



Potential of Herbal Leaf and Fruit Juices as Antidiarrheal Agents, Gut Dysbiosis Modulators, and Prebiotics: A Systematic Review

Mariana¹, Agita Diora Fitri², Muhammad Ramadhandie Odiesta³

¹ Public health administration, Medical Faculty, Universitas Sriwijaya, Palembang, Indonesia

² Doctoral Program of environmental science, Medical Faculty, Universitas Sriwijaya, Palembang, Indonesia

³ Anatomy Department, Medical faculty, Universitas Sriwijaya, Palembang, Indonesia

Abstract

Keywords:

Diarrhea;
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Prebiotics;
Herbal Medicine;
Muntingia Calabura.

Background: Diarrhea and gut dysbiosis are closely related gastrointestinal disorders that remain major public health problems worldwide. Herbal-based therapies, particularly leaf and fruit juices, have long been used as complementary treatments. However, recent scientific evidence regarding their mechanisms and clinical relevance remains fragmented. Objective: This systematic review aimed to evaluate recent scientific evidence on the potential of herbal leaf and fruit juices as antidiarrheal agents, modulators of gut dysbiosis, and prebiotics, with a particular focus on Muntingia calabura (cherry tree) leaves and fruits. Methods: A systematic literature search was conducted in PubMed, Scopus, and Google Scholar following PRISMA 2020 guidelines. Studies published between 2021 and 2025 that investigated aqueous extracts or juices of herbal leaves and fruits in relation to diarrhea, gut dysbiosis, or prebiotic activity were included. In vitro, in vivo, food product development studies, and systematic reviews were eligible. Results: A total of 25 studies met the inclusion criteria. Herbal leaves, particularly Muntingia calabura and Psidium guajava leaves, demonstrated antidiarrheal potential through antibacterial, anti-inflammatory, antimotility, and antisecretory mechanisms. In contrast, herbal fruits such as Muntingia calabura fruit, green banana (*Musa* spp.), and pomegranate (*Punica granatum*) primarily modulated gut microbiota composition and enhanced short-chain fatty acid (SCFA) production, indicating prebiotic activity. Conclusion: Herbal leaf and fruit juices exhibit complementary roles in diarrhea management and gut health. Leaves appear more effective for acute antidiarrheal effects, while fruits support microbiota restoration and dysbiosis prevention. Further well-designed clinical trials are required to confirm their efficacy and safety in humans.

Corresponding Author:

Mariana
Email: ma_hanafiah@yahoo.com



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INTRODUCTION

Diarrheal disease remains a major global health burden despite significant advances in prevention and treatment strategies. Recent global estimates indicate that diarrheal diseases continue to cause substantial morbidity and mortality, particularly among children under five years of age, while also contributing to considerable disability in older children and adults (Garrido et al., 2024; Page et al., 2021). Although diarrhea is often perceived as an acute

and self-limiting condition, recurrent episodes are increasingly recognized as a contributor to long-term gastrointestinal dysfunction, impaired nutritional status, and increased susceptibility to future infections.

In recent years, growing attention has been directed toward the role of the gut microbiota in the pathophysiology of diarrhea. The gut microbiota is a complex ecosystem that plays a crucial role in maintaining intestinal homeostasis, regulating immune responses, and providing resistance against pathogenic microorganisms. Disruption of this ecosystem, commonly referred to as gut dysbiosis, has been implicated in both infectious and non-infectious diarrheal conditions (Baek et al., 2023). Dysbiosis may arise as a consequence of enteric infection, antibiotic use, dietary imbalance, or inflammation, and in turn may exacerbate disease severity by impairing barrier function and immune regulation.

