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Article

Cooking Spices: Potential Modulators for Gut Dysbiosis and Role in Therapy

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Abstract: The gut microbiota plays a vital role in human health, primarily by metabolizing nutrients and producing short-chain fatty acids with anti-inflammatory properties [1]. Dysbiosis, characterized by a shift in microbial composition, has been linked to various diseases, including inflammatory bowel disease, colorectal cancer, obesity, diabetes, asthma, and allergies [2]. Dietary habits significantly influence gut microbiota diversity, with balanced diets crucial for maintaining microbial equilibrium. Nutritional insufficiencies and poor diversity in food classes can lead to dysbiosis, altering gut permeability and inducing low-grade inflammation [3]. Culinary herbs and spices have previously been recognized for their potential impact on health through antioxidant and antimicrobial properties [4]. They may also be promoters of positive microbial modulation by inhibiting inflammation, stimulating beneficial gut bacteria during fermentation, increasing the production of short chain fatty acids and exhibiting a prebiotic effect [5]. This paper reviews recent research findings on the effects of common culinary spices on gut microbiota composition and inflammation. Studies demonstrate that mixed spices and individual spices like ginger, turmeric, and chili can induce favorable changes in gut microflora, promoting the growth of beneficial probiotics while inhibiting pathogenic bacteria [6]. Additionally, spices such as turmeric and curcumin exhibit potent anti-inflammatory properties, contributing to their protective effects against chronic diseases like colon cancer and metabolic disorders [7]. These findings highlight the importance of incorporating culinary spices into dietary interventions for overall well-being. Further research is needed to elucidate their mechanisms of action and optimize their therapeutic applications in clinical.

Objective: The main objective of this paper is to investigate current research on gut microbial modulation with culinary herbs and spices. A secondary objective is to highlight gut related health effects potentially associated with herb and spice consumption.

Keywords: functional food; antioxidant; gut dysbiosis; gut modulation; spices and herbs; immunomodulator

Introduction

The gut microbiota, comprising a diverse community of microorganisms residing in the gastrointestinal tract, plays a crucial role in human health. Disruption of this microbial ecosystem, termed gut dysbiosis, is associated with a spectrum of diseases [8]. Recently, there has been growing interest in the therapeutic potential of dietary interventions, particularly the inclusion of culinary spices, which are rich in bioactive compounds [9]. These compounds, including polyphenols and terpenoids, possess antimicrobial and anti-inflammatory properties [10]. Emerging evidence suggests that dietary incorporation of culinary spices may mitigate gut dysbiosis and associated metabolic disorders [11]. However, the precise mechanisms underlying their effects on gut health remain unclear. This review aims to provide an overview of the current understanding of the interaction between culinary spices and gut health, examining their bioactive constituents and potential mechanisms of action. Additionally, it will evaluate existing evidence from experimental

and clinical studies, discussing future research directions in harnessing the therapeutic potential of culinary spices for gut health promotion.

Methods

A comprehensive literature search was conducted to identify relevant research articles exploring the impact of culinary spices on the gut microbiome and their modulation. The search utilized the PubMed database, a trusted resource for biomedical literature. The key terms included "culinary spices," "gut microbiome," and "gut modulation," alongside additional terms such as "Gut dysbiosis," "common spices" and gut health are included. 35 articles published within the last 5 to 8 years (2016-2024) were considered for review. Only 8 articles directly addressing the effects of culinary spices on the gut microbiome and modulation were included. Priority was given to peer-reviewed journals and reputable scientific sources.

Results

Study /Author	Intervention	Results
Khine WWT, (2021)	Single meal containing mixed spices	<ul style="list-style-type: none"> - Modification/restoration of gut microflora within 24-48 hours. - Prebiotic potential altering greater than 120 bacterial species, including growth promotion of certain probiotics (e.g., Bifidobacterium spp.) and inhibition of growth of pathogenic bacteria (e.g., Clostridium spp.). - Significant reductions in Bacteroides populations with increasing mixed spices dose [12].
Lu et al. (2017)	Aqueous culinary spice extracts (oregano, ginger, rosemary, cinnamon, black pepper, cayenne pepper, turmeric)	<ul style="list-style-type: none"> - Promotion of Bifidobacterium spp. by six out of seven spice extracts. - Stimulation of Lactobacillus spp. and inhibition of certain Clostridium spp. by all seven spices. - Increase in most Clostridium spp. after turmeric and curcumin intervention observed in human study [13].
Peterson, Vaughn et al. (2018)	Turmeric and curcumin tablets	<ul style="list-style-type: none"> - Modulation of gut microbes in healthy humans, with alterations thought to be due to a prebiotic effect of turmeric and curcumin. - Increase in butyrate producing microbes with turmeric observed in vitro [14].
Ma ZJ (2020)	Ginger decoction	<ul style="list-style-type: none"> - Improvement in diversity of gut microbiota and accelerated gut microbiota recovery. - Decrease in Escherichia Shigella and increase in Bacteroides levels. - Moderate restoration of intestinal barrier function, especially ZO-1 protein [15].

Wang J (2019)	Ginger supplementation	<ul style="list-style-type: none"> - Decrease in body weight, liver steatosis, and low-grade inflammation. - Modulation of gut microbiota composition, including increase in Bifidobacterium genus and SCFA-producing bacteria (<i>Alloprevotella</i> and <i>Allobaculum</i>). - Increase in fecal SCFA concentrations. - Anti-obesity and microbiota-modulating effects observed in fecal microbiota transplantation (FMT) experiment [16].
Scazzocchio B (2020)	Curcumin treatment	<ul style="list-style-type: none"> - Improvement in intestinal tight junction structure and reduction in serum concentrations of TNF-α and LPS in rats fed high-fat diet. - Restoration of intestinal barrier function and expression of tight junction proteins ZO-1 and claudin-1 in mice fed Western diet [17].
Lu QY (2019)	Daily intake of mixed spices	<ul style="list-style-type: none"> - Significant reduction in relative abundance of phylum Firmicutes and trend of increase in phylum Bacteroidetes observed in healthy subjects [18].
Pacharatrakul T (2016)	Chili and curcumin	<ul style="list-style-type: none"> - Potential therapeutic role of chili in functional gastrointestinal disorders (FGIDs) through desensitization of transient receptor potential vanilloid-1 receptor. - Effects of curcumin on gut inflammation, gut permeability, and brain-gut axis observed in preclinical studies and uncontrolled clinical trials, especially in FGIDs [19].

Discussion

While polyphenolic compounds in diet are known to modulate gut microbiome metabolism of dietary polyphenols also rely on the gut microbiome to exert their biological effects in humans, particularly for their breakdown into secondary metabolites and subsequent absorption [20]. This bi-directional association between dietary polyphenols and the gut microbiome is integral to the host-gut bacteria symbiosis [21]. The diverse array of culinary spices demonstrates promising potential in modulating gut microbiota composition and promoting gut health [22]. Further research is warranted to elucidate the underlying mechanisms and optimize their therapeutic applications in various health conditions.

Gut Modulatory Effects

The research findings compiled in this article indicate that various culinary spices satisfy the criteria of modulating effect on gut microbiota composition by reducing inflammation and preserving the beneficial biome [23]. Studies show that even a single meal containing mixed spices can induce modifications in gut microflora within a short timeframe [24]. Mixed spices exhibit prebiotic potential, altering the abundance of bacterial species, including the promotion of beneficial probiotics like *Bifidobacterium* spp. while inhibiting the growth of pathogenic bacteria such as *Clostridium* spp. [25]. Furthermore, certain spices, such as ginger, have been found to improve gut microbiota diversity and accelerate microbiota recovery, indicating their potential in restoring gut health [26]. Additionally, daily intake of mixed spices has been associated with a reduction in Firmicutes abundance and an increase in Bacteroidetes, suggesting a favorable impact on gut microbiota composition [27].

Anti-inflammatory Effects

The therapeutic potential of culinary spices extends beyond gut modulation to include anti-inflammatory effects. Turmeric and curcumin, in particular, have been shown to possess potent anti-inflammatory properties [28]. Studies demonstrate that turmeric and curcumin tablets can modulate gut microbes in healthy humans, potentially through their prebiotic effects [29]. These interventions lead to alterations in bacterial composition, including an increase in butyrate-producing microbes, known for their anti-inflammatory properties [30]. Moreover, curcumin treatment in animal models has been associated with improvements in intestinal tight junction structure and barrier function, highlighting its potential in mitigating gut inflammation and maintaining gut integrity [31]. Such anti-inflammatory effects may contribute to the protective effects against colon cancer and metabolic diseases associated with chronic inflammation.

Preventive and Wellbeing Application

Beyond their specific effects on gut health and inflammation, culinary spices have broader applications in promoting overall well-being. Mixed spices and individual spices like ginger, turmeric, and chili have been traditionally used in culinary practices worldwide for their appetizing benefits [32]. They have been explored for their therapeutic potential in various health conditions, including functional gastrointestinal disorders (FGIDs), obesity, diabetes, and allergies [33]. Their versatility in culinary and traditional medicine makes them valuable components of dietary interventions aimed at improving overall health and preventing chronic diseases [34]. Further research is reasonable to explain the mechanisms underlying their effects and optimize their therapeutic applications in clinical settings.

Conclusions

In conclusion, culinary spices show promising potential in promoting gut health and reducing inflammation. These findings highlight the importance of incorporating spices into dietary interventions for overall well-being. As herbs and spices generally have low bioavailability, this may affect the extent of health benefits of that substrate [35]. This is thought to be one reason for inconsistent results in some herb and spice interventions and also why results seen in *in vitro* experiments are not always replicable to *in vivo* studies [36]. In addition to this, polyphenol content is not consistent and may vary according to use of the bioactive compound versus its natural form, harvesting methods, storage time, processing and cooking method. Further research is needed to better understand their mechanisms of action and optimize their therapeutic applications.

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