Microencapsulation of Live Probiotic Bacteria

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Scientific research regarding the use of live bacterial cells for therapeutic purposes has been rapidly growing over the years and has generated considerable interest to scientists and health professionals. Probiotics are defined as essential live microorganisms that, when administered in adequate amounts, confer a health benefit on the host. Owing to their considerable beneficial health effects, these microorganisms are increasingly incorporated into dairy products; however, many reports have demonstrated their poor survival and stability. Their survival in the gastrointestinal tract is also questionable. To overcome these problems, microencapsulation techniques are currently receiving considerable attention. This review describes the importance of live probiotic bacterial microencapsulation using an alginate microparticulate system and presents the potentiality of various coating polymers such as chitosan and polylysine for improving the stability of this microencapsulation.

Keywords: Live probiotic bacteria, microencapsulation, alginate, chitosan, polylysine

LIVE PROBIOTIC BACTERIA

Live bacterial cells have been paid considerable attention for treating several diseases including kidney failure uremia, cancer, inflammatory bowel disease, cholesteremia, and others [10–11, 35, 58]. Probiotic live bacteria are recognized as good or friendly bacteria and thought to reduce potentially harmful bacteria from the intestine [27]. Therefore, these live bacterial microorganisms can improve microbial balances in intestine and exert positive health effects on the host [24]. Lactobacillus and Bifidobacteria are the two most common types of microbes used as probiotics and are extensively investigated for their beneficial importance [72].

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Lactobacillus or lactic acid bacteria, a heterogeneous group of Gram-positive, microaerobic, or anaerobic species, are found to be the most beneficial bacteria in the digestive tract. The name “lacto” represents that they can convert milk sugar to lactic acid. When they produce lactic acid, an unsuitable environment exists in the intestine for the harmful bacteria and forces them to leave the niches [73]. For the production of yogurt, cheese, and fermented milk, they also play an important role. Lactic acid bacteria can participate in the synthesis of thiamine, riboflavin, folic acid, niacin, vitamin B complex, and absorption of minerals [21]. During the digestion of food, they also partially break down protein, fats, and carbohydrates [28, 48]. Lactobacillus facilitates several essential beneficial effects such as immunomodulatory, anticarcinogenic, and antimicrobial actions. Certain Lactobacillus spp. have been shown to significantly suppress intestinal tumors [4, 50, 65]. Several other studies suggest that lactobacilli have a possible effect on lowering cholesterol when consumed by humans [4, 65]. In another study, freeze-dried live Lactobacillus acidophilus consumed by patients with advanced chronic kidney failure was shown to lower the elevated levels of uremic toxins [64]. Recently, it has been reported that Lactococcus lactis can be genetically engineered to produce interleukin-10 (IL-10) and used for the treatment of inflammatory bowel disease by oral delivery [67]. Bifidobacteria, another essential probiotic bacteria and normal inhabitants in the human gut, have been shown to play beneficial roles in human health [43]. They are Gram-positive, strictly anaerobic, and grow at pH 4.5 to 8.5 [72]. Found usually in the large intestine in humans, bifidobacteria have been reported to function against many intestinal pathogens including E. coli [80], Salmonella typhimurium, and rotaviruses [62, 63]. Lyophilized strains of B. breve or B. longum, while consumed by premature infants, can restore the imbalance in the gut microflora [3, 65]. There is evidence that ingesting Bifidobacterium lactis can enhance general immunity [5]. Table 1 shows the applications of different live probiotic bacteria for various therapeutic purposes.
To achieve positive health effects by using probiotic bacteria, they must be delivered alive through oral administration to the intestine, which is the target site for their action. After reaching the intestine, they should establish themselves in certain numbers to exert positive health effects [15]. Thus, it appears that there are considerable evidences to support the importance of oral feeding of live probiotic bacteria for diverse therapeutic applications, although their oral delivery has several limitations. When probiotic bacteria are administered orally, they must be protected from the stomach acidic condition [66]. They can also be denatured by bile acid, antimicrobial compounds, and degradative enzymes before reaching the target site. These obstacles limit the survival and stability of the live bacterial cells before their arrival to the intestine alive. Thus, for an efficient oral delivery of live probiotic bacteria, an effective carrier system is mandatory to protect them from the unfavorable conditions. The microencapsulation technique facilitates a suitable carrier system for this purpose.

**DELIVERY SYSTEM OF LIVE PROBIOTIC BACTERIA**

**Microencapsulation Technique**

Microencapsulation of live bacterial cells has received considerable research interest because of its growing and promising potential in therapeutic applications against many diseases [10, 50]. This technique, hypothesized as a means to protect encapsulated active contents from the external environment, has been successfully used to entrap live probiotic bacteria or other therapeutic live cells for oral delivery to protect from the harsh gastric conditions and to deliver them with improved survival rate [12].