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PROBIOTICS AND PREBIOTICS: ROLE AS FUNCTIONAL FOODS IN GENERAL AND ORAL HEALTH

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ABSTRACT

Each day, every human being ingests a large number of living microorganisms, predominantly bacteria. Although these organisms are naturally present in food and water, they can also be deliberately added during the processing of foods such as sausages, cheese, yogurt and fermented milk products. For several decades now, bacteria called probiotics have been added to some foods because of their beneficial effects for human health. Although only a few clinical studies have been conducted so far, the results to date suggest that probiotics could be useful in preventing and treating oral infections, including dental caries, periodontal disease and halitosis. This article summarizes the currently available data on the potential benefits of probiotics for general and oral health.

KEYWORDS: Lactobacillus; Microflora; Probiotic; Prebiotic.

INTRODUCTION

The role of diet in health and well-being is universally acknowledged. With the evolution of the science of nutrition, research is now being directed towards improving the understanding

of specific physiologic effects of the diet beyond its nutritional effect.[1] In this aspect, probiotics are the subject of intense and widespread research in food and nutritional science.

The term “probiotic” was first used by Lilly and Stillwell in 1965 to describe “substances secreted by one microorganism which stimulates the growth of another” and thus was contrasted with the term antibiotic. The term prebiotic was introduced by Gibson and Roberfroid who exchanged “pro” for “pre” which means “before” or “for”. They defined prebiotics as a “non-digestible food ingredient that beneficially affects the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon. The term synbiotic is used when a product contains both probiotics and prebiotics.[2] According to this approach, a food or food supplement will include both the live cells of the beneficial bacteria and the selective substrate. The idea being that the beneficial bacterial cells can grow quickly and competitively because of the presence of selective substrate and establish their predominance.[3]

HISTORY

The name probiotic comes from the Greek 'pro bios' which means 'for life'.[4] The term "probiotics" was first introduced in 1953 by Werner Kollath. In 1989, Roy Fuller suggested a definition of probiotics that has been widely used: "A live microbial feed supplement which beneficially affects the host animal by improving its intestinal microbial balance". Parker in 1974, proposed that probiotics are ‘organisms and substances which contribute to intestinal microbial balance’.[5] Salminen et al. defined probiotics as the 'food which contains live bacteria beneficial to health', whereas Marteau et al. defined them as 'microbial cell preparations or components of microbial cells that have a beneficial effect on the health and well-being.[6,7]

Some modern definitions include more precisely a preventive or therapeutic action of probiotics. Charteris et al. for example, defined probiotics as 'microorganisms which, when ingested, may have a positive effect in the prevention and treatment of a specific pathologic condition.[8]

The currently used consensus definition of probiotics was put forward by the World Health Organization and by the Food and Agriculture Organization of the United States in 2001. They defined probiotics as “live microorganisms which when administered in adequate amounts confer a health benefit on the host”.[9]

COMPOSITION OF PROBIOTICS

Probiotics can be bacteria, moulds, yeast. Among them, lactic acid producing bacteria are more popular. Some of the species are.[10]

1. Lactic acid producing bacteria (LAB): Lactobacillus, bifidobacterium, streptococcus.
2. Non lactic acid producing bacterial species: Bacillus, propionibacterium.
3. Non-pathogenic yeasts: Saccharomyces.
4. Non spore forming and non-flagellated rod or coccobacilli.

The lactobacillus species help in production of enzymes to digest and metabolize proteins and carbohydrates. Important probiotic microbial species useful in oral cavity are L. acidophilus, L. casei, L. rhamnosus GC, L. sporogens, L. bulgaricus, L. johnsonii, L. termophilus, L. bifidum, L. reuteri, L. salivaricus, L. paracasei, S. thermophilus, S. salivarius, W. cibaria and bifidobacterium. They aid in synthesis of vitamin B, vitamin K and facilitates breakdown of bile salts. They are usually dispensed in gel, paste, powder and liquid forms. Most common vehicles for probiotics in oral health include lozenges, tablets, yoghurt, cheese, milk and mouth rinse.[11]

Characteristics Of Good Probiotics

Fuller in 1989 listed the following as features of a good probiotic.[12]

1. It should be a strain, which is capable of exerting a beneficial effect on the host animal, e.g. increased growth or resistance to disease.
2. It should be non-pathogenic and non-toxic.
3. It should be present as viable cells, preferably in large numbers.
4. It should be capable of surviving and metabolizing in the gut environment.
5. It should be stable and capable of remaining viable for periods under storage and field conditions.

