

**Table 12.5** Multilayer encapsulation of various probiotic microbes with multilayer wall materials.

Microorganisms	Special treatment	Reference
<i>Lactobacillus</i> spp.	Alginate + chitosan and corn starch	[88]
<i>Lactobacillus gasseri</i> and <i>Bifidobacterium bifidum</i>	Alginate + chitosan	[83]
	Alginate + resistant starch	[89]
<i>Lactobacillus casei</i> and <i>Bifidobacterium lactis</i>	Alginate + resistant starch	[90]
BAL	Alginate + starch	[91]
<i>Bifidobacterium animalis</i> subsp. <i>lactis</i> Bb12	Alginate + chitosan-acryl-eze	[92]
<i>Bifidobacterium</i>	Alginate + poly-L-lysine	[93]
<i>Lactobacillus casei</i>	Alginate + starch	[94]
<i>Lactobacillus acidophilus</i> and <i>Lactobacillus casei</i>	Alginate + resistant starch	[95]

### 12.7.3 Improvement of the Alginate Encapsulation: Prebiotics Addition

The alginates used in beverages are established to act as dietary fibers that help in the growth of beneficial microorganisms in the intestine. This nature of alginate makes it an effective prebiotic substance. The use of alginates as a stabilizer, thickener, emulsifier, and coating material in beverages is also reported to contribute to many health benefits like regulating the glucose and insulin release, reducing food intake, and also enhancing the growth of intestinal beneficial microbes.

The combination of alginate with prebiotic compounds such as resistant starch, inulin, and fructo-oligosaccharides enhances the protection of probiotic microbes in the food systems due to its synergistic and symbiotic relationship [96, 97]. The three-dimensional microcrystal structure of prebiotics along with the complex alginate structure contributes to an effective protective layer for bacterial cells [98].

Homayouni *et al.*, [90] showed that alginate and starch combination improved the stability of probiotic microbial cultures due to the formation of prebiotic starch–alginate complex and effective microencapsulation. The addition of prebiotics ensures protection of the probiotic microbes and also aids in their growth in the stimulated digestive system.

In another study, Nazzaro *et al.*, [99] developed a functional fermented carrot juice with probiotic microbes (*L. rhamnosus* DSM20711 and *L. bulgaricus*