Potential Role of Phytochemicals in Modulating Gut Microbiome

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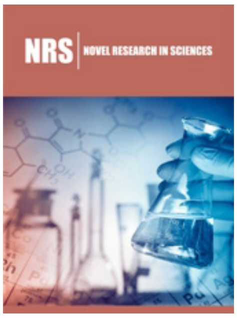

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Abstract

Phytochemicals of medicinal plants possess a wide variety of medicinal properties. Current research suggests that phytochemicals can modulate the gut microbiome, resulting in altered gut microbiome metabolites. This mini-review summarizes the emerging role of phytochemicals in the gut microbiome

Keywords: Phytochemicals; Gut microbiome; Medicine; Genetics; Immunology

Abbreviations: LPS: Lipopolysaccharide; TLR4: Toll-Like Receptor 4

Introduction

Over the course of history, the experiences of individuals and societies have transformed the way people live, act, and learn. Popular customs are widely adopted based on advances in science, medicine, genetics, and immunology, which become a part of our day-to-day routine lives. Research has been conducted extensively worldwide on plant-based phytochemical compounds used in these practices [1]. Research findings have organized phytochemicals by their origin and chemical structure. Specifically, they have been divided into different categories: phenolic compounds, terpenoids, nitrogen compounds, alkaloids, betalains, glucosinolates, and cyanogenic compounds [2]. In the past few years, researchers have postulated the potential role of phytochemicals in humans. The comprehensive medicinal properties of phytochemicals include the following characteristics: sterols have been used as hormones and vitamins; triterpenes showed anthelminthic, antiseptic, expectorant, antibacterial, as well as diuretic properties. Additionally, the phenols proved to be antifungal. Also, the tannins (condensed tannins) perform astringent, antiseptic, antibacterial, and antifungal properties. Coumarins are used for their anticoagulant and antibacterial action in the medicine. The flavonoid glycosides such as anthocyanins and quercetins play a major role in bronchodilation [3-5]. Additionally, the quinones, like naphthoquinones, have antibacterial and antifungal properties. On the other hand, the alkaloids possess a medically beneficial ability to stimulate the central nervous system, and they have an anesthetic effect on humans [4]. Polyphenols and flavonoids are known to be "free radical scavengers" as well as lipid peroxidation inhibitors [6,7]. Several findings strongly stated that the application of various phytochemical compounds is the primary source of medical treatment in certain countries because of their more effective against different pathologies, low cost in their production, and a minor residual effect [4,5]. It has been estimated that approximately 75 to 80% of the world population utilizes phytochemical compounds either one way or another in medicine. The two major countries such as China and India use the many natural products that originated from the various plant sources, which is part of their cultural roots [3,8]. With advanced progress in the area of phytochemicals research in the past few years, the significance of many natural products focuses more towards investigating possible new active ingredients from plants with their valuable properties for treatment against specific systemic as well as various infectious diseases in humans and animals [5,9]. Moreover, it has been proven that in some cases, synthetic substances have significant harmful side effects than the diseases themselves. Synthetic antioxidant compounds cause mutagenic and toxic effects. Thus, scientists demonstrated that there is a need to reuse natural preparations as an alternative to the extensive use of antibiotics and their microbial resistance properties [10,11]. However, it is still poorly understood that how these phytochemical compounds are highly compatible with the human organism because they do not have any enzymatic affinity and are also not easily absorbed by the gastrointestinal lumen [12]. Furthermore, these compounds may support and enhance the growth of some beneficial bacteria in the intestine under healthy or disease conditions in the host. As it is already been known from various research papers, the gut microbiota in human starts to become mature from their second year of life. They play many beneficial roles in a host such as nutrient absorption, fermentation of food, modulation of the immune system, and the physiological mechanisms to protect against various pathogens [13-16].

In adults, the most prevalent phyla are represented by *Clostridium leptum*, Bacteroidetes and Firmicutes and Clostridium coccoides being the dominant groups, Lactobacillus the subdominant that belongs to the Firmicutes phyla [17]. This gut microbiota is highly stable ideally. It is estimated that the GI tract inhabits approximately 500-1000 different types of microbial species, with the highest concentrations observed in the colon (up to 1012 cells per gram of feces); Escherichia coli are also present (in 7.7log10CFU/g), which is considered as a subdominant microbial population in adults and dominant bacterial species in infants [18]. The bacterial inheritance of the Bifidobacterium genus is considered as the minor constituents of the gut microbiota and it appears with a concentration that is eight to ten times lower than the two major phyla [19]. The Bifidobacterium spp. plays a significant role in enhancing the barrier function of the gut epithelium and also in improved gut health. The decrease in the population of this bacterial genus due to various internal as well as external factors resulting in the chronic low-grade inflammation with Lipopolysaccharide (LPS) (endotoxemia), that is related to the multiple abnormal processes in the organism. Moreover, the composition of the microbiota in the elderly is greatly affected by a significantly decreased level of Bacteroidetes and Bifidobacterium, also accompanied by a decrease in Lactobacilli [20]. The human gastrointestinal tract contains many numbers of bacterial species. There is the presence of commensal microbial flora in the intestine, as well as a few other flora that is highly pathogenic e.g. Helicobacter pylori, *Salmonella enterica, Salmonella Enteritidis*, and some more, that causes the gastrointestinal diseases with different pathogenesis concerning the individual's age, gut health, chronic diseases and also due to immune diseases. The disturbances in the microbiota may cause gut dysbiosis and also leads to bacterial translocation, which is mediated by lipopolysaccharide-binding to Toll-Like Receptor 4 (TLR4) and the transcription factor nuclear factor NFκB as an inflammatory response [21,22]. Currently, many investigations target the search for a potential therapeutic approach through diet for modulating the intestinal microbiota, the reduced inflammation, also in preventing various chronic and degenerative diseases [23]. Various studies have demonstrated that the active ingredients in medicinal plants or other plant sources possess microbiostatic and microbicidal activities against enteric pathogenic organisms [24]. There are reports that firmly suggest that alkaloids, steroids, phenols, flavonoids, glycosides, coumarins, quinones, tannins, and terpenoids can modulate gut bacteria [25].

Various *In-vitro* and *In-vivo* experiments have shown these beneficial phytochemicals can reduce the proliferation of pathogenic bacteria in the gastrointestinal tract via specific biochemical and physiological processes. These processes disrupt the bacterial cell membranes, which causes competitive exclusion in the epithelial membrane by increased expression of Bifidobacterium spp. and Lactobacillus spp; thus, it helps in lowering the appearance of dysbiosis, translocation of bacteria, damage to the intestinal barrier, and various gastrointestinal problems [21,26,27]. In conclusion, it may be possible to use phytochemicals to modulate the gut microbiome and develop phytochemical based intervention together with current therapeutics.

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