General Health and Probiotics

Reddy and Srivastava described probiotics in general health, such as.[13]

1. Prevention and/or reduction of duration and complaints of rotavirus-induced or antibiotic-associated diarrhoea as well as alleviation of complaints due to lactose intolerance.
2. Reduction of the concentration of cancer-promoting enzymes and/or putrefactive (bacterial) metabolites in the gut.
3. Prevention and alleviation of unspecific and irregular complaints of the gastrointestinal tracts in healthy people.

4. Beneficial effects on microbial aberrancies, inflammation and other complaints in connection with: inflammatory diseases of the GI tract, Helicobacter pylori infection or bacterial overgrowth.
5. Normalization of passing stool and stool consistency in subjects suffering from constipation or an irritable colon.
6. Prevention or alleviation of allergies and atopic diseases in infants.
7. Prevention of respiratory tract infections (common cold, influenza) and other infectious diseases as well as treatment of urogenital infections.

Probiotics exert their beneficial effects on health, by modulation of immune responses via the mucosal immune system of the gut. There is evidence that certain bacteria activate Peyer's patch T cells to drive the mucosal immune system via Toll-like receptors on antigen-presenting cells also at other sites of the human body such as the oral cavity. Promoting T helper type 1 (Th1) cytokine responses and down regulating Th2 may influence distant mucosal sites.[11,14]

Probiotics in oral health

Given the widespread emergence of bacterial resistance to antibiotics, the concept of probiotic therapy has been considered for application in oral health. Dental caries, periodontal disease and halitosis are among the oral disorders that have been targeted. An essential condition for a microorganism to represent a probiotic of interest for oral health is its capacity to adhere to and colonize various surfaces of the oral cavity. The mechanism of adhesion to oral surfaces is an issue of importance for the long term probiotic effect of the microorganisms. [Fig. 1] Most of the experiments on adhesion have been carried out with strains broadly used as probiotics in dairy products such as yogurt and cheese.[15] The probiotic bacterial strains lactobacilli and bifidobacteria can be found in breast milk, suggesting early exposure of the oral cavity to these bacteria.[13,16]

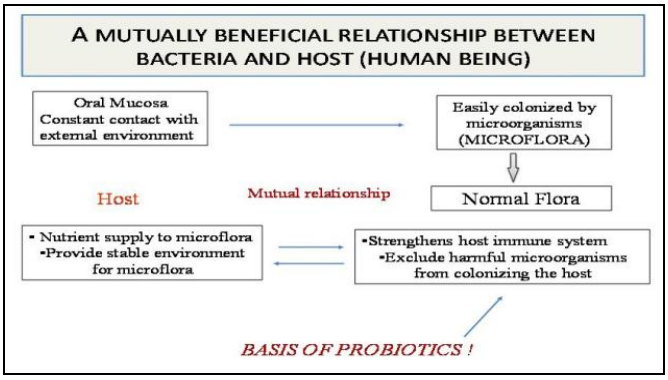

Fig 1: Relationship between host and bacteria

Since the mouth represents the first part of the gastrointestinal tract, there is every reason to believe that at least some probiotic mechanisms may also play a role in that part of the system. It may also be anticipated that resident probiotics could exist in the oral microflora, and that they may function in the complex ecosystem of dental plaque and in the formation and development of oral biofilms in general. [Fig. 2]

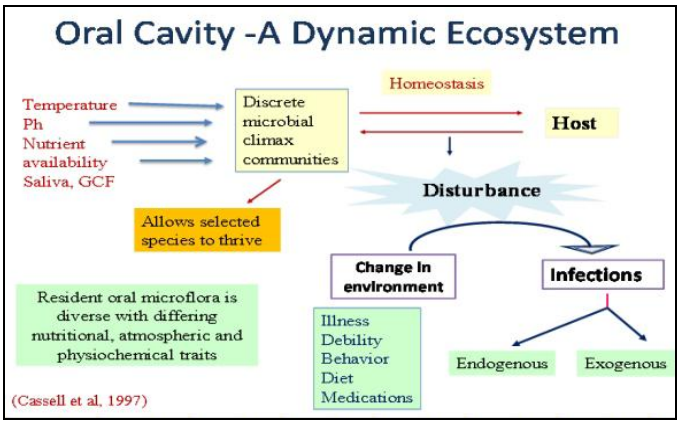

Fig 2: Role of microflora in oral cavity

Hypothetical mechanisms of probiotic action in the oral cavity (oral biofilms and microflora) are suggested in Table 1.