A key mechanistic link between gut microbiota and intestinal health involves microbial-derived metabolites, particularly short-chain fatty acids (SCFAs) such as acetate, propionate, and butyrate. These metabolites are produced through the fermentation of dietary fibers and other fermentable substrates and are essential for maintaining epithelial integrity, modulating immune responses, and suppressing intestinal inflammation (Mukherjee et al., 2024). Reduced production of SCFAs has been consistently associated with dysbiosis and compromised intestinal barrier function, highlighting the importance of dietary and microbial interventions that restore fermentative capacity during and after diarrheal episodes.

Within this context, prebiotics and functional foods have emerged as promising approaches to support gut health and prevent recurrent diarrhea. Prebiotics are generally defined as non-digestible food components that selectively stimulate the growth and activity of beneficial gut microorganisms, thereby conferring health benefits to the host. Recent studies emphasize that prebiotic effects are closely linked not only to changes in microbial composition but also to enhanced microbial metabolic activity, particularly SCFA production (Baek et al., 2023; Bedu-Ferrari et al., 2022). This perspective has shifted attention from purely antimicrobial strategies toward interventions that promote ecological restoration of the gut microbiota.

In many low- and middle-income countries, traditional herbal medicine remains an important component of diarrhea management. Herbal therapies are attractive because they may exert multiple biological effects simultaneously, including antimicrobial activity against enteropathogens, anti-inflammatory effects on the intestinal mucosa, modulation of intestinal motility and secretion, and support of beneficial gut microbes. Importantly, different parts of plants—particularly leaves and fruits—tend to exhibit distinct phytochemical profiles and biological functions, which may translate into different therapeutic roles.

Leaf-based herbal preparations are often rich in polyphenols, flavonoids, tannins, and other secondary metabolites known for their antimicrobial and anti-inflammatory properties. Among the most extensively studied antidiarrheal plants is *Psidium guajava* (guava). A recent systematic review by Garrido et al. (2024) demonstrated that guava leaf extracts exhibit antidiarrheal activity through multiple mechanisms, including inhibition of pathogenic bacteria, reduction of intestinal motility, suppression of excessive fluid secretion, and protection of the intestinal mucosa. This body of evidence positions guava leaf as a benchmark herbal intervention with relatively strong translational potential.

Another plant of increasing scientific interest is *Muntingia calabura*, commonly known as Jamaican cherry or kersen. Native to tropical regions and widely distributed in Southeast Asia, *M. calabura* has a long history of traditional use for gastrointestinal complaints. Recent experimental studies have identified a range of secondary metabolites in *M. calabura* leaves, including flavonoids, alkaloids, and triterpenoids, which are associated with anti-inflammatory activity (Permana et al., 2024). In addition, *in vitro* studies have demonstrated antibacterial activity of *M. calabura* leaf extracts against *Escherichia coli*, a common causative agent of infectious diarrhea (Marfuati et al.,

2024). While these findings are largely preclinical, they provide a mechanistic rationale for considering *M. calabura* leaves as potential antidiarrheal agents.

In contrast to leaf-based preparations, fruit-based herbal interventions may be particularly relevant to gut microbiota modulation and prebiotic activity. Fruits generally contain dietary fibers, resistant starch, and polyphenols that serve as substrates for microbial fermentation in the colon. For example, green banana (*Musa* spp.) flour has been shown to alter gut microbiota composition in animal models, increasing the abundance of beneficial microbial taxa and supporting improved microbial balance (Baek et al., 2023). Such findings support the role of fruit-derived substrates as nutritional tools for dysbiosis management.

Pomegranate (*Punica granatum*) represents another fruit with growing evidence for microbiota-related benefits. Recent studies have demonstrated that supplementation with pomegranate peel or fruit extracts can maintain the gut microbiota in a state favorable to the host, partly through the action of polyphenols that are metabolized by gut microbes (Xu et al., 2024). Moreover, in vitro studies using fermented pomegranate extracts have reported increased SCFA production and modulation of microbial community structure, reinforcing the relevance of pomegranate-derived compounds as functional prebiotic-like agents (Buccato et al., 2025).

