The Nature and Manufacturing of Probiotics/Prebiotics for Gastrointestinal Health and Other Health Benefits

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Abstract
Probiotics are live bacteria such as lactic acid bacteria and Bifidobacterium, that are beneficial for gastrointestinal health. These live probiotics bacteria colonized in the large intestine (colon), suggesting that these live probiotics bacteria assist in the maintenance of the natural balance of micro flora in the digestive system by reducing the effect of harmful and pathogenic bacteria in the digestive system. This competitive exclusion system preventing gastrointestinal tract from infection diseases and colon inflammation. Also, the intake of this live probiotics demonstrates to strengthen the host immune system and assumed to have significant potential impact as therapeutic options for variety of diseases.

Prebiotics are natural fibers of polysaccharides that target selected groups of healthy human colonic microflora, thus enhancing colonization of Bifidobacteria and Lactobacilli species that offering health benefits to the host. Prebiotics are non-digestible by digestive enzymes in small intestine and are fermentable when reached the colon. This fermentation process of prebiotics in the colon produce organic acids, short chain fatty acids, bacteriocins and other metabolites. These generated metabolites in the colon protecting the host against enteric infection in addition to enhances the growth of beneficial bacteria (probiotics) in the colon. There are two categories of prebiotics: Prebiotics fibers that are naturally occurred in whole grain, broccoli, asparagus, radish, cabbage, etc. and Prebiotics oligosaccharides such as Fracto-oligosaccharide (FOX), Galacto-oligosaccharides (GOS) and Xylo-oligosaccharides (XOS). These Prebiotics of oligosaccharides are manufactured enzymatically using microbial enzyme and carbohydrates extracted from plant sources as enzymes substrates.

Synbiotics concept was first introduced as a mixture of probiotics and prebiotics that beneficially effect the host gastrointestinal tract. This synbiotic relation formula that contains both probiotics and prebiotics are manufactured by using microencapsulation technology and are marketed in the form of capsules, tablets, or powders.

Keywords: Probiotics; Lactic Acid Bacteria; Lactobacillus, Bifidobacterium; Prebiotics; Fructo-Oligosaccharides (FOS); Galacto-Oligosaccharides (GalOS); Xylo-Oligosaccharides (XOS); Synbiotics; Microencapsulation

Introduction
The human intestinal tract harbors a mixture of prokaryotic and eukaryotic bacteria, fungi (molds), Archaea, viruses and bacteriophages. These mixture of microflora in the intestinal tracts is referred to intestinal microbiota. It is estimated in human intestinal tract a total of $10^{14}$ microbiota cells that are mainly present in the colon [1]. These intestinal microbiota are colonized immediately in human

intestinal tract after birth and lasts for lifetime [2]. Probiotics are living microorganisms when ingested and colonize in the large intestine provide health benefits to the host. It is also, colonize in the upper part of the intestine and prevent adherents of pathogens to the intestinal tract. This mechanism of preventing the adherent of pathogens to the intestinal tract is known by the name competitive exclusion [3]. Many types of microorganism are classified as probiotics. All have different benefits and come from two major groups Lactobacillus and Bifidobacterium. In addition to these two major groups Lactobacillus and Bifidobacterium the yeast Saccharomyces boulardii is also classified as probiotic. These probiotics are naturally presence in human stomach, intestines and vagina [4]. These probiotics are also available in foods such as yogurt, milk, juices, soy beverages and as dietary supplements in the form of capsules, tablets and powders [5].

Probiotics

The term probiotic is derived from the Greek language meaning “for life”. Food and Agriculture Organization (FAO) and World Health Organization (WHO) defined probiotics as “live microorganisms which when administered in adequate amounts confer a health benefits to the host (human or animal)” [6]. These live microorganisms that are falling under probiotics definition are:

**Lactobacillus**: Is a genus of rod shape, Gram-positive, non-spore former, facultative anaerobic or microaerophilic bacteria. They are belonging to lactic acid bacteria that convert sugars into lactic acid. They are constitutent a significant component of the microbiota in human body sites such as the digestive system, urinary tract and genital system [7]. Some of Lactobacillus species are used as starter culture in fermented foods such as yogurt, cheese, sauerkraut, pickles, beer, cider, kimchi, cocoa, kefir, wine, etc. Some species of the genus Lactobacillus produce by fermentation low molecular weight compounds known by name bacteriocins that inhibit the growth spoilage and pathogenic bacteria in foods [8]. The representative probiotics species of Lactobacillus are mainly: *L. acidophilus*, *L. plantarum* and *L. rhamnosus*, *L. johnsonii*, *L. gasseri*, *L. casei*, *L. Paracasei*, *L. salvarius*, *L. bulgaricus* and *L. reuterai* [9].

**Pediococcus**: Is Gram-positive cocci often found in pairs or tetrads and commonly found in fermented vegetables, fermented dairy products and meat. The species *P. acidilactici* [10] has emerged as a potential probiotic in animal and human experiments by being able to colonize in the digestive tract and exert antagonism against other microorganisms, including enteric pathogens, through the production of lactic acid and the secretion of bacteriocins. It is homofermentative and facultative anaerobe bacteria grow in a wide range of pH, temperature and osmotic pressure.

**Streptococcus**: Is Gram-positive bacteria and a fermentative facultative anaerobe, it is widely consumed in fermented dairy products. However, its probiotic attributes are often considered secondary as it is rarely used as a probiotic product. Some strains of species *Streptococcus thermophilus* have been studied in vitro and demonstrated probiotics potential and anti-cancer activity [11].

**Bifidobacterium**: Is Gram- positive bacteria, non-spore former, anaerobic and branched characterized by Y-shaped morphology [12]. Bifidobacteria was isolated in Pasteur Institute-Paris in the year 1988 from intestinal tract of breast-fed infants and named by the name Bifidus [13]. They are ubiquitous inhabitant in gastrointestinal tract, mouth, vagina in human and other mammalians. Some species of Bifidobacteria used as probiotics are such as *B. bifidum*, *B. breve*, *B. lignum* and *B. infantis*.

**Saccharomyces boulardii**: Is the only yeast species that are identified as probiotics. This yeast is unicellular with diameter of 2 - 8 µm and length 3 - 8 µm. *Saccharomyces boulardii* is used for general digestion problems and for treating and preventing diarrhea symptoms [14].

**Other microorganisms**: The two Gram-negative bacteria of *Escherichia coli* Nissle 1917 and *Enterococcus faecium* SF68 are also identified as probiotic [15]. *Escherichia coli* Nissle 1917 is successfully being used in the treatment of intestinal inflammation, especially for patient suffering from ulcerative colitis [16]. *Enterococcus faecium* SF68 effectiveness as probiotic is claimed for the treatment of diarrhea, irritable bowel syndrome, lowering serum cholesterol and for immune regulation. These effectiveness has been investigated in very few studies. As a result, there are no enough data to firmly conclude the efficiency of *Enterococcus faecium* SF68 as probiotics [17].

Live probiotic microorganisms are present in fermented foods and are marketed as dietary supplements. Many of these fermented foods such as yogurt contains live beneficial bacteria of *Lactobacillus bulgaricus* and *Streptococcus thermophilus* [18]. In dietary supplements probiotics are available in the form of capsules, powder or liquid. These dietary supplements contain mixed cultures of live probiotics microorganisms rather than single strains. Marketed dietary supplements contains from 1 to 10 billion CFU (colony forming units) plus oligosaccharides as growth factors (bifidis factor) to enhance the growth of probiotics and beneficial bacteria in the digestive system [19]. These oligosaccharides that enhance the growth of probiotics are known by the name prebiotics [20]. The relationship between probiotics and prebiotics that benefit the host are known the name synbiotics [21].

**Prebiotics**: The term prebiotics was first introduced in the year 1995 by Gibson and Roberfroid [22] to describe food grade ingredients that are nondigestible by the host but are able to promote the growth of healthy endogenous live beneficial bacteria in the colon. Thus, enhancing colonization of *Lactobacilli* and *Bifidobacteria species* that offering health benefits to the host. The enhancement of healthy bacteria (probiotics) and the inhibition of harmful bacteria in the colon is known by the name competitive exclusion [3]. The most common prebiotics incorporated with probiotics in dietary supplements or in fermented foods are fructo-oligosaccharides, galact-oligosaccharides and Xylo-oligosaccharides. These polysaccharides are also known by the name functional oligosaccharides due their other health benefits in addition to their prebiotic's property [23].