Table 1 - Suggested mechanisms of probiotic in the oral cavity [3,17]

Direct interactions in dental plaque	Indirect probiotic actions in the oral cavity
- Involvement in binding of oral micro-organisms to proteins (biofilm formation). - Action on plaque formation and on its complex ecosystem by competing and intervening with bacteria-to-bacteria attachments. - Involvement in metabolism of substrates (competing with oral micro-organisms of substrates available). - Production of chemicals that inhibit oral bacteria (antimicrobial substances).	- Modulating systemic immune function. - Effect on local immunity. -Effect on non-immunologic defense mechanisms. - Regulation of mucosal permeability. -Selection pressure on developing oral microflora towards colonization by less pathogenic species.

Sookkhee and colleagues isolated 3,790 strains of lactic acid bacteria from 130 individuals and found that the isolates identified as Lactobacillus paracasei ssp. paracasei and L. rhamnosus had a high capacity to antagonize important oral pathogens, including Streptococcus mutans and Porphyromonas gingivalis.[18]

Weissella cibaria (formerly classified in the genus Lactobacillus), a Gram-positive facultative anaerobic lactic acid bacterium that has been isolated from humans, is present in fermented foods and is considered a potential probiotic agent. W. cibaria secretes a significant quantity of hydrogen peroxide, as well as a bacteriocin that acts against Gram-positive bacteria.[19,20,21] This bacterial species has the capacity to coaggregate with Fusobacterium nucleatum and to adhere to epithelial cells.[20] These properties could enable W. cibaria to effectively colonize the oral cavity and limit the proliferation of pathogenic bacteria.[10]

A concomitant feature of the probiotic activity observed was the diminished risk of hyposalivation and the feeling of dry mouth of the subjects.[3,13]

Probiotics and Dental Caries

To have a beneficial effect in limiting or preventing dental caries, a probiotic must be able to adhere to dental surfaces and integrate into the bacterial communities making up the dental biofilm. It must also compete with and antagonize the cariogenic bacteria and thus prevent their proliferation. Finally, metabolism of food-grade sugars by the probiotic should result in low acid production. The advantage of incorporating probiotics into dairy products lies in their capacity to neutralize acidic conditions. For example, it has already been reported that cheese prevents demineralization of the enamel and promotes its remineralization.[10,22,23]

It has been now proved by a numbers of studies that probiotics can reduce the risk of occurrence of Streptococcus mutans in the oral cavity. In an in vitro study, it was suggested that Lactobacillus rhamnosus GG can inhibit colonization by streptococcal cariogenic pathogens and therefore reduce tooth decay incidence in children.[11]

Comelli and colleagues reported that of 23 bacterial strains used in the dairy industry, Streptococcus thermophilus and Lactobacillus lactis ssp. Lactis were the only ones with the capacity to integrate into a biofilm present on a hydroxyapatite surface and to interfere with development of the cariogenic species Streptococcus sobrinus.[10]

Nikawa et al. showed that bovine milk fermented with Lactobacillus reuteri was effective against S. mutans, resulting in a reduced risk for tooth decay.[11]

Several clinical studies have demonstrated that regular consumption of yogurt, milk or cheese containing probiotics led to a decrease in the number of cariogenic streptococci in the saliva and a reduction in dental plaque. Çaglar et al. in a comparative study of S. mutans reduction

effects by several probiotic administration forms showed a reduced S. mutans level in patients receiving fluid or tablet probiotic forms. In another study by Çaglar et al., S. mutans reduction effects were compared in subjects using probiotics, xylitol, or probiotics plus xylitol-enriched chewing gums, and a placebo control group; a reduced S. mutans level was observed in subjects using probiotics or xylitol-enriched chewing gum; no synergic effect was seen when combining both agents. These promising results suggest a potentially beneficial application of probiotics for the prevention of dental caries.[10]

Probiotics and Periodontal Disease

The main pathogenic agents associated with periodontitis are P. gingivalis, Treponema denticola, Tannerella forsythia and Aggregatibacter actinomycetemcomitans. These bacteria have a variety of virulent characteristics allowing them to colonize the subgingival sites, escape the host's defence system and cause tissue damage.[10,24]

Various observations suggest that lactobacilli residing in the oral cavity could play a role in the oral ecological balance. The beneficial effect of L.reuteri against gingivitis was assessed. Probiotic strains included in periodontal dressings at optimal concentrations of 10^8 CFU ml were shown to diminish periodontal pathogens.[13] [Fig. 3**]** The effect of probiotics tablets on gingivitis and different grades of periodontitis was studied by Grudianov et al. and it found that probiotics treatment resulted in better microbiota normalization than control group.[11,25] Krasse et al. showed a significantly reduced gingival index and bacterial plaque amount in patients treated with L. reuteri than in a placebo group and concluded that this probiotic was effective to reduce gingivitis and bacterial plaque deposition in patients with moderate-to-severe gingivitis.[11,26]

