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An overview of the last advances in probiotic and prebiotic field

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ABSTRACT

Probiotics and prebiotics play an important role in human nutrition. In recent years there has been a significant increase in research on the characterization and verification potential health benefits associated with the use of probiotic and prebiotic. The main effects attributed to selected probiotics/prebiotic products have been proved by clinical trials, while others have been acquired on the basis of *in vitro* tests which require *in vivo* transposition in order to be validated. The main clinical reports in the literature for the application of probiotic have been done for the treatment of infectious diseases including viral, bacterial or antibiotic associated diarrhoea, relief of chronic bowel inflammatory diseases, immuno-modulation, lowering of serum cholesterol, decreased risk of colon cancer, improve lactose digestion, reduce allergies, and effect on intestinal microbiota. Although the large investigation for the health benefits, information on probiotic species, a specific strain-therapeutic application, and sufficient dosages, is not sufficiently studied to allow practical and rational consumption. Moreover, prebiotic oligosaccharides although provided curative and nutritional values, they are poorly understood in regard to their origin, the processes employed to generate them, their fermentation profiles, and dosages required for health effects. The present review summarizes guidelines reported on the literature in regard to clinician or therapeutic trials of probiotic and prebiotic.

1. Introduction

There is general agreement on the important role of the gastrointestinal (GI) microbiota in the health and wellbeing status of human and animals. The concept that certain micro-organisms, when supplied in sufficient quantities, confer direct benefits to the host is defined by the term 'probiotic'. This term is defined by a United Nations and World Health Organization Expert Panel as "live micro-organisms which when administered in adequate amounts confer a health benefit on the host" (FAO/WHO, 2002). More recently, prebiotics have been used; these are defined as non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacterial species already resident in the colon (Gibson & Roberfroid, 1995). At the present time, all prebiotics described are short-chain carbohydrates with a degree of polymerisation of between two and about sixty, and are thought to be non-digestible by human, or animal digestive enzymes. Due to the nature of the metabolism of bifidobacteria and lactobacilli, prebiotic proteins or lipids are unlikely to exist (Cummings & Macfarlane, 2002).

Dairy products fermented with lactic acid bacteria, such as *Bifidobacterium* and *Lactobacillus* strains, sugar fortified with FOS (fructo-oligosaccharides) or inulin, or food supplements containing probiotic bacteria have been emerged on the food market for more than 10 years. Beneficial effects, such as ensuring the correct balance or good working order of the intestinal flora, regulation of the intestinal immune system or reinforcement of the intestinal barrier, are claimed for each of these products. In this context linking food and health, probiotics and prebiotics have been the subject of numerous scientific studies and publications demonstrating their therapeutic effectiveness on both systemic and gastrointestinal tract. In parallel, industry is exploiting these results and promoting its products by making claims suggesting that eating these foods will be beneficial to health. Nutrition and health claims are about to be harmonized at European level to better protect consumers. EU regulation, EC No. 1924/2006, amended by the European Parliament and the Council of 15 January 2008

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(EC No. 109/2008), establishes the necessary authorization procedures to ensure that the allegations contained on packages and in marketing of foodstuffs are clear, precise and based on evidence accepted by the scientific community.

2. Probiotic micro-organisms

According to recent Food and Agriculture Organization (FAO) and WHO guidelines (FAO/WHO, 2002), probiotic organisms used in food must be able of surviving passage through the gut; i.e., they must have the ability to resist gastric juices and exposure to bile. Furthermore, they must be able to proliferate and colonise the digestive tract. In addition, they must be safe and effective, and maintain their effectiveness and potency for the duration of the shelf-life of the product.

micro-organisms most commonly used as probiotics belong to the heterogeneous group of lactic acid bacteria (*Lactobacillus*, *Enterococcus*,..) and to the genus *Bifidobacterium* (FAO/WHO, 2001; Holzapfel, Haberer, Geisen, Bjorkroth, & Schillinger, 2001). The properties of adhesion have been proposed by many authors as a decisive factor for selection of new probiotic strains. The mechanisms of action of probiotics against gastrointestinal pathogens (Fig. 1), consist principally on: (*i*) competition for nutrients and sites of accession, (*ii*) Production of antimicrobial metabolites (Alvarez-Olmos & Oberhelman, 2001), (*iii*) changes in environmental conditions and, (*iv*) modulation of the immune response of the host (Tien et al., 2006). Other less commonly used probiotic micro-organisms are strains of: *Streptococcus*, *Escherichia coli*, *Bacillus* and *Saccharomyces*. *Streptococcus thermophilus* has been used in probiotics to enhance digestion of lactose in intolerant subjects (De Vrese et al., 2001). Table 1 summarizes some potential probiotic strains namely used. Furthermore, the bioactive components of probiotics include proteins and/or lipoteichoic acids of the cell wall surface, nucleic acids, organic acids and short-chain fatty acids, antimicrobial proteins and other factors identified less soluble.