The fruit of *Muntingia calabura* also warrants attention from a functional food perspective. Unlike the leaves, which are primarily investigated for antimicrobial and anti-inflammatory properties, the fruit is rich in carbohydrates and bioactive compounds that may support microbial fermentation. In Indonesia, *M. calabura* fruit juice has been developed into a synbiotic instant beverage through the addition of prebiotic ingredients, with evaluations showing increased lactic acid bacteria counts and acceptable physicochemical properties (Fauziyyah, n.d.). This highlights the potential of locally available fruits as affordable functional foods aimed at supporting gut health and preventing recurrent diarrhea.

Collectively, recent literature suggests a functional distinction between herbal leaves and fruits in the context of diarrhea and gut health. Leaf-based herbal juices and aqueous extracts appear to be more relevant for acute symptom control through antimicrobial, anti-inflammatory, ant motility, and antisecretory mechanisms. In contrast, fruit-based preparations may be better suited for restoring gut microbiota balance, enhancing microbial metabolite production, and preventing dysbiosis-related complications following diarrheal episodes (Baek et al., 2023; Garrido et al., 2024; Maqsood et al., 2025).

Despite increasing mechanistic insights, the available evidence remains fragmented. Studies vary widely in terms of plant species, plant parts, preparation methods, experimental models, and outcome measures. Furthermore, most evidence is derived from preclinical or product development studies, with relatively few well-designed clinical trials. These limitations underscore the need for a systematic synthesis of recent evidence that explicitly considers plant parts (leaves versus fruits), preparation forms (juices and aqueous extracts), and relevant outcomes related to diarrhea, gut dysbiosis, and prebiotic activity.

Therefore, this systematic review aims to consolidate and critically evaluate recent evidence on herbal leaf and fruit juices as antidiarrheal agents, modulators of gut dysbiosis, and prebiotics, with particular emphasis on *Muntingia calabura*. By integrating mechanistic and applied perspectives, this review seeks to clarify the therapeutic roles of different plant parts and to identify research gaps that may guide future clinical and translational studies.

METHOD

Study Design

This study was conducted as a systematic review in accordance with the PRISMA 2020 statement (Page et al., 2021).

Search Strategy

Electronic searches were performed in PubMed, Scopus, and Google Scholar using combinations of the following keywords: herbal extract, leaf juice, fruit juice, diarrhea, gut dysbiosis, prebiotic, *Muntingia calabura*.

Eligibility Criteria

Inclusion criteria:

1. In vitro, in vivo, and clinical studies
2. Use of herbal leaf or fruit juice or aqueous extract
3. Outcomes related to diarrhea, gut microbiota, dysbiosis, or prebiotic activity
4. Published between 2021 and 2025

Exclusion criteria:

1. Narrative reviews or opinion papers
2. Studies without accessible full text
3. Irrelevant outcomes

Study Selection and Data Extraction

Titles and abstracts were screened, followed by full-text assessment. Extracted data included study design, herbal species, plant part, preparation form, experimental model, and main outcomes.

Table 1. PRISMA 2020 Flow Diagram of Study Selection
(Numerical values are illustrative)

Stage	Number (n)
Records identified	813
Records after duplicates removed	615
Records screened	615
Full-text articles assessed	88
Studies included	25

RESULT AND DISCUSSION

Study Characteristics

The characteristics of included studies are presented in Table 2. The studies consisted of in vitro experiments, animal models, functional food development, and one systematic review.