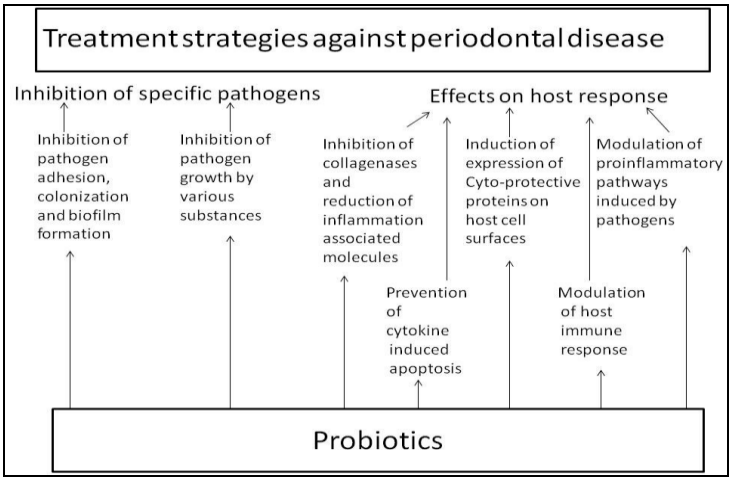

Fig 3: Theoretical possibilities for probiotics to affect periodontal health

Various studies have reported the capacity of lactobacilli to inhibit the growth of periodontopathogens including P. gingivalis, Prevotella intermedia and A. actinomycetemcomitans. Together, these observations suggest that lactobacilli residing in the oral cavity could play a role in the oral ecological balance.[10]

Recently Shimazaki and colleagues used epidemiological data to assess the relationship between periodontal health and the consumption of dairy products such as cheese, milk and yogurt. The authors found that individuals, particularly nonsmokers, who regularly consumed yogurt or beverages containing lactic acid exhibited lower probing depths and less loss of clinical attachment than individuals who consumed few of these dairy products.[27]

Probiotics and Halitosis

Kang and colleagues reported the capacity of various strains of W. cibaria to inhibit the production of volatile sulphur compounds by F. nucleatum. They concluded that this beneficial effect resulted from the production of hydrogen peroxide by W. cibaria, which inhibited the proliferation of F. nucleatum. These authors also found that gargling with a solution containing W. cibaria was associated with a net reduction in the production of hydrogen sulphide and methanethiol and consequently a reduction in bad breath.[10,28]

Regular use of probiotics can help to control halitosis. The use of W. cibaria resulted in reduced levels of volatile sulfide components produced by Fusobacterium nucleatum. Streptococcus salivarius also suppress volatile sulfide compounds by competing for colonization areas with volatile sulfide-producing species.[11]

Limitations

The probiotic should maintain genetic stability in oral microflora.[29] Clinical characteristics of Lactobacillus bacteremia is highly variable, ranging from asymptomatic to septic shock-like symptoms. The absence of acquired antibiotic resistances is another safety criterion to be tested in potential probiotic candidates.

Some probiotics are closely related to opportunistic bacteria and this may also cause transferral of antimicrobial resistance genes in between microorganisms. Several results from antibiotic susceptibility tests claim that the tet (W) and tet (S) genes in some probiotic lactobacilli and bifidobacteria strains are responsible for gentamycin, sulfamethoxazole,

polymyxin B, and tetracycline resistance.[2] These findings show the need of minimal safety evaluation during the selection of strains for probiotic use.

Future prospects

In field of oral immunology, probiotics are being used as passive local immunization vehicle against dental caries. Recently, by means of systemic immunization with a multivalent vaccine, L. rhamnosus GG was chosen as the vehicle to harbor IgG because of its widely known health benefits in humans and animals.

In oncology field, treatment with probiotics "L. plantarum 299v" improves food intake and body weight in chemotherapized animals. Chosen probiotic strain reinforces the oral cavity, along with the gastrointestinal tract, as a source for bacterial dissemination.

Various processing advances, such as microencapsulation and bacterial coating and addition of prebiotic compounds used as growth factors for probiotic organisms, will provide a means to optimize the delivery and survival of strains at the site of action.

In the present day, technology has improved drastically. NASA of USA is carrying out research to develop probiotic products which enable humans live in space.[30] For all these valid reasons, the use of probiotics has become an emerging subject in the field of dentistry at present.

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