Potential use of probiotics

Ekachai Chukeatirote

Abstract

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Probiotics (Greek: for life) are commonly defined as mono- or mixed cultures of live microbes that, when applied to animal or human, possess a beneficial effect on health of the host. These beneficial effects include disease treatment and prevention as well as improvement of nutrients’ digestion and absorption. Probiotic microorganisms are generally, albeit not exclusively, lactic acid bacteria (LAB) including Lactobacillus acidophilus, L. bulgaricus, L. casei, L. plantarum, and L. rhamnosus. However, use of other bacterial species such as Bacillus and Bifidobacterium spp. as probiotic strains has also been described in several commercial products. This article intends to present an up-to-date version regarding probiotics, strains currently used and health benefit obtained from their consumption.

Key words : probiotics, lactobacilli, lactic acid bacteria, beneficial effect

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The idea of using microbes to promote a good health and to prevent disease is not new. Initially, several microbes have been used unintentionally in food production such as dairy products and fermented vegetables. Such fermented foods are popular due to their distinct characteristic in terms of taste and aroma. In recent years, there has been a renewed interest in microbial uses due to, apart from improving food flavour, their beneficial aspect in health restoration and disease treatment. Several microorganisms, under the name of “probiotics”, have been proposed and used in a wide range of clinical trials, ranging from diarrheal disease to cancer prevention (Fuller, 1994; Kaur et al., 2001).

The term “probiotics” was originally used by Lilley and Stillwell (1965) to mean a substance(s) that stimulates growth of other microorganisms. The meaning of this term has now been redefined and restricted to “a viable microbial agent(s) which, when used in animal or man, beneficially affects the host possibly by improving the balance of the indigenous microflora (Fuller, 1991; Salminen et al., 1999). Based on this meaning, several terms such as “friendly”, “beneficial”, or “healthy” bacteria are also commonly known for probiotics.

The first study regarding beneficial effect of probiotics was carried out by Metchnikoff in the early 1900’s (Metchnikoff, 1908). He reported the favourable effects of soured milk in human and suggested that consumption of live microbes (possibly LAB) in such fermented milk may help improve the balance of the gut microflora. Since then, microbial probiotics have gained an increasing interest and their use is now widely accepted. The purpose of this review is to describe probiotics in terms of strains availability and their beneficial effect.

Probiotic strains

Ideally, microbial probiotics should have a beneficial effect and not cause any harm to the host. Therefore, all strains must have been studied comprehensively prior to use in humans or animals and thus are given GRAS (Generally Regarded As Safe) status (see Table 1). Typically, safety evaluation of a proposed or accepted probiotic strain(s) includes i) ability of cells to produce metabolites and enzymes, ii) colonisation (or adhesion) properties, iii) factors that influence the strain survival and, last but not least, iv) interactions with host, particularly in terms of pathogenicity.

As previously mentioned, the predominant species used as probiotic agents belong to the group of LAB. Due to their long history of safe use in foods, most species of LAB are considered as commensal microorganisms with no pathogenic potential. The LAB, a group of Gram-positive bacteria, consist of several species including the genera Lactobacillus, Lactococcus, Leuconostoc, Pediococcus, Aerococcus, Bifidobacterium, and Weissella. Within the LAB group, the genus
**Potential use of probiotics**

Lactobacillus is the most widely encountered for probiotics (Havenarr et al., 1992; Greene and Klaenhammer, 1994; Reid, 1999); these include L. acidophilus, L. bulgaricus, L. casei, L. fermentum, L. plantarum, L. reuteri, L. rhamnosus, and L. salivarius. These Lactobacillus species possess several important properties and therefore can be used as effective probiotic organisms. These features are as follows: i) efficient adherence to intestinal epithelial cells to reduce or prevent colonisation of pathogens (Reid et al., 1993; Bernet et al., 1994; Sarem-Damerdji et al., 1995; Kirjavainen et al., 1998; Ouwehand et al., 1999); ii) competitive growth (Casas and Dobrogosz, 1997; Holzapfel et al., 1998; Netherwood et al., 1999); iii) production of metabolites to inhibit or kill pathogen (Jack et al., 1994; Reid and Burton, 2002); and iv) nonpathogen (Gonzalez et al., 1995; Reid, 1999). Recently, use of genetically modified LAB (GM-LAB) has been introduced to enhance quality, texture, flavour and aroma for the food products such as buttermilk and yoghurt (Wymer, 1998).