**Fructo-oligosaccharides (FOS)**: Also, known by the name oligofructose or oligo fructan. They are naturally present in higher plants such as, fruits and vegetables [24]. FOS are short chain of fructose polymer that are different from inulin in the degree of fructose polymerization (DP) and are mixture of the kestose (GF2), nystose (GF3) and fructofuranosyl nystose (GF4), of which the fructose units (F) are linked at the β (2-1) glycosidic bonds and the terminal glucose unit (G) is linked to fructose unit at the α (1-2) glycosidic bond (Figure 1). FOS are, produced enzymatically at high yield from the polysaccharide inulin [25] as a substrate using the enzyme inulinase (EC 3.2.1.7), derived from *Aspergillus niger*. Also, manufactured enzymatically from sugar sucrose as a substrate using the enzyme fructosyl-transferase (EC 2.4.1.9), or the enzyme β-fructo-furanosidase (EC 3.2.1.26). Both enzymes are derived from mold or bacteria such as, *Aspergillus niger* or *Lactobacillus bulgaricus*, respectively [26].

![Figure 1: Fructo-oligosaccharides. A mixture of ketose (GF), Nystose (GF) and fructofuranosyl nystose (GF) with fructose unit (F) are bound to β (2-1) glycosidic bonds, and glucose terminal unit (G) is bound at a α (1-6) glycosidic bond.](image-url)
Galacto-oligosaccharides (GalOS): are naturally occurred in milk at low concentration [27] and commercially produced enzymatically by trans galactosylation of milk sugar lactose as a substrate, using the microbial enzyme β-galactosidase (EC 3.2.1.23) derived from the mold Aspergillus oryzae [28]. Chemical structure of galacto-oligosaccharides chain [G-(Gal)2-Gal], are varies in galactose (Gal) unit’s length with a terminal of glucose (G) unit. The degree of galactose polymerization is in the range of two to eight galactose units (Figure 2).

**Figure 2:** Galacto-oligosaccharides (GalOS)

Composed of Galactose chain linked together with β (1-6) glycosidic bonds and bound to glucose terminal by β (1-3) or β (1-4) glycosidic bond.

Xylo-oligosaccharides (XOS): are naturally present at low concentration in fruits, vegetables, bamboo, honey and milk [29]. XOS are polymer of five carbons (C₅) of the pentose sugar xylose which, makes XOS are different from other oligosaccharides that are polymers of six carbon (C₆) of hexose sugars. The number of xylose units in XOS chemicals structure are linked together by β (1→4) glycosidic bonds and are vary from tow to ten units (Figure 3). XOS are produced enzymatically using xylan as a substrate. Xylan is a pentose polymer of sugar xylose present in hemicellulose structure of plant cells and can be extracted from agriculture residue [30] by using alkali chemicals such as, potassium or sodium hydroxide (KOH or NaOH), or by using dimethyl sulfoxide (DMSO). Enzymatic process for the production of XOS from xylan as a substrate, is by the microbial enzyme xylanase (EC 3.2.1.8). This enzyme hydrolysis β (1→4) glycosidic bonds that linked xylose units in xylan chemical structure (Figure 3).

**Figure 3:** Xylo-oligosaccharides.

Composed of xylose residues linked together by β (1-2) glycosidic bonds. (n) is variable number of xylose units linked together.
Synbiotics: United Nations Food and Agriculture Organization (FAO) recommends that the term "synbiotic" be used only if the net health benefit is synergistic. That said, Synbiotics can be defined as a mixture of probiotics and prebiotics in dietary supplements, or in foods that beneficially effect the host (human or animal) by enhancing the growth and improve the survival of beneficial bacteria (probiotics) in the gastrointestinal tract [31].

Manufacturing and delivery system of probiotics/prebiotics mixture to the host digestive system

Maintaining probiotic bacteria viable during storage (shelf life) and during passing through gastrointestinal tract to reach the target (colon) is important to achieve probiotics health benefits. In storage conditions, probiotics must be protected from moisture and temperature to extend its shelf life as viable cells [32]. In gastrointestinal tract probiotics must be protected from the low acidity environment in the host stomach and small intestinal tract to reach viable to its target in the colon [33]. In addition, food or beverages that contains probiotics, must maintain its organoleptic characteristics by preventing potential microbial fermentation from incorporated viable probiotics bacteria [34]. Microencapsulation technology with hydrocolloids is the promising technique that extend probiotics shelf life and as a delivery system by facilitate delivery live probiotics bacteria to the colon [35].

This microencapsulation technology has multiple applications in addition to probiotics encapsulation such as in, foods, beverages, pharmaceuticals, cosmetics and agriculture chemicals by assisting in making ingredients free-flowing, providing ingredients stability, preventing ingredients interaction, deliver active ingredients to its target, enhance the bioavailability of nutrients, enhance flavor, mask off taste or odors and improve the quality of end products [36].

