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Need to Explore Further Connections between Nanotechnology and Probiotics

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Abstract

Due to their synergistic net health benefits, synbiotics have recently gained attention. These are a combination of probiotics and prebiotics that have a positive impact on the host by enhancing the survival and activity of healthy gut microbial flora. Consolidating the two in the eating routine has useful impacts on gastrointestinal and natural well-being. However, diminished intestinal delivery of probiotic active ingredients due to losing vitality during absorption may occur. Due to the capacity to nanotechnology to increase the bioavailability of loaded active ingredients, it has been rapidly expanding its use in nutraceuticals, resulting in improved outcomes. This paper highlights the connections between the nanotechnology and probiotics.

Keywords: Probiotics; Nanotechnology; Microbiota; Bioavailability; Microencapsulation

Abbreviations: NEMS: Nano Electro Mechanical frameworks; FOS: Fructose-Oligo-Saccharides

Introduction

Probiotics are helpful microorganisms that have a positive impact on the health of the host and are frequently employed in the diagnosis and treatment of illness. Probiotics are now found in many commercially available food, medicine, and supplement items. Probiotics improve the gut microbiota and the immune system by regulating the innate system response and production of anti-inflammatory cytokines [1]. Medical applications of nanotechnology are promising in creating efficient and targeted therapies. Nanotechnology and microencapsulation techniques can improve probiotics' efficiency. Probiotics have been used for a variety of purposes. Their use in skin wound healing was also discovered through recent researches. In order to maintain the control of homeostasis, absorption and excretion, skin tissue repair is of critical importance. The most recent methods for treating wounds use novel therapeutics including probiotics. Probiotics provide a wide variety of advantages for surgical wounds whether used alone or in conjunction with nanotechnology-based methods [2]. With no negative impacts on health, probiotics have demonstrated good benefits in wound re-epithelization, neovascularization, and wound healing. Table 1 shows the various immunomodulatory mechanisms of probiotics.

Probiotic-Generated Nanoparticles

The use of probiotics in the field of nanotechnology, particularly in the creation of nanoparticles, has greatly grown in recent years [3]. Bacteria, fungi, algae, and medicinal plants are employed to synthesize gold, silver, copper, zinc, and other nanoparticles. Bacteria like Bacillus *licheniformis, Bifidobacterium animalis, Brevibacterium linens, Lactobacillus acidophilus, Lactobacillus casei,* and many others have been employed for the synthesis of gold, selenium, silver, platinum, zinc oxide [4], copper oxide, iron oxide, and titanium oxide

nanoparticles. Being more biocompatible and effective, probiotic-generated nanoparticles can be explored as novel nutraceuticals for their ability to ensure sustained release and bioavailability of the loaded bioactive ingredients for diagnosis, targeted drug delivery, and therapy [5-12].

Increasing Bioavailability to Enhance the Impact

Keeping food ingredients and bioactive molecules bioavailable is the most crucial step in making functional foods. The proportion of a nutrient that is digested, absorbed, and metabolized in accordance with normal pathways is referred to as its bioavailability. Food security against outrageous circumstances can be upgraded by nanotechnology in the food business. It is essential to increase the bioavailability of food-bioactive compounds in order to enhance their absorption and stability by epithelial cells [13]. Utilizing nanoparticles to enhance bioavailability, absorption, viability, and shelf life, nanotechnology is well-established in the food industry [14]. Many bioactive substances, such as iron, coenzyme Q10 (CoQ10), curcumin, vitamins, and calcium, have been studied in nano-delivery systems. Numerous associative colloids, including biopolymer nanoparticles, casein micelles, nanoemulsions, lipid-based nanocarriers, and nanofibers, have been extensively developed. Increasing the surface area to volume ratio of the particles is necessary to increase their solubility, which in turn increases their bioavailability. CoQ10, for instance, is lipophilic and poorly bioavailable. A lipid-free nano-CoQ10 system was developed and modified with multiple surfactants to improve the solubility and bioavailability of CoQ10 upon oral administration due to the fact that CoQ10 is poorly soluble in water [15]. Natural polymers like carbohydrates, gums, proteins, and others can be used as nanostructured materials to encapsulate probiotics. Probiotic microencapsulation has been suggested as a good way to increase sensitive microorganisms' survival, resistance, and targeted release in the gastrointestinal tract. Due to their unique physical and chemical properties, nanostructured microcapsules offer a promising improvement for protecting probiotics from harsh environments (Table 1) [16].

S.no	Probiotic strains	Associated Health Benefits	Immunomodulatory activity	Mechanism of action	References
1	*Bifiidobacterium breve*	Immune stimulation (cytokine release)	Down-regulation of LPS-induced TNF- α production	Reduced LPS-FITC binding and inhibition of NF- κB	[6,7]
2	*Streptococcus thermophilus*	Immune stimulation (cytokine release)	Down-regulation of LPS-induced TNF- α production	Reduced LPS-FITC binding and inhibition of NF- κB	[6,7]
3	*Lactobacillus reuteri CRL 1098*	Antimicrobial activity (reduce the production of pro-inflammatory cytokines)	Increase free secretory IgA (sIgA) levels in rats	Inhibit the colonization of pathogenic microbes and remodel the commensal microbiota composition in the host	[8]
4	*Bacillus subtilis*	Attenuates inflammation, Immune stimulation	Enhance their immune function by increasing iNOS activity and stimulating NO and cytokine production	Trigger-specific humoral and cell-mediated immune responses	[6,9,10]
5	*Lactobacillus acidophilus NCFM*	Improve cardiovascular disease, lactose intolerance, prevent and treat cancer, regulate immunity, and improve gastrointestinal diseases	Increased production of IL-10 by dendritic cells leads to an increase in T cell polarization to Th2 phenotype	Interaction of S layer protein A with DC-SIGN on DCs	[7,11]
6	*Bifidobacterium breve M-16V*	Reducing the risk of developing necrotizing enterocolitis (NEC) in premature infants	Down-regulation of IL-8, MCP-1 and IL-6	Modulation of NF-κB and MAPK pathways via increased transcription of A20	[7,12]

Table 1: Various immunomodulatory mechanisms of probiotics.

A gathering of nanosensors called nanoelectromechanical frameworks (NEMS) has recently been enrolled in food organizations, and can, explicitly, recognize dangerous materials in food. The quality control industry makes use

of NEMS because they have advanced transducers that can specifically detect biochemical signals and chemicals. There are many benefits in regard to the usage of nanosensors in the food innovation class, for example, low expenses, and versatile instrumentation with speedy reactions. These nanosensors' main core is made of substances derived from tiny silicon particles that can detect food-borne pathogens and toxic proteins [13]. The control batch's probiotic viability remained higher. Inulin, hello maize, and FOS (fructose-oligo-saccharides) were viewed as advantageous in saving the feasibility of probiotic living beings. The oligosaccharide hydrocolloids have been displayed to safeguard probiotic microscopic organisms. Hi-Maize starch increased the number of live bacteria in microcapsules, despite the fact that FOS was found to be the most effective prebiotic for preserving the viability of probiotic organisms. By increasing the amount of alginate and the size of the capsule, probiotic viability and effectiveness are both enhanced. In addition, it was discovered that peptides function as prebiotics [17].

Nanomaterials have the potential to be used in the food industry to control the release of nutraceutical compounds, increase their encapsulating power, delay oxidation, increase effectiveness, and enable the creation of new functional products. Nanotechnology is turning into an important source of steady assistance for the once brilliant principles of gastroenterology. The developing connection between nanotechnology and probiotics for various applications should be emphasized in future research.

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