In addition, use of other bacterial groups such as Bacillus spp. (Adami and Cavazzoni, 1999; Casula and Cutting, 2002), Bifidobacterium spp. (Charteris et al., 1998; Gill et al., 2001a), and Propionibacterium spp. (Glatz, 1992; Zarate et al., 2002) for probiotics has currently been recognised and accepted. B. subtilis in particular, is now being used for oral bacteriotherapy; ingestion of appropriate quantities of B. subtilis is anticipated to revive the normal microflora after antibiotic use or critical illness (Green et al., 1999). Propionibacterium species is also a potential candidate because of its historical use as dairy starters such as cheese (Dupuis et al., 1995). Propionic acid, produced by this species, is thought to play a key role by inhibiting certain bacteria and fungi.

**Health improvement by probiotics**

For centuries, microbial probiotics have been used, without specific knowledge of how they function, as supplementary diets to promote the good health. It was Metchnikoff (1908) who first pointed out that some small living organisms or substances produced in fermented food products (such as yoghurt) might influence the balance of intestinal microflora. Since Metchnikoff’s discovery, a number of studies have been carried out in this area and an increasing amount of information gained regarding the beneficial effects of probiotic use. Probiotics have currently used to improve the health of humans and animals in

**Table 1. Microbial probiotics and their safety status**

<table>
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</tr>
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</tr>
<tr>
<td>Bifidobacterium</td>
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<tr>
<td>Propionibacterium</td>
<td>Dairy propionibacterial group is a potential candidate for probiotics.</td>
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<td>Saccharomyces</td>
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**Source:** Adapted from Donohue and Salminen, 1996.

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However, due to various applications of probiotics, there is an attempt to screen and identify new probiotic strains with specific characteristic(s) to be appropriate for specific work. For example, in fish farming, there is a need to seek alternative probiotics that are bile-tolerant and stable at low pH (Joborn, 1998). New probiotic candidates that are acid resistant would be an ideal for this approach; these include Vibrio alginolyticus and Carnobacterium spp. (Austin et al., 1995; Robertson et al., 2000; Nikoskelainen et al., 2001).

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various aspects (see Table 2). These topics will be discussed as follows:

### Improvement of intestinal microflora balance

It is estimated that almost 100 different species (with a total bacterial population between \(10^{10} - 10^{12}\)) are present in human intestinal tract (Simon and Gorbach, 1984). There are differences in microbial composition of the gastrointestinal (GI) tract among individuals, and also within the same individual during life. Microbes present in the GI tract are composed of both ‘friendly’ bacteria and pathogens forming a complex symbiosis. Various kinds of factors such as diet, climate, ageing, medication (particularly antibiotic consumption), illness, stress, and lifestyle, can upset this balance (Sanderson and Walker, 1993) leading to diarrhea, mucosal inflammation or other serious illness. For optimum gut flora balance, the so-called “eubiosis”, the friendly bacteria such as the Gram-positive lactobacilli and bifidobacteria should dominate (> 85% of total bacteria) representing a barrier to pathogenic bacteria. As a result, use of probiotics is likely to be the most natural and safe means for maintaining this balance. ‘Friendly’ bacteria that are predominant will prevent colonisation of bacterial pathogens by competing for essential nutrients or attachment sites. For example, *L. casei* Shirota in Yakult (Japanese soured milk) appears to colonise efficiently with the epithelial cells of the intestine (Spanhaak et al., 1998) and thus limiting the GI area for other undesired microbes. In addition, several strains of lactobacilli contained in probiotics also inhibit, by producing antimicrobial compounds (i.e., bacteriocins), the growth of enteric pathogens such as *Salmonella* species (Gill et al., 2001b). For instance, *Lactobacillus* strain GG, when orally given at greater doses (~ 10⁹ CFU/day), is able to adhere to the intestine and its use is reported to alleviate diarrhoea symptoms from *Enterobacteria* (Reid et al., 1993; Greene and Klaenhammer, 1994).

### Enhancement of immune system

Microbial probiotics (especially those of LAB) can influence the systemic immune systems in various ways (Perdigon et al., 1995; Fang et al., 2000). Firstly, they can enhance the defensive property of intestinal mucosa whose function is