Microencapsulation may be defined as the packaging technology of solids or liquid materials in thin polymeric coatings, forming small particles called microcapsules [37]. The polymeric coating acts as a protective film, isolating solid or liquid materials in the core as a protection from inadequate exposure (Figure 4). The selected polymeric coating membrane must dissolve itself through a specific stimulus, releasing the solid or liquid materials in the target place or at the ideal time. Microencapsulation, a mixture of probiotics (live bacteria) and prebiotics (oligosaccharide) can be employed in capsules smaller than 1 mm. Hydrocolloids that are used as wall materials or capsules in microencapsulation technology are edible carbohydrate polymers such as alginate, chitosan, carrageenan, locust bean, xanthan gum, gelatin, pectin, whey protein and resistant starch [38]. The main purpose for probiotics microencapsulation is to protect probiotic bacteria from the harsh gastric environment and intestinal bile in the upper gastrointestinal (GI) passage tract prior reaching the colon where live probiotics bacteria will exert their health benefits [39]. In the colon the polymeric coating (hydrocolloid) is consumed by enteric microbiota releasing live probiotics bacteria from microcapsules cores at the site of its action. This target release concept is known by the name control release [40].

**Figure 4:** Single microcapsule protecting viable bacteria in the core.

Microcapsule technology protecting probiotics bacteria during storage and from gastric tract harsh environments, plus target the delivery of viable probiotics to the colon for colonization.
There are two microencapsulation techniques [41] that are being use for probiotic/prebiotic microencapsulation. These two techniques are extrusion method and emulsion method (Figure 5).

**Extrusion method:** This method is based on a polysaccharide gel that immobilizes the core when it contact with a multivalent ion. As an example, incorporating the core containing live probiotics bacteria and the prebiotic (polysaccharide) in a sodium alginate solution, followed by undergoing drop-wise extrusion via a syringe into a hardening solution such as, calcium chloride. Microcapsules produced by this method is almost impermeable barrier against oxygen and increase the shelf life of sensitive compounds to oxygen.

**Emulsion method:** This method is based on the core of probiotics/prebiotic mixture is dispersed first in an organic solvent where the hydrocolloid such as sodium alginate is present. The dispersion is emulsified in vegetable oil, which contains an emulsion stabilizer such as calcium chloride. This emulsion method is commonly used for its simplicity to encapsulate enzymes, minerals, vitamins and microorganisms.

**Drying stage:** After microencapsulation by either one of these two methods, drying stage by freeze dryer, spray dryer, or fluidized bed dryer are applied to produce dry microcapsules of probiotics/prebiotic mixture encapsulated in the microcapsule core [42].

**Mechanisms of probiotics/prebiotics activities**

Probiotics have various mechanisms of action, although their mechanisms of activities are not fully understood. It is demonstrated that prebiotics (oligosaccharides) selectively enhance the growth of healthy probiotics bacteria of *Lactobacillus* and *Bifidobacterium* species.
resulted in the inhibition of harmful microbiota in the colon. The enhancement of good bacteria (probiotics) and the inhibition of bad or pathogenic bacteria is known by the name competitive exclusion [3]. The most of the prophylactic health effect to the host (human or animals) from these prebiotics such FOS, GaOS and XOS are due to the selective consumption of these prebiotics by *Lactobacillus* and *Bifidobacterium* species as a fermentative substrate producing organic acids, short chain fatty acids, bacteriocins and other metabolites. These generated metabolites in the colon protect the host against enteric infection. In addition, the intake of probiotics/prebiotics as dietary supplements increase mineral absorption, stimulate immunomodulation for the prevention of allergies and gut inflammatory conditions [43]. Other trophic effects from the intake of probiotics/prebiotics are providing the host with healthy colonic epithelial cells, prevent constipation symptoms by increasing fecal bulking and may reduce risk factors for colon cancer by reducing the toxicogenic and carcinogenic generated from intestinal microflora (microbiota) metabolism [44]. Immunomodulation mechanism by probiotics/prebiotics have been investigated by numerous researchers demonstrated considerable evidences that probiotics influence several aspects in triggering both acquired and innate immunity responses [45] by induce phagocytosis, activate B-cell for the of secretion IgA and IgG antibodies, modify T-cell response for cell immunities, enhance T-cell helper (Th1) responses, attenuated T-cell helper (Th2) responses and assist in the secretion of cytokines such as IFNγ and IL-2, IL-3, IL-4 and IL-5 (Figure 6).
bloating, flatulence, diarrhea, constipation, poor digestion), maintain a healthy-immune system and energy level, support the gut during and after antibiotics treatment, maintain healthy liver function and support clear healthy skin. In addition, there are scientific evidences supporting probiotics intake for the treatment of acute diarrhea diseases, prevention of antibiotic-associated diaries, improve lactose metabolism and reducing serum cholesterol levels [46]. Health benefits mediated by probiotics intake is not limited to the above, some researchers claim that probiotics intake decrease cancer incidence and possibly contribute to coronary heart disease prevention [47]. Such claims as therapeutic treatments required clinical trials to investigate and to confirm the efficacy of probiotics. It is important to highlight that, in addition to gastrointestinal tract health, probiotics in dairy products improve bacterial vaginosis for women by inhibit yeast infection and enhance the growth of healthy bacteria such as *Lactobacillus spp.*

