Biocatalysis and Agricultural Biotechnology 4 (2015) 423–431

Contents lists available at ScienceDirect

Biocatalysis and Agricultural Biotechnology

journal homepage: www.elsevier.com/locate/bab

The potential applications of probiotics on dairy and non-dairy foods focusing on viability during storage

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ARTICLE INFO

Article history:
Received 24 April 2015
Received in revised form
20 July 2015
Accepted 21 September 2015
Available online 25 September 2015

Keywords:
Probiotics
Dairy products
Non-dairy products
Probiotics viability

ABSTRACT

Probiotic foods products are a fast growing area of functional food, as found to be strongly accepted by the consumers. The application of probiotics in dairy products is already common. However, the food industry is seeking to produce different varieties of probiotic foods other than dairy products with potential health benefits. The success of new probiotic foods depends on the ability of probiotics to provide sufficient numbers of viable cells that beneficially modify the gut microflora of the host. It is highly desirable that the viable counts of probiotics in the final product to be at least 10^6–10^7 cfu ml^{-1} to offering health benefits to the consumers. Therefore, the objective of this study is to review the applications of selected probiotics in dairy and non-dairy foods and their viability during the storage.

Contents

1. Introduction

Foods are not only to satisfy hunger and to deliver essential nutrients but also to prevent the development of nutrition-related diseases and to improve physical and mental well-being of consumers (Stanton et al., 2005; Arihara, 2006). This leads to the development of novel food for special health use that named functional food. Probiotic foods are the fastest growing area of functional food development. Probiotic cultures are successfully applied in different types of food matrices. A number of food products including dairy products (Vinderola et al., 2002; Buriti et al., 2005a, 2005b; Sheehan et al., 2007), meats products

http://dx.doi.org/10.1016/j.bcab.2015.09.010
1878-8181/

(Klingberg et al., 2005; Sidira et al., 2014b; Rubio et al., 2014), beverages products (Buriti et al., 2007a, 2007b; Espírito Santo et al., 2012; Vinderola et al., 2002), cereals products (Kedia et al., 2007; Rozada-Sánchez et al., 2008), vegetables and fruits products (Tsen et al., 2004; Kim et al., 2010; Blaiotta et al., 2012; Sarvan et al., 2013) and bread products (Palacios et al., 2006) have been utilised as delivery vehicles for probiotics. In general, the selection strain of lactic acid bacteria is important to ensure health benefits of probiotic foods. A number of health benefits associated with probiotic food products include treatment of diarrhoea (Reid et al., 2003), alleviation of symptoms of lactose intolerance (De Vrese et al., 2001), reduction of blood cholesterol (Jackson et al., 2002), anti-carcinogenic properties (Wollowski et al., 2001; Rafter, 2003) and improvement in immunity (Reid et al., 2003; Broussard et al., 2004). Many factors may affect the viability of probiotic bacteria in foods including the probiotic strains used, pH, the presence of hydrogen peroxide and dissolved oxygen, the concentration of metabolites such as lactic and acetic acids, the medium buffering capacity, storage temperature, the nature of the added ingredients and food matrices (Donkor et al., 2006; Pereira et al., 2011; Fonteles et al., 2011; Costa, et al., 2013). Viability and metabolic activity of the bacteria are important features of probiotics inclusion in food during manufacture thus the choice of appropriate probiotic strains will be essential. Probiotic foods must maintain survival of the probiotic strain at suitable levels ranging from 10^6 to 10^7 cfu ml^{-1} at the time of consumption (Madureira et al., 2011) to offering health benefits to the consumers. Therefore, the object of this study is to review the applications of selected probiotics in dairy foods (yogurt and cheese) and non- dairy foods (desserts, cereals, fruits, vegetables and meats products) and their viability during storage.

2. Dairy probiotics products

Dairy products are established as healthy natural products (Ramchandran and Shah, 2009). Regular consumption of certain dairy products has beneficial effects in the prevention of disease (Bozanic et al., 2001). Lactic acid bacteria (LAB) and their metabolites play a key role in enhancing microbiological quality and shelf life of fermented dairy products (Lourens-Hattingh and Viljoen, 2001; Leroy and De Vuyst, 2004). LAB has an essential role in most fermented foods for their ability to produce various antimicrobial compounds promoting probiotic properties (Temmerman et al., 2002). A number of dairy food products including yogurt (Kailasapathy and Rybka, 1997) and cheese (Stanton, 2001) have been utilised as delivery vehicles for probiotic to consumer.