Foods containing such bacteria fall within the category of functional foods, which are described as foods claimed to have a positive effect on health. The term "functional food" itself was first used in Japan, in the 1980s, for food products fortified with special constituents that possess advantageous physiological effects (Kwak & Jukes, 2001; Stanton, Ross, Fitzgerald, & Van Sinderen, 2005). Such products are gaining more widespread popularity and acceptance throughout the developed world and are already well accepted in Japan and the United States. Furthermore, increased commercial interest in exploiting the proposed health attributes of probiotics has contributed significantly to the rapid growth and expansion of this sector of the market. The global market for functional food is in fast growth since the early 2000's, and is estimated at least to 33 billon US$ (Hilliam, 2000). Between 2000 and 2002, other experts such as Sloan estimated meanwhile, the global market for functional foods to 47.6 billion US$, of which the United States being the largest market segment, followed by Europe and Japan. Otherwise, these three dominants market contribute to more than 90% of the total sales (Benkouider, 2005).

In United States, functional foods have a share of about 2–3% of the food market, and this percentage is expected to be doubled by 2008 (Siró, Kápolna, Kápolna, & Lugasi, 2008). According to Datamonitor predictions, the US market is likely to reach 25 billion US$ by the year of 2009 (Side, 2006).

On the other hand, Japan considered the birthplace of functional foods, the market for these foods is very important. Indeed, more

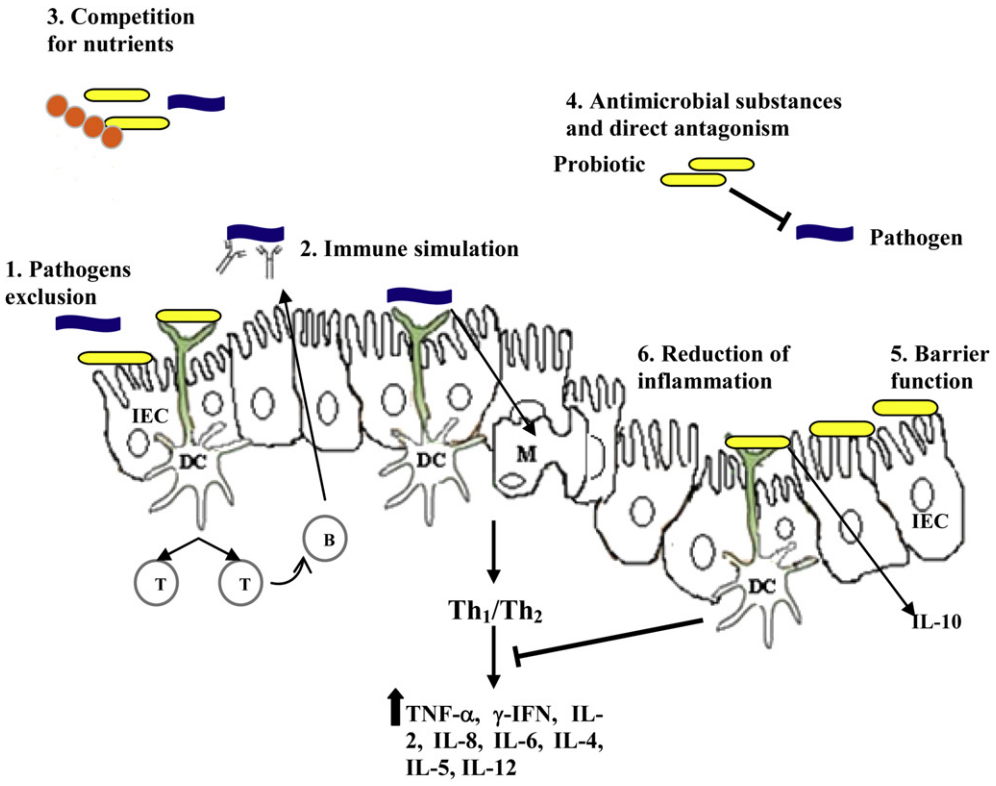

Fig. 1. Some probiotic mechanisms whereby induce several beneficial host responses. Most effect consist on 1) Exclusion and competing with pathogen to epithelial cells adhesion, 2) innate immune stimulation, 3) competition for nutrients and prebiotic products, 4) production of antimicrobial substances and thereby pathogen antagonism, 5) protection of intestinal barrier integrity and 6) regulation of anti-inflammatory cytokine and inhibition of pro-inflammatory cytokine production. IEC: intestinal epithelium cells, DC: dendritic cell; IL: interleukin; M: intestinal M cell.