Microencapsulation of probiotics in hydrocolloid gel matrices: a review

Wunwisa Krasaekoopt
Assumption University, Faculty of Biotechnology, Hua Mak Campus, Hua Mak, Bangkapi, Bangkok 10240, Thailand

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ABSTRACT: The use of hydrocolloid gel matrices to encapsulate probiotics is of interest due to their gentle and simplicity of gel formation as well as mild condition used. This technique enhances the viability of entrapped cells during the product shelf life at least above therapeutic minimum level as well as in the gastrointestinal tract to ensure the health benefits of consumers. This review describes the advantages of microencapsulation, hydrocolloid gel matrices such as alginate, carrageenan and whey protein, microencapsulation processes, special treatments for further improvement in encapsulation efficiency of gel matrices as well as food applications of microencapsulated probiotics.

INTRODUCTION

Probiotics are living microorganisms that have been used in a manufacturing of functional food products such as yogurt and cheese because they improve the intestinal microbial balance of the host (1). The health benefits of probiotics include intestinal infection control, cholesterol level control, immune system stimulation, lactose utilization improvement in lactose maldigestors (persons who cannot digest lactose), providing antitumorogenic activity, and reduction of inflammatory bowel disease as well as Helicobacter pylori infection (2-4). In order to achieve these benefits, probiotic bacteria should be metabolically stable and active both in the product and host, which were influenced by food composition (acid, oxygen and hydrogen peroxide (5) and digestive system of host (acid, enzyme and bile salt). To make a healthy claim, the therapeutic minimum level should be at least 10^7 CFU/g or ml of the product (6), which can be achieved by using microencapsulation technology. Simultaneously, low level or poor survival of free probiotic bacteria was demonstrated by many studies (7-13). It was influenced by many factors such as pH, post acidification, hydrogen peroxide and storage temperature, including food compositions.

Microencapsulation of probiotics is a process that probiotic bacteria (core material or internal phase) is coated with or entrapped within another material (supporting material or wall material). This technique provides a physical barrier to the bacterial cells and has been proved to improve the survival of probiotic bacteria in adverse conditions such as in food products and simulated digestive system (14-17). Selection of microencapsulation techniques is of consideration. Since probiotics are living microorganisms, therefore, the microencapsulation techniques should provide the non-toxic condition in order to maintain cell viability and assist the releasing of cell in the GI tract where probiotics can colonize and provide the health benefits. Physical methods of microencapsulation techniques, such as spray drying, freeze-drying and spray-freeze drying methods, involve with the conversion of cell suspension in to solid dried powder (18). The encapsulated cells are released by rehydration as soon as they are wet when the powders are applied in foods. Conversely, microencapsulation of probiotics by using hydrocolloid gel matrices is achieved through chemical reaction. The microencapsulated cells remain in the gel when they are applied in wet condition of foods and will be released when the gel matrices are broken due to the changes in ionic condition. Moreover, the nutrient and metabolites can transport through the semipermeable membrane of gel matrices easily, minimizing cell release and contaminations. Therefore, this paper reviews the microencapsulation techniques of probiotics in hydrocolloid gel matrices including microencapsulation process, drying methods of microcapsules as well as the application of microencapsulated probiotics in foods.

BENEFITS OF MICROENCAPSULATION IN HYDROCOLLOID GEL MATRICES

Since the microencapsulation in hydrocolloid gel matrices uses and provides friendly environment to probiotic cells, the entrapped cells are saved from the harmful organisms and environment such as bacteriophages, freezing, freeze-drying, storage condition, harmful compounds in foods and gastric condition. Microencapsulated probiotics are protected from bacteriophages due to the smaller pore size of gel matrices than the smallest size of bacteriophages (19). Calcium alginate gel, for example, provides the pore size of 7-20 nm in diameter, whereas the smallest lactic acid bacteriophages are approximately 150 nm in length and exhibit a head diameter of approximately 50 nm (20, 21). Processing techniques also considerably influence to the survival of probiotic cells. Increasing in number of entrapped cells after freezing and freeze-drying are recognized. The viability of microencapsulated probiotics was remarkably improved by 30-40% during freezing and freeze-drying (22-24). In addition, the greater stability of entrapped cells was of interest. Many researchers have reported that probiotic bacteria encapsulated in hydrocolloid gel matrices, such as alginate and xanthan gum, provide better stability during storage than free cells (25-27). Kebary et al. (28) also reported that the survival of bifidobacteria increased by 10-20% during the storage at 20°C. Moreover, injured probiotic cells caused by high osmotic pressure and freezing injury in frozen dessert were