**Figure 7:** Probiotics health benefits. Various health benefits from probiotics bacteria consumption.

**Probiotics safety and risks**

Probiotics have been used safely in foods and dairy products for hundreds of years. Food and Drug Administration (FDA) in United States designate Generally Recognized as Safe (GRAS) for certain probiotic organisms when added to foods. These probiotics organisms with GRAS status are strains from the genera *Lactobacillus, Bifidobacterium, Saccharomyces, Streptococcus* and *Enterococcus*. Most popular marketed probiotic strains from these genera are mixture of *Lactobacillus* and *Bifidobacterium* strains. These strains are considered as components of normal healthy intestinal microbiota and did not pose any risk to the host (human or animals). The most common probiotics side effects are a temporary increase in gas, bloating, constipation and thirst. In addition to these gastrointestinal side effects, other theoretical risks have been described in clinical trial, include systemic infections, excessive immune stimulation in susceptible individuals and gene transfer. These theoretical risk needs further research investigation to properly describe the incidence and severity of adverse events related to probiotics consumption [48]. High-risk populations such as critically ill patients and immunocompromised subjects deserves particular attention in these research investigations. In general, prebiotics/probiotics supplements for most healthy adults are safe.

with rare side effects and it is recommended for a consumer considering taking probiotics/prebiotics as dietary supplement to consult with his or her personal doctor first.

**Global probiotics market**

Wide range of food products containing live probiotic bacteria strains are continue to grow. The current global probiotics market is in dairy-based products, nondairy foods, dietary supplements and animal feeds. Dairy-based products includes yogurts, fermented milk, cheeses, ice cream and milk powder. Non-dairy foods products include cereals, soy-based products, nutrition bars, juices and beverages. These marketed food products are in addition of marketed probiotics as dietary supplements for human consumption in the form of capsules, tablets and powders. Probiotics in animal feeds are also growing due to the ban of incorporating antibiotics in animal feeds as growth promoter. These antibiotics ban in animal feeds is due to the concern of emerging antibiotic resistant microbial pathogens that might affects both human and animal health. The current global market of probiotics is estimated to $ 48.4 billion and it is estimated to reach $ 77.0 billion by the year 2025 [49]. Probiotics in animal feed market is currently estimated to $ 4.6 billion and due to the ban of use antibiotics in animal feeds it is expected to reach $7.0 billion by the year 2025 [50].

**Discussion**

Probiotics are live microorganisms that are intended to have health benefits for both human or animals when consumed. The most common specific probiotic bacteria strains are from the genera of *Lactobacillus*, *Bifidobacterium*, *Enterococcus*, *Streptococcus*, *Pediococcus*, *Escherichia coli* and the yeast *Saccharomyces boulardii*. It is important to highlight that health benefits have been demonstrated from specific probiotics strains and different types of probiotics may have different health effects. For example, if a specific strain of *Lactobacillus acidophilus* helps prevents a health symptom, it doesn't necessarily mean that another strain of *Lactobacillus acidophilus* would prevent the same health symptom. These probiotics bacteria are naturally present in fermented foods or added to beverages and to non-fermented food products. In addition, marketed dietary supplements of probiotics contains mixed live prebiotics species and strains.

The first reference to prebiotic concept was initiated in the year 1954, when a researcher by the name Gyorgy reported that a component of human milk (N-acetyl-glucosamine) promoted the growth of a strain from the genus *Bifidobacterium* [51]. The recent definition of prebiotics is nondigestible food ingredients that target and select groups of healthy human colonic microflora, thus enhance and help colonization of good bacteria such as *Bifidobacteria* and *Lactobacilli* species offering health benefits to the host. These prebiotics of oligosaccharides that enhance the growth of beneficial bacteria are known by the name bifidus factor or growth factor are polysaccharides (carbohydrates) that are fermented and enzymatically metabolize by intestinal microbiota producing short-chains fatty acids and other metabolites, that have healthy affect not only to gastrointestinal tracts but also to the health of other distant organs. These prebiotics are inulin, fructo-oligosaccharides, galacto-oligosaccharides, xylo-oligosaccharides, soy-oligosaccharides, lactulose and others. Fructo-oligosaccharides, galacto-oligosaccharides and xylo-oligosaccharides are the most common prebiotics that are incorporated at low concentrations with probiotics bacteria in microcapsules and marketed as dietary supplements. The property of these prebiotics is non-digestible, resistant to acidic PH in the stomach host, fermentable by intestinal microbiota and selectively stimulate the growth of beneficial bacteria (probiotics) in the host colon.

Due to, the great interest of consumers for these types of prebiotics as bifidum factor for health benefits, manufacturing of these prebiotics is by enzymatic processes from natural sources of carbohydrates as enzymes substrate have been developed. These developed enzymatic processes produce prebiotics with higher yield and less costly comparing to the traditional prebiotics production process by plants extraction that are very costly due to lower yields.

Synergistic combinations of probiotics and prebiotics are called by the name synbiotics. This synbiotic concept was first introduced as "mixtures of probiotics and prebiotics that beneficially affect the host by improving the survival and implantation of live microbial in the gastrointestinal tract. Currently, the United Nations Food and Agriculture Organization (FAO) recommends that the term "synbiotic" must be used for any other combinations only if the net health benefit to the host is synergistic.

Microencapsulation is a process by which solid or liquid material (the core) are coated with a film of polymeric material (the shell) to produce capsules in the micrometer to millimeter range, known as microcapsules. This microencapsulation technology is currently used to maintain the viability of probiotic bacteria during food products processing and storage, plus to improve the survival rates of probiotics bacteria during gastric transit to reach its target in the colon for colonization. A variety of natural edible hydrocolloids are commonly used for microencapsulation such as alginate, chitosan, carrageenan, locust bean, xanthan gum, gelatin, pectin, whey protein and resistant starch. From these hydrocolloids, alginate and gellan are the most commonly used materials for probiotics/prebiotics microencapsulation. Methods used for probiotics/prebiotics microencapsulation are emulsion method or extrusion method. These two methods of microencapsulation required drying stage before marketing.

The regulation of marketed probiotics is differing between countries and so far, there is no universally agreed framework [52]. Regulation of probiotics in the United States is complex depending on the purpose of probiotic product’s intended to be used. Probiotics that are marketed as a dietary supplement, or as food ingredients are regulated differently than probiotics that are marketed as biological product.

Probiotics marketed as dietary supplements, or as food ingredients does not need premarket review or approval by Food and Drug Administration (FDA) in United States. But must comply with Good Manufacturing Practice (GMP) guidelines that are recommended by FDA [53]. In addition, manufacturers of probiotics as dietary supplements must labeled the end product with complete information’s (Figure 8) and may add claims about how the product affects the structure or function of the consumer body but does not allow to make health claims, such as disease treatment without FDA’s consent. Probiotics marketed as biological products need premarket review for safety, purity, potency and efficacy that are required by FDA before approval for marketing [54].

Figure 8: Probiotics bacteria as dietary supplements labels. Reading the information’s on the label is important before choosing a probiotic supplement.
Conclusion

Probiotics are mixed live microorganisms from different genes, species and strains, when administered in adequate amount in the form of microcapsules confer health benefits to the host (human or animals). Incorporation of oligosaccharides (prebiotics) with probiotics in microcapsules improve the host health benefits. The relationship between probiotics and prebiotics is synbiotic relationship.

Probiotic bacteria in foods, beverages and as dietary supplements have become increasingly popular during the last two decades as a result of the continuously expanding scientific evidence pointing to their beneficial health effects to human and animals.

Probiotics/prebiotics regulations are differing among countries, but all is emphasis on scientific credibility of health benefits.

Bibliography


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