Probiotics as Antibiotic Alternatives for Human and Animal Applications

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Probiotics are live microorganisms recognized as natural candidates to substitute antibiotic substances, usually used to treat bacterial infections responsible for numerous human and animal diseases. Antibiotics are mostly prescribed for treating infections caused by bacteria. However, their excessive and inappropriate use has resulted in the increase of bacterial antimicrobial resistance (AMR) and host microbiota imbalance or dysbiosis phenomena. Even though antibiotics are the most well-known lifesaving substances, the AMR within the bacterial community has become a growing threat to global health, with the potential to cause millions of deaths each year in the future. Faced with these worldwide issues, it is high time to discover and develop antibiotic alternatives. There exists some evidence of probiotic roles in antagonizing pathogens, modulating immune systems, and maintaining general host health by restoring the gut microbiota balance. The multi-antimicrobial action mechanisms of such beneficial living microorganisms are one approach to practicing the "prevention is better than cure" concept to avoid antibiotics. The current review proposes a comprehensive description of antibiotic-related AMR issues and the potential of probiotics as antibiotic alternatives, while discussing pros and cons, as well as some evidence of beneficial uses of probiotics for human and animal health protection through recent results of experimental models and clinical trials.

Keywords: antimicrobial resistance; immunomodulation; gut microbiota; bacteriocins; human health; animal health

The use of antibiotics has a long history of applications in bacterial infection treatment, owing to their ability to inhibit the growth of or kill living microorganisms [1]. However, the current dissemination of antibiotic resistance genes into pathogenic bacteria has raised concern about the effectiveness of today's antibiotic repertoire in the near future. Antimicrobial and antibiotic resistance problems have spread worldwide and have prompted the World Health Organization to classify such issues as an unpredictable global health threat with broad, multiple-sector impacts to human, animal, food, and environment safety [2]. Antibiotic-resistant pathogen-related deaths are projected to rise to 10 million per year worldwide by the year 2050 [3]. Therefore, alternative approaches to target bacterial pathogens have been advocated, such as directly treating diseases with therapeutic agents or indirectly modulating the gut microbial community with beneficial live microorganisms, the so-called probiotics [4]. In fact, probiotics play a key role in the microbiota equilibrium by re-populating, for instance, a gut in dysbiosis [5].

The mammalian gut microbiota confers health-promoting benefits to the host by modulating the immune system, by increasing the efficiency of nutrient utilization, and by eliminating the presence of pathogens [6]. An overall balance in the proportion of gut microbiota is essential in maintaining the healthy condition of the host [2]. The intestinal microbiome is unique in each individual and may be affected by genetic and environmental factors. Inappropriate and systematic administration of antibiotics is one of the environmental factors that cause alteration of gut microbiota (dysbiosis), leading to a deficiency of beneficial microorganisms in favor of potentially harmful microorganisms, as well as lower microbial diversity [6].

Probiotics are well-known as “good microorganisms" as opposed to “bad or harmful microbes" like pathogens. The term probiotic comes from the Latin “pro" and Greek “bios", literally meaning “for life", whereas antibiotic signifies “against life". The most common probiotic definition is a live microorganism with beneficial effects when provided in appropriate conditions to a host. [5]. By possessing antagonistic properties, probiotics have been found to hinder the growth of gut pathogens through (i) the production of bioactive metabolites such as bacteriocins, hydrogen peroxide, organic acids, antioxidants, and antimicrobial peptides [10][11]; (ii) competition for nutrients and attachment sites [12]; and (iii) the modulation of immune system functions [13]. The first antimicrobial activity mechanism of probiotics is comparable to the direct antibiotic molecular reactivity against pathogens, whereas the second and third ones are inherent to probiotic cells, owing to their adhesion and colonization capacities, and indirect mechanisms through immune cells, respectively. By developing multi-antimicrobial mechanisms, probiotics induce low risks of resistance to pathogens, aside from transferring resistance genes which are normally verified before any microorganisms are recognized as probiotics. Some experimental
studies and clinical trials on humans and animals have been reported in the literature, indicating some evidence of probiotic applications as alternatives of antibiotics to inhibit or/and destroy pathogens responsible for various diseases [14][15].

This review proposes a comprehensive description of antibiotic-related antimicrobial resistance issues, states the potential of probiotics as antibiotic alternatives while discussing pros and cons of their uses, and illustrates with recent examples some evidence of probiotic applications instead of antibiotics in human and animal health protection.

References


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