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Influence of probiotics, prebiotics, synbiotics and bioactive phytochemicals on the formulation of functional yogurt

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ABSTRACT

The new concept of functional foods has led to the varieties in the production of foods that deliver not only basic nutrition, but can also warrant good health and longevity. Yogurt has become one of the prevalent choices and considered as a healthy food since it provides excellent sources of essential nutrients. As the popularity of yogurt continues to grow, manufacturers and scientists continuously investigate the value adding ingredients such as probiotics, prebiotics and different kinds of plant extracts to produce functional yogurt comprising extra beneficial properties than the conventional yogurt. This review summarises the current knowledge on functional yogurt, applications and roles of probiotic, prebiotic and synbiotic in yogurt as well as the effects of phytochemicals added in innovative yogurt products. Their important properties were focused based on significance influences on quality and sensory attributes of yogurt products and associated health aspects.

1. Introduction

Yogurt or yoghurt is a long time known appreciated dairy food product available in various textures (i.e., liquid, set, smooth), fat contents (luxury, low-fat, virtually fat-free) and flavours (natural, fruit, cereal) (Shah, 2003; McKinley, 2005). It is traditionally made from the spontaneous or induced lactic acid fermentation of milk (Widyastuti, Rohmatussolihat, & Febrisiantosa, 2014). Basically, yogurt can be classified into two groups, which are standard culture yogurt and bio-yogurt or probiotic yogurt (Pandey, Du, Sanromán, Soccol, & Dussap, 2017). Standard yogurt is typically manufactured from the conventional starter culture strains, *Lactobacillus delbrueckii* subsp. *bulgaricus* and *Streptococcus thermophilus* (Arena et al., 2015). Meanwhile bio-yogurt or probiotic yogurt is supplemented with probiotic strains such as *Bifidobacterium* and *Lactobacillus acidophilus* that are claimed to have numerous health benefits and should remain live at adequate numbers (Lourens-Hattingh & Viljoen, 2001; Weerathilake, Rasika, Ruwanmali & Munasinghe, 2014; Baltova & Dimitrov, 2014; Chen et al., 2017). For instance, the National Yogurt Association (NYA) of the United States specifies that bio-yogurt products must contain 10^8 CFU/g lactic acid bacteria (LAB) at the time of manufacture to using "Live and Active Culture" logo while the Australian Food Standards Code regulations require that the LAB used in yogurt fermentation must be present in a viable form in the final product; nonetheless, the numbers of CFU/g are not specified (Pandey et al., 2017). Yogurt is considered as the most popular vehicle for the delivery of probiotics for the consumers (Lourens-Hattingh & Viljoen, 2001). The most commonly consumed yogurts are the set type yogurt and strains yogurt but nowadays, frozen and drinking yogurts are also part of yogurt's commercial varieties and have become increasingly popular.

Organoleptic, rheological, texture and microstructure properties of yogurt depend on several factors such as fermentation process, type of milk, starter cultures and probiotic strains, packaging and storage conditions. As depicted in Fig. 1, the conventional processing for manufacturing of yogurt involved several steps: initial treatment of milk (an optional step for using a high quality of raw milk (i.e., grade A or grade B milk as defined under the US Pasteurised Milk Ordinance, Food and Drug Administration (FDA) (Murphy, Martin, Barbano, & Wiedmann, 2016) in yogurt production), standardisation of milk, homogenisation, heat treatment, fermentation process, cooling and

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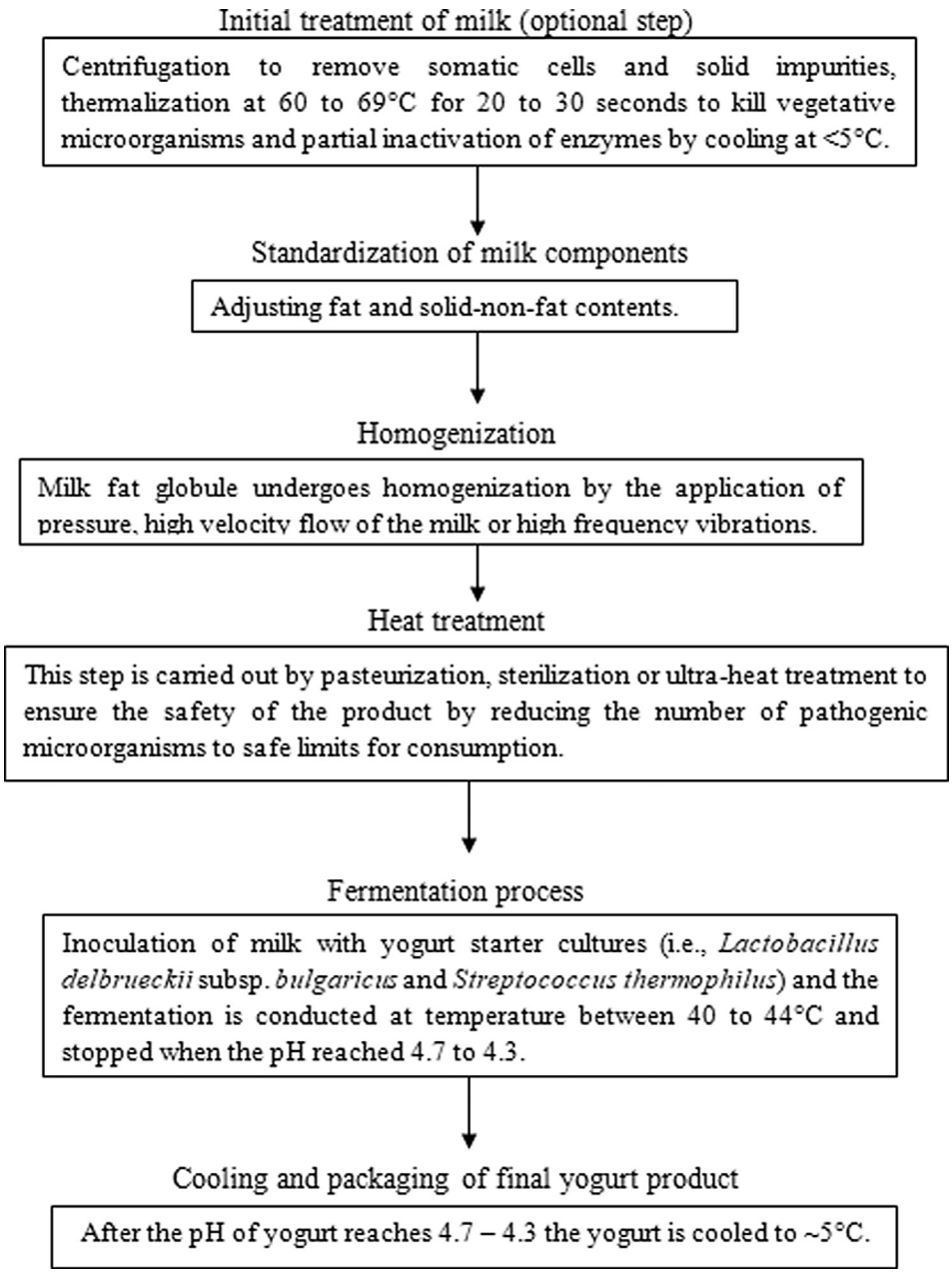

Fig. 1. Standardized yogurt manufacturing process.

ending with the packing of the final yogurt product (Sfakianakis & Tzia, 2014). Yogurt can be manufactured with or without the supplementation of natural derivative of milk (i.e., skim milk powder, caseinates or cream, whey concentrates), the addition of sugars (i.e., sucrose, fructose) and stabilisers (i.e., pectin, starch, gelatine, alginate) and increased solids in milk by adding fat and proteins to alter the texture and flavour (Lee & Lucey, 2010). For instance, protein and fat are commonly added to combat the defects in texture, physical properties and mouthfeel of low fat yogurt (Laiho, Williams, Poelman, Appelqvist, & Logan, 2017). Meanwhile, hydrocolloids stabilisers such as carrageenan, gelatin, xanthan gum and modified starch are often added to milk base to improve the texture, appearance, viscosity, consistency, mouthfeel as well as to prevent whey separation in yogurt (Nguyen, Kravchuk, Bhandari, & Prakash, 2017).

In general, the health benefits of fermented food products can be classified into two groups, which are nutritional function and physiological function (Bell, Ferrao, & Fernandes, 2017). The nutritional effect is related to the food function in supplying sufficient nutrients while physiological function concerns on the prophylactic and therapeutic benefits (Marco et al., 2017) that include the reduction in risk of diabetes (i.e., consumption of fermented kimchi decreases insulin resistance and increases insulin sensitivity (An et al., 2013)) and reduced muscle soreness from the consumption of fermented milk by *Lactobacillus helveticus* (Iwasa et al., 2013). In response to the consumers' awareness of these two imperative benefits, manufacturers are exploiting the demand by producing varieties of fermented food products with additional functional properties (Siro, 2008). Functional foods are currently part of the new market niche and the industry is kept on expanding with natural ingredients as the most influential drivers (Balthazar et al., 2017; da Silva, Barreira, & Oliveira, 2016; Granato, Nunes, & Barba, 2017). In particular, innovative processing of functional yogurt products includes the addition of probiotics, prebiotics or their combination, which is termed as synbiotic and incorporation of various bioactive components from natural sources to improve nutritional values, sensory profile, physiochemical and rheological characteristics as well as to provide therapeutic properties.