products may also adversely affect their quality and sensory properties. Several attempts have been made during the last few decades to improve the viability of probiotics in different food products during their production until the time of consumption. Major emphasis has been given to protect the microorganisms with the help of encapsulation technique, by addition of different protectants, and by alteration of processing and storage conditions. This contribution provides an overview of probiotic foods, factors responsible for survival of probiotics, and advance technologies used to stabilize their viability during processing and storage.

1. Introduction

Probiotics are defined as live microorganisms when administered in adequate amounts confer a health benefit on the host (FAO/WHO, 2001). Elie Metchnikoff hypothesized the concept of probiotics around the year 1900, when he noticed that the long, healthy lives of Bulgarian peasants were the result of their consumption of fermented milk products. Later on it was found that yogurt contained the organisms necessary to protect the intestine from the damaging effects of other harmful bacteria. Different microorganisms have been used thereafter as probiotics in the last century for their ability to prevent and cure diseases (Lee, Nomoto, Salminen, & Gorbach, 1999). Probiotic microorganisms are usually available as culture concentrates in dried or deep-freeze form to be added to a food for industrial or home uses. These may be consumed either as food products (fermented or non-fermented) or as dietary supplements (products in powder, capsule or tablet forms).

Consumption of probiotic cells through food products is the most popular approach at present. Most of the probiotic food products are categorized as functional foods, and represent a significant part of it. The demand of probiotic functional foods is growing rapidly due to increased awareness of consumers. The global market for functional foods and beverages has grown from $33 billion in 2000 to $176.7 billion in 2013 that accounts for 5% of the overall food market, and is the driving growth for the food industry as a whole (Granato, Branco, Cruz, Faria, & Nazzaro, 2010; Hennessy, 2013). It has been estimated that probiotic foods comprise between 60% and 70% of the total functional food market (Holzapfel, 2006; Kołozyn-Krajewskaa & Dolatowski, 2012; Stanton et al., 2001).

Significant success has been achieved during the past few decades in development of dairy products containing probiotic

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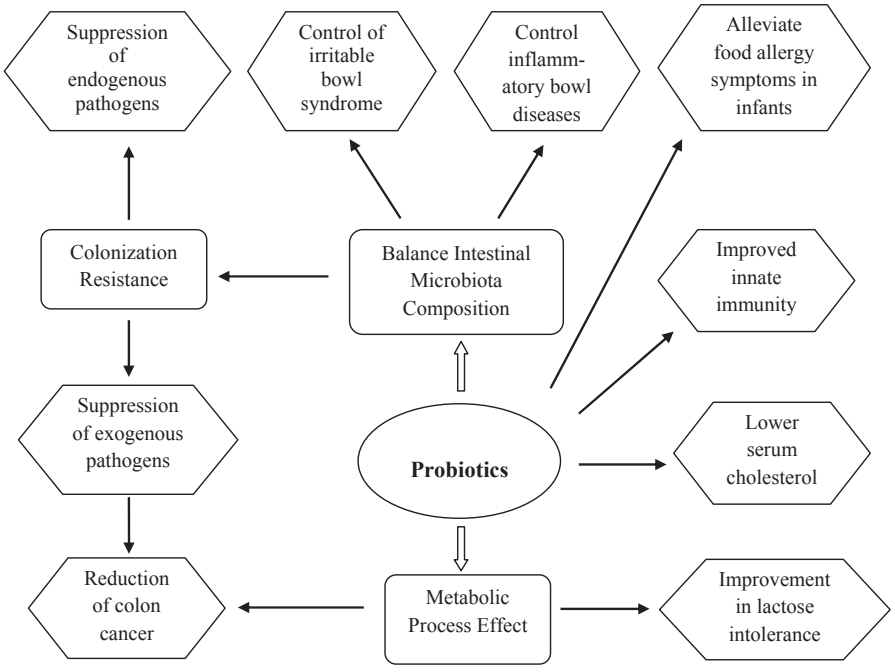

Fig. 1 – Probiotics consumption and health benefits (*Adapted from* Parvez, Malik, Ah Kang, & Kim, 2006).

bacteria, such as fermented milks, ice cream, various types of cheese, baby food, milk powder, frozen dairy desserts, whey-based beverages, sour cream, buttermilk, normal and flavored liquid milk (Mohammadi & Mortazavian, 2011). However, keeping in mind the high prevalence of lactose intolerance, different non-dairy probiotic products such as vegetarian-based products, cereal-based products, fruit juices, soya-based products, oat-based desserts, confectionary products, breakfast cereals and baby foods have been developed in recent years (Anekella & Orsat, 2013; Chen & Mustapha, 2012; Granato et al., 2010; Gupta & Abu-Ghannam, 2012; Lee & Salminen, 1995; Mortazavian, Khosrokhvar, Rastegar, & Mortazaei, 2010; Noorbakhsh, Yaghmaee, & Durance, 2013; Rivera-Espinoza & Gallardo-Navarro, 2010).

The probiotic foods should be safe and must contain the appropriate probiotic organisms in sufficient numbers at the time of consumption. Therefore, the probiotic strains selected should be suitable for large-scale industrial production with the ability to survive and retain their functionality during production and storage as frozen or dried cultures. It must survive during the food processing operations, and also in the food products into which they are finally formulated. The purpose of this contribution is to provide an overview of probiotic foods and factors responsible for survival of probiotic microorganisms, and recent technological advances in maintaining their viability during processing, packaging and storage.

2. Probiotic microorganisms in food

2.1. *Beneficial health effects of probiotics*

Probiotics provide a number of health benefits mainly through maintenance of normal intestinal microflora, protection against gastrointestinal pathogens (D'Aimmo, Modesto, & Biavati, 2007; Lourens-Hattingh & Viljoen, 2001), enhancement of the immune system (Gilliland, 1990), reduction of serum cholesterol level and blood pressure (Rasic, 2003), anti-carcinogenic activity (Rasic, 2003), improved utilization of nutrients and improved nutritional value of food (Lourens-Hattingh & Viljoen, 2001) (Fig. 1). Therapeutic applications of probiotics include prevention of infantile diarrhea, urinogenital diseases, osteoporosis, food allergy and atopic diseases; reduction of antibody-induced diarrhea; alleviation of constipation and hypercholesterolemia; control of inflammatory bowel diseases; and protection against colon and bladder cancer (Lourens-Hattingh & Viljoen, 2001; Mattila-Sandholm et al., 2002; Salminen, 1996; Venturi et al., 1999).

There are several evidences supporting potential clinical applications of probiotics in the prevention and treatment of gastrointestinal, urinogenital tracts and respiratory diseases (Gardiner et al., 2002). Mann and Spoerry (1974) discovered that blood serum cholesterol levels reduced significantly by drinking yogurt fermented with wild strains of Lactobacillus sp. Harrison, Peat, and de Heese (1975) reported decreased levels of serum cholesterol by consuming infant formula added with cells of *Lactobacillus acidophilus*. Similarly, Gilliland (1990) and Gill and Guarner (2004) showed control of serum cholesterol levels in adult human experiments.

It is hypothesized that these benefits may result from the growth and action of the probiotics during the manufacturing of cultured foods, while some may result from the growth and action of certain species of probiotics in the intestinal tract (Rasic, 2003). Stanton et al. (2005) stated that the claimed health place benefits of fermented functional foods are either due to probiotic effect (through the interaction of ingested live microorganisms with the host), or indirectly due to biogenic effect