### Table 2. Probiotic bacteria and their effects

<table>
<thead>
<tr>
<th>Strain</th>
<th>Beneficial effect</th>
</tr>
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</table>
| *Lactobacillus acidophilus* LA1 | Adherence to human intestinal cells  
Balances intestinal microflora  
Immune enhancement |
| *Lactobacillus GG*          | Prevention of antibiotic-associated diarrhea  
Treatment of rotavirus diarrhea  
Treatment of diarrhea caused by *Clostridium difficile*  
Stabilisation of Crohn’s disease |
| *Lactobacillus casei* Shirota | Prevention of intestinal microbiota disturbance  
Positive effects on bladder cancer |
| *Lactobacillus gasseri*     | Carcinogenic-associated enzyme reduction |
| *Bacillus subtilis*         | Use for oral bacteriotherapy  
Restoration of normal microbial flora  
Immunostimulatory agent |
| *Bifidobacterium bifidum*   | Prevention of viral diarrhoea |
| *Propionibacterium freudenreichii* | Growth stimulation of other ‘friendly’ bacteria |

Source: For detailed references see Salminen et al., 1998.
like a barrier against the antigens (i.e., bacterial pathogens) (Salminen et al., 1996a; 1996b). For example, Crohn’s disease, associated with impairment of the barrier function, can be cured by including probiotic supplement in patient’s diets (Isolauri et al., 1998). In addition, some certain strain of LAB and bifidobacteria are able to induce tumour necrosis factor-α (TNF-α) and interleukin-6 (IL-6) as well as to stimulate other nonspecific immune system (Isolauri et al., 1998). Potential use of L. casei Shirota has also been described as probiotic agent for stimulating immune responses, preventing enterobacterial infections (Matsuzaki, 1998).

**Application of probiotic use in this aspect is challenging and hence further clinical trials in humans are certainly warranted.**

**Prevention of cancer**

In *in vitro* experiments, it is found that LAB in dairy products can reduce mutagenicity of some known mutagens such as 1, 2-dimethylhydrazine (Salminen et al., 1998). Besides, several studies reported that growth of the tumour cells can be inhibited by LAB (reviewed in Reddy, 1998; Burns and Rowland, 2000). For both phenomena, it is assumed that LAB may be indirectly involved by lowering carcinogenicity of carcinogen-activating bacterial enzymes in the GI tract. *L. acidophilus* NCFM strain exhibits ability to reduce levels of free amines in the intestine, leading to a low risk of colon cancer (Goldin and Gorbach, 1984). Furthermore, Ling et al. (1994) reported the decrease of enzyme activity (i.e., β-glucoronidase, azoreductase, and glycocholic acid hydrolase) in human volunteers following the intake of yoghurt containing *Lactobacillus* strain GG. These enzymes are thought to be involved in pathogenesis of bowel cancer.

**Commercially available probiotics**

Currently, there is a wide range of probiotic products commercially available to consumers. Such products are as follows: animal feeds, dairy foods, infant & baby foods, fruit juice-based products, cereal-based products, and pharmaceuticals. Before these products are sold, the probiotic strains used must have been studied and characterised extensively to ensure their safe and effective use. Among these commercial products, use of *Lactobacillus* species is predominant and there is probably no shortage of *Lactobacillus* products in health food products. Incorporation of *B. subtilis* in probiotic products is also found on the market.

<table>
<thead>
<tr>
<th>Table 3. Commercial probiotic products available to date</th>
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<tbody>
<tr>
<td><strong>Brand product</strong></td>
</tr>
<tr>
<td>Yakult</td>
</tr>
<tr>
<td>Adult formula CP-1</td>
</tr>
<tr>
<td>KE-99 LACTO</td>
</tr>
<tr>
<td>Trenov Trio Capsules</td>
</tr>
<tr>
<td>Multibionta</td>
</tr>
<tr>
<td>Enterogermina</td>
</tr>
<tr>
<td>Biosubtyl</td>
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</tbody>
</table>

**Source:** Adapted from Reid, 1999.
(Green et al., 1999). Table 3 summarises commercial probiotic products currently available.

### Concluding remarks

Use of microbial probiotics to promote health maintenance and disease prevention is now widely accepted. Viable microbes possibly play a key role in balancing the intestinal microflora naturally although their modes of action have not been completely understood and further investigation is needed to understand the mechanism of these microbe-microbe interactions. Beneficial effects of use of microbial probiotics are now well-documented. However, questions regarding reliability, quality of many commercial products as well as safety issues have been raised (Saarela et al., 2000; Ishibashi and Yamazaki, 2001). The latter topic is of great importance due to its use in humans. Traditional probiotic dairy strains such as LAB are considered as major sources due to their long history of safe use in foods. However, with a broad range of applications, several probiotic strains are now being investigated and proposed for an alternative. It is therefore necessary to ensure that novel isolated probiotics are being screened and subjected to appropriate field tests with animals or humans.

### References


Gonzalez, S.N., Cardoza, R., Apella, M.C. and Oliver,