2.1. Yogurt

Yogurt is fermented milk obtained by lactic acid bacteria fermentation of milk and is a popular product throughout the world. Probiotics mainly *Lactobacillus acidophilus* and *Bifidobacterium* spp. are added to improve the fermentation process for production probiotic yogurt (Donkor et al., 2006). The key problems associated with incorporating probiotic bacteria into milk during fermentation are slow growth in milk and low survival rate during storage (El-Dieb et al., 2012). One of the strategies applied to improve the growth of probiotic bacteria is the addition of prebiotic substances with proper selection of starter cultures (El-Dieb et al., 2012; Oliveira et al., 2012). In order to provide functional properties and increase the growth and viability of probiotic bacteria in yogurt many other supplements with active components have been studied such as plant extracts, milk proteins, inulin and lactulose as prebiotic substances (Table 1).

2.1.1. Probiotics viability of yogurt in the presence of fruits

It is important to emphasise that the addition of fruit juices or pulps might be deleterious to the viability of some species and strains of probiotics in food products, particularly as a result of acidity and the presence of antimicrobial compounds (Vinderola et al., 2002). Several studies have demonstrated the effect of plant compounds on the growth and metabolism of probiotics in yogurt (Lahtinen et al., 2007; Possemiers et al., 2010; Ranadheera et al., 2012). Previous study detected that yogurt enriched with flavouring agents such as strawberry, vanilla, peach and banana essences did not affect the growth of the probiotic bacteria (Table 1) in the optimum concentrations commonly used in dairy industry (Vinderola et al., 2002). Similarly, the presence of mango and guava pulps and their natural essences did not affect the growth of probiotic and starter bacteria in yogurt (Bedani et al., 2014). Another study conducted by Ranadheera et al. (2012) found that the

Table 1
Applications of probiotics in different types of yogurt.

Probiotics	Yogurt type	References
***Lactobacillus acidophilus*,*Lactobacillus casei*,*Lactobacillus paracasei*, *Lactobacillus rhamnosus*, and bifidobacteria**	Yogurt with flavouring agents such as strawberry, vanilla, peach, and banana essences	(Vinderola et al., 2002)
***L. acidophilus*La-5 and*Bifidobacterium animalis*Bb-12**	Soy yogurt enriched with mango and guava pulps	(Bedani et al., 2014)
***L. acidophilus*La-5,*B. animalis*Bb-12 and*Propionibacterium jensenii*702**	Stirred fruit yogurts	(Ranadheera et al., 2012)
L. acidophilus	stirred fruit yogurts	(Kailasapathy et al., 2008)
***L. acidophilus*L10 and*B. lactis*Bl04**	Açai pulp yogurt	(Espírito-Santo et al., (2010))
B. bifidum	Dates yogurt	(El-Nagga and Abd El–Tawab, 2012)
***Streptococcus thermophilus*ST-20Y,*L. acidophilus*LA-5, and Bifidobacterium BB-12**	Yogurt enriched with whey protein concentrate (WPC)	(Martín-Diana et al., 2003)
S. thermophilus*,*L. delbrueckii*subsp.*Bulgaricus*and*B. animalis*subsp.*Lactis	Yogurt enriched with skimmed milk powder, WPC and sodium caseinate	(Marafon et al., 2011)
L. bulgaricus*and*S. thermophilus	Yogurt enriched with L-cysteine (Cys)	(Michael et al., 2010)
L. rhamnosus*and*L. acidophilus	Yogurt enriched with pea protein, chickpea flour, lentil flour, pea fibre, soy protein concentrate and soy flour	(Zarea et al., 2012)
L. acidophilus*and*B. lactis	Yogurt enriched with green lentils	(Agil et al., 2013)
***L. rhamnosus*IMC 501 and *L. paracasei* IMC 502**	Yogurt enriched with buckwheat flour and oat bran	(Coman et al., 2013)
***L. plantarum*(6E and M6)**	Yogurt-like beverages enriched with rice, rice and soy, rice and barley, rice and emmer and rice and oat	(Coda et al., 2012)
S. thermophilus*,*L. acidophilus*,*L. rhamnosus*,*L. bulgaricus*and*B. lactis	Yogurt enriched with inulin	(Oliveira et al., 2011a)
L. acidophilus*,*L. rhamnosus*,*L. bulgaricus, B. lactis*and*S. thermophilus	Yogurt enriched with Lactulose	(Oliveira et al., 2011b)
***B. bifidum*Bb-02 and*L. acidophilus*La-5**		
	Yogurt enriched with Lactulose	(Ozer et al., 2005)