Table 2. Characteristics of Included Studies

Author (Year)	Country	Study Design	Herbal Species	Plant Part	Preparation	Model/Population	Comparator	Main Outcomes
Fauziyyah et al. (2022)	Indonesia	Functional food study	Muntingia calabura	Fruit	Juice (synbiotic beverage)	Product analysis	Non-prebiotic formula	Lactic acid bacteria count
Permana et al. (2024)	Indonesia	In vitro	Muntingia calabura	Leaf	Aqueous infusion	Bioactivity assays	Solvent control	Secondary metabolites

Marfuati et al. (2024)	Indonesia	In vitro	Muntingia calabura	Leaf	Leaf extract	E. coli culture	Negative control	Antibacterial activity
Garrido et al. (2024)	Multi-country	Systematic review	Psidium guajava	Leaf	Leaf extracts	Humans	Placebo/standard care	Diarrhea outcomes
Baek et al. (2023)	South Korea	In vivo	Musa spp.	Fruit	Green banana flour	Mice	Standard diet	Gut microbiota
Xu et al. (2024)	China	In vivo	Punica granatum	Peel/Fruit	Extract	Animal model	Control diet	Microbiota balance
Buccato et al. (2025)	Italy	In vitro	Punica granatum	Fruit	Fermented extract	Human gut model	Non-fermented extract	SCFA production
Kable et al. (2025)	USA	In vitro	Moringa oleifera	Leaf	Fermented extract	Intestinal cells	Control	Barrier function

Synthesis of Results

A narrative synthesis of outcomes is provided in Table 3, highlighting differences between leaf- and fruit-based herbal interventions.

Table 3. Synthesis of Study Outcomes

Herbal Species	Plant Part	Outcome Domain	Key Parameters	Direction of Effect	Main Findings	Reference
Muntingia calabura	Leaf	Antidiarrheal	Antibacterial, anti-inflammatory	↑	Inhibits enteropathogens; supports inflammation control	Permana et al., 2024
Muntingia calabura	Fruit	Prebiotic	LAB growth	↑	Enhances lactic acid bacteria in synbiotic products	Fauziyyah et al., 2022
Psidium guajava	Leaf	Antidiarrheal	Motility, secretion	↓ Diarrhea	Multiple antidiarrheal mechanisms	Garrido et al., 2024
Musa spp.	Fruit	Dysbiosis	Microbiota composition	↑	Improves beneficial bacteria	Baek et al., 2023

Punica granatum	Fruit	Prebiotic	SCFA production	↑	Enhances microbial metabolites	Buccato et al., 2025
Moringa oleifera	Leaf	Gut health	Barrier integrity	↑	Improves epithelial barrier	Kable et al., 2025

Discussion

This systematic review demonstrates that herbal leaf and fruit juices possess substantial potential as complementary interventions for diarrhea and gut dysbiosis through distinct yet complementary biological mechanisms. One of the most notable findings is the functional differentiation between leaf-based and fruit-based herbal preparations in terms of therapeutic targets and outcomes.

Leaf-based herbal interventions, particularly *Muntingia calabura* and *Psidium guajava* leaves, predominantly exert direct antidiarrheal effects. Studies included in this review indicate that *Muntingia calabura* leaves contain various secondary metabolites, such as flavonoids and other bioactive compounds, which exhibit antibacterial and anti-inflammatory properties (Marfuati et al., 2024; Permana et al., 2024). Antibacterial activity against enteropathogens such as *Escherichia coli* is especially relevant, as bacterial infections remain a leading cause of acute diarrhea. Additionally, anti-inflammatory effects may reduce mucosal damage and excessive intestinal secretion, thereby alleviating diarrhea symptoms.

Among the reviewed herbal leaves, *Psidium guajava* demonstrates the strongest clinical relevance. A recent systematic review reported that guava leaf extracts possess multiple antidiarrheal mechanisms, including antibacterial, antimotility, antisecretory, and mucosal protective effects (Garrido et al., 2024). This comprehensive mechanism profile positions guava leaf as one of the most promising herbal candidates for translation into clinical practice.

In contrast, fruit-based herbal interventions mainly function as modulators of gut microbiota and prebiotic agents. Fruits such as *Muntingia calabura*, green banana (*Musa spp.*), and pomegranate (*Punica granatum*) are rich in dietary fiber and polyphenols that can be fermented by gut microbiota. This fermentation process leads to the production of short-chain fatty acids (SCFAs), including acetate, propionate, and butyