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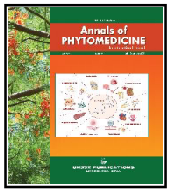

Invited Commentary : Open Access

Ayurvedic foods and spices to heal the gut microbiome

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1. Introduction

Food is important for both health and illness. A healthy diet is the foundation of a healthy life. Diet is classified as one of the three pillars of support in Ayurveda. Food consumption should be based on one's digestive system. A significant relationship exists between the gut microbiota and diet. Adopting a diet could be a fantastic way to raise awareness of the complexities of gut health in humans and protect the host from pathological diet variations and other various reasons. Adhering strictly to the diet regimens, consuming seasonal foods, and other practices can alter the gut flora in a way that promotes health (Sukesh Suni *et al*., 2021).

The microorganisms can be significantly altered by food and lifestyle choices, and the dysbiosis of these communities can exacerbate immunological disorders, metabolic health issues such as non-communicable illnesses, and pathogen susceptibility. According to the nutritional content of each of its components, which include carbs, protein, vitamins, and minerals; modern science characterizes diet. This classification in Ayurveda is predicated on the rasa (taste) and the biological action of the diet. For instance, all varieties of rice may be grouped based solely on their carbohydrate content. Freshly harvested rice; however, is deemed heavy for digestion by Ayurveda. On the other hand, rice that has been stored for more than six months is said to be lighter and more beneficial for the typical individual. A person's entire existence is dependent on eating. When the right diet is eaten, the body is satisfied, nourished, strengthened, and becomes more immune.

The most important element influencing the composition of the human gut microbiome; however, is believed to be food. The population of microbes in an individual's gut controls immunological response, thermoregulation, the nutritional content of food ingested, and physiological processes. Metabolic homeostasis is achieved by a healthy microbiota in which beneficial strains predominate over dangerous ones; disease-causing potential is triggered by dysbiosis. *Actinobacteria, Firmicutes, Proteobacteria, Verrucomicrobia,* and *Bacteroidetes* predominate in the human gut, whereas *Cyanobacteria, Spirochaetes, Saccharibacteria,* and *Fusobacteria* are found in smaller amounts (Arumugam *et al*., 2011). Trillions of bacteria, fungus, and other microorganisms make up the gut microbiome.

The gut microbiome regulates digestion, strengthens the immune system, and supports numerous other elements of health, all of which have a significant positive impact on your overall health. Weight gain, excessive blood sugar, high cholesterol, and other conditions may be influenced by an unbalanced population of beneficial and harmful bacteria in the intestines.

Two ways that diet modifies the composition of the gut microbiota are by providing indigestible materials that feed into the intestinal regions and specifically support the growth and activity of beneficial microbes (prebiotics) and by incorporating live microorganisms called probiotics that resist digestion, colonize the gut, and beneficially modulate the microbial composition. The digestive tract heats up in response to a reduction in temperature, which enhances cravings for diet. Due to the resilient digestive systems of humans; food should be rich in both quantity and quality to prevent the consumption of bodily tissues.

Standard diet procedures can either balance the gut or cause changes and health implications, as they demonstrate that regular exercise can prevent obesity despite a high-fat diet by altering the population ratio of major bacterial phyla, maintaining intestinal morphology and integrity, and thus decreasing inflammatory infiltration. The right regimen described for each season can help maintain the intestinal bacteria as well. Many Ayurvedic foods and spices can support gut health and enhance digestion when included in an Ayurvedic diet.

2. Ayurvedic foods and spices for gut microbiome

2.1 Ginger (*Zingiber officinale* Rosc.)

Strong digestive support can be obtained from ginger, an herb with anti-inflammatory qualities that can help alleviate bloating, gas, and other digestive problems. In addition, ginger can prevent dyspepsia and flatulence, lessen intestinal cramps, and has carminative (gas-relieving) properties (Nikkhah Bodagh *et al*., 2018). The numerous active components in fresh and dried ginger are responsible for these qualities. When used in food preparation, ginger oil has also been demonstrated to have antifungal and antibacterial qualities (Jakribettu *et al*., 2016).

Additionally, Xiaolong Wang's study demonstrated that the proteobacteria population and the firmicutes to bacteroidetes ratio went up with short-term ginger juice intake. Bacteroidetes and firmicutes are crucial for controlling the metabolism of sugar, bile acid, and host lipids (Wang *et al*., 2021).

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Benefits of ginger for the microbiome

- Assists in easing gas, cramps, bloating, and digestive pain.
- Reduces gas and dyspepsia.
- Boosts proteobacteria and the ratio of firmicutes to bacteroidetes.

2.2 Turmeric (*Curcuma longa* L.)

Turmeric can aid in reducing inflammation because of its anti-inflammatory and antioxidant qualities. In the digestive tract, it promotes the development of good bacteria like lactobacilli and bifidobacteria while also assisting in the decrease of harmful strains. Turmeric's key ingredient is called curcumin, and it has benefits for digestive health (Sivakumar *et al*., 2022; Menon and Sudheer, 2007).

Problems including metabolic syndrome, arthritic conditions, nervousness, high blood fat levels, and destruction from dangerous chemicals and inflammation can all be managed with the use of curcumin. Additionally, it might aid in the management of post-exercise inflammation and muscular pain, which could speed up recovery and improve performance (Hewlings and Kalman, 2017).

Benefits of turmeric for the microbiome

- Assists in lowering pathogenic strains.
- Encourages the growth of *Lactobacilli and Bifidobacteria*.

2.3 Cumin (*Cuminum cyminum* L.)

By boosting the breakdown of meals in the digestive tract and stimulating digestive enzymes, cumin seeds aid with digestion (Milan *et al*., 2008). All irritable bowel syndrome symptoms can be effectively alleviated by cumin extract as well (Agah *et al*., 2013). The fruit of the cumin plant possesses several qualities, such as antibacterial, antidiabetic, antioxidant, antidiarrhea, and anticancer activities (Deng *et al*., 2023).

Cumin's microbiome-friendly advantages

- It aids in promoting digestive enzymes.
- Aids in easing the symptoms of irritable bowel syndrome, such as diarrhea.

2.4 Coriander (*Coriandrum sativum* L.)

Due to their anti-inflammatory and antispasmodic qualities, coriander seeds might reduce discomfort and inflammation in the gastrointestinal tract. Additionally, inflammatory diseases like blepharitis, stomatitis, and heated skin irritation can be treated with coriander (Sobhani *et al*., 2022). Coriander has been used to treat heart and gastrointestinal ailments. Moreover, diarrhea, dyspepsia, and excessive blood pressure are treated with coriander (Jabeen *et al*., 2009). In addition to their anti-inflammatory and antibacterial qualities, coriander seeds are utilized to combat intestinal parasites. Based on recent research, coriander seed extracts have been linked to improved glucose tolerance (Eidi *et al*., 2009). Furthermore, it was discovered that coriander altered the composition of gut bacteria, resulting in increased concentrations of the beneficial *Bifidobacterium* and *Oscillibacter* bacteria (Wang *et al*., 2022) strains of *Bifidobacterium* that support immunological function and gut health.

Coriander benefits for the microbiome

- May reduce digestive discomfort; used for diarrhea, indigestion, stomach pain, and high blood pressure.
- Encourages *Oscillibacter* and *Bifidobacterium* development.

2.5 Fennel (*Foeniculum vulgare* Mill.)

Stomach pains and gas can be effectively relieved by using fennel seeds. They also help to regulate bowel movements and promote the development of digestive enzymes. In addition, fennel has antiviral, antibacterial, and anti-inflammatory qualities (Badgujar *et al*., 2014). Numerous medical conditions can be treated with fennel seeds and oil, such as headaches, the flu, eye disorders, and digestive difficulties. Fennel seed tea is a rich source of vitamins and minerals. Additionally, intestinal bacterial infections and the removal of hookworms are advised uses for it. Fennel tea is also used as an herbal treatment for gastrointestinal problems and distress (Saddiqi and Iqbal, 2011).

Fennel's benefits for the microbiome include

- Relieves gas, bloating, and cramping in the abdomen.
- Encourages the synthesis of digestive enzymes.
- Support the control of bowel movements.

2.6 Cardamom (*Elettaria cardamomum* L.)

Cardamom encourages the breakdown of nutrients in the digestive tract, aids in the relief of gastrointestinal discomfort, and accelerates digestion. Additionally, cardamom reveals its medicinal and prophylactic qualities against diabetes (Yahyazadeh *et al*., 2021). It has therapeutic qualities as a diuretic, heart stimulant, carminative for stomachaches, and antiemetic.

The cardamom-based essential oil demonstrated antispasmodic and antidiarrheal properties in addition to its antibacterial properties. Because of their flavoring and antibacterial qualities, cardamom extracts are thought to be a better option than synthetic chemicals for use as stabilizers in food products. Besides, cardamom demonstrated antispasmodic, antidiarrheal, and antibacterial properties (Alam *et al*., 2021).

It has been documented that cardamom essential oil possesses antibacterial properties against negative bacteria, including *Pseudomonas aeruginosa* and *Escherichia coli*. *E. coli* is a widespread colony-dwelling bacteria that usually causes diarrhea in humans. *P. aeruginosa* also causes diarrhea, which is difficult to treat because of its natural resistance to many medications. It can also affect people who are immunocompromised or who have just received antibiotic treatment (Alam *et al*., 2021).

Cardamon's microbiome-friendly advantages

- Promotes healthy digestion and eases pain in the gastrointestinal tract.
- Encourages the digestive tract's ability to absorb nutrients.

2.7 Mint (*Mentha piperita* L)

The soothing and cooling qualities of mint leaves can aid in the relief of nausea, indigestion, and abdominal pain. Additionally, mint contains antibacterial qualities that may support the maintenance of a balanced population of gut flora. Other health

benefits of mint include its ability to inhibit the progression of cancer, combat obesity, and have antidiabetic properties (Tafrihi *et al*., 2021).

In addition to its relaxing properties, fresh mint fights bacteria and relieves spasms. Alkaloids, saponins, organic acids, vitamins, carotenoids, chlorophylls, and other important nutrients are abundant in mint leaves. The essential oils found in mint have a potent antibacterial effect on pathogens, particularly *E. coli* strains (Hutsol *et al*., 2023). Certain *E. coli* strains have the potential to be harmful, particularly when they generate specific toxins.

Traditionally, peppermint has been used to treat morning sickness, nausea, vomiting, flatulence, and abdominal pain. According to clinical research, peppermint oil can be used to treat postoperative nausea, diffuse esophageal spasms, dyspepsia, and irritable bowel syndrome (Sali and Vitetta, 2007). Incorporating these Ayurvedic herbs in the diet, will assist in promoting gut health, aid with digestion, and relieve digestive discomfort.

Microbiome-friendly advantages of mint

- Potentially useful in treating irritable bowel syndrome.
- May help reduce nausea, indigestion, gas, and stomach pain.

3. An ayurvedic view of probiotics

The relevance of helpful microorganisms in preserving the immune system and digestive health has long been recognized by Ayurveda. Foods high in probiotics, in particular, provide a great way to maintain a healthy gut ecosystem.

3.1 Fermented foods

According to Ayurveda, fermented foods are essential because they boost the good bacteria in our digestive tracts. Foods that have undergone natural fermentation have an increase in microbial content and an improvement in digestion (Bilodeau, 2018). Yogurt, buttermilk, fermented rice, and fermented vegetables are examples of traditional Ayurvedic fermented foods. Probiotic bacteria that are good for the gut and the immune system, like *Lactobacillus* and *Bifidobacterium* strains, are abundant in these meals.

3.2 Fermented rice

Fermented rice is an ancient Ayurvedic medicine. Rice is soaked in water and let ferment overnight. It is applied to support gut health and facilitate digestion. Probiotic bacteria and digestive enzymes found in fermented rice water aid in digestion, reduce gastrointestinal discomfort, and improve nutritional absorption.

It has been discovered that fermented rice water has probiotic properties because it contains lactic acid bacteria like *Lactiplanti bacillus plantarum* and *Limosilactobacillus fermentum*. The ability of these microorganisms to suppress the growth of harmful bacteria has been widely reported. Antioxidants like inositol, found in fermented rice water, can promote hair growth and lessen hair loss. Rice water's protein, amino acid, and oligopeptide content rises during fermentation, which leads to its beneficial effects (Ying *et al*., 2022).

3.3 Fermented vegetables

Drinking fermented vegetables have probiotic properties. Carrots, beets, and other vegetables are fermented with water, salt, and spices to make this beverage. Probiotic bacteria, vitamins, and minerals found in fermented veggies favor intestinal health, increase immunity, and facilitate better digestion. Fermented vegetables also promote general health and an even distribution of microorganisms in the gut. Fermentation can add certain vitamins and antioxidants to meals and veggies while also making them easier to digest (Leeuwen-daal *et al*., 2022). Research has shown that fermented vegetables contain *Lactobacillus*. In addition to fermenting carbohydrates and lactic acid production, *Lactobacilli* significantly contribute to the formation of an acidic environment that prevents the growth of pathogenic bacteria. By strengthening the gut membrane and synthesizing antimicrobial chemicals that assist in pathogen protection and enhance immunological function (Dempsey and Corr, 2022).

3.4 Pickles

Indian pickles are created by combining salt, spices, and oil with vegetables or fruits to ferment them. Pickles can improve digestion, enhance taste, and offer minimal levels of microorganisms to promote gut health. Research has indicated that pickled foods contain *Lactobacillus* and *Weissella*. As probiotics, *Lactobacillus* and *Weissella* are beneficial to human health because they support healthy digestion and the immune system. Pickles can help decrease cholesterol and prevent infections from entering the digestive tract when consumed regularly. Potential probiotic qualities seen in the microbiome extracted from pickled foods could assist in reducing intestinal inflammation and hyperuricemia (Cai *et al*., 2023). Fermented foods are thought to boost metabolism, strengthen the digestive system, and ease digestive discomfort when incorporated into the diet.It is advised to consume these foods in moderation, considering each person's unique nature and level of digestion.

4. Herbal mixtures

Herbal medications can help balance gut flora and improve digestive health. Herbs with anti-inflammatory, antibacterial, and immune-modulating qualities are combined to create these medications. Certain herbs used in Ayurveda medicine can promote the growth of good gut flora while preventing the establishment of dangerous pathogens. Combining these herbs will result in specialized herbal medicines for different digestive disorders and constitutions.

Ayurvedic treatment makes use of the plant *Holarrhena antidysenterica*, which is widely distributed throughout India. This plant's seeds are primarily utilized as an antidiabetic agent. The plant's seed extract has been found to have antidiabetic effects. The herb can be utilized for treating leukoderma and has anti-hyperglycemic and anti-hyperlipidemic properties (Jamadagni *et al*., 2017).

The herb *Cyperus rotundus* is used to cure several ailments, including inflammation, diabetes, diarrhea, malaria, and gastrointestinal and stomach issues. Various health benefits of *Cyperus rotundus* are anti-inflammatory, antioxidant, antidiabetic, and anticancer abilities. High amounts of active components, including flavonoids, phenolic acids, ascorbic acids, and essential oils, are present in the roots and tubers (Pirzada *et al*., 2015).

Terminalia chebula is a medicinal herb that is native to India. Its ability to both prevents and treat illness makes it highly valued in Ayurveda. The fruit skin has been used in traditional medicine and as one of the compositions of Triphala. *T. chebula* is used to treat fungal infections, inflammations of the mouth mucous membrane, and external wound healing. It helps with coughs, piles, and asthma (Ratha and Joshi, 2013).

Piper longum, an Ayurvedic medicine, is used to reduce inflammation and soreness in the muscles, increase hunger, release gas from the intestines, and move the placenta after childbirth. Research has demonstrated that *P. longum* can significantly influence a range of diseases and ailments, such as hepatotoxicity, diabetes, cancer, inflammation, depression, and obesity. The plant can also be used to treat radiation side effects, heart conditions, and microbiolo-gical infections (Kumar *et al*., 2011). To promote digestive health, these herbs can be taken as powders, pills, or various tea blends.

5. Conclusion

Food, or diet, is the fundamental source of a living thing's strength, complexity, and vitality. It is capable of both promoting health and controlling the pathophysiology of illness. Diet supports the body when taken in moderation; when taken in excess, improperly, or insufficiently, it has detrimental effects on the body. To attain the maximum advantages from each taste, diet should carefully incorporate each taste. The ultimate basis for morality, prosperity, fulfillment, and salvation is health. Ayurveda places more emphasis on maintaining and fostering good health than it does on treating illness. Ayurveda places more focus on prevention than on treating illnesses; as a result, it highlights the type of food that is best to eat in order to achieve and maintain good health. Food is necessary for a healthy life, but when consumed incorrectly, it may also be the primary cause of many illnesses. The dietary modifications can alter an individual's human microbiome in both children and adults. Nonetheless, there is strong evidence that a healthy diet and microbiome can avoid Westernized diseases and increase the period of a person's healthy life.

I confidently believe that **Annals of Phytomedicine: An International Journal** publication provides an up-to-date, freely disseminated assessment of research findings. This publication covers every facet of the methods and approaches used today to work with aromatic and medicinal plants. It is well recognised that the Annals of Phytomedicine offer a thorough scientific foundation in herbal medicinal products, their reproducible quality, and their evidence-based efficacy in therapy. I offer my warmest regards for many more successes down the road and for its ongoing prosperity.

Conflict of interest

The author declares no conflicts of interest relevant to this article.

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Biography

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Dr. T. Prabha has expertise in the research areas of anticancer, immune modulator drugs, and antituberculosis drug discovery. She has hands-on experience in handling some analytical instruments like gradient binary pump HPLC, FTIR, UV, *etc*. She is also good at handling some computational tools like Python packages, QSARINS, MOE software, AutoDock 4.2, Discovery Studio, and other online and offline computational software. She had written a textbook on "Computer Aided Drug Design” and the practical book on “Medicinal Chemistry-III” for B.Pharm. Students. She has contributed to more than 5 book chapters, and 5 more book chapters are in pipeline with highly impacted publishers, *viz*., Elsevier, Bentham, Springer, Taylor and Francis, *etc*. To the credit of her candidature, she had around 105 International and National research article publications in highly indexed Scopus, WOS, and UGC care list journals. She has delivered a resource person talk at various offline and online conferences and seminars at the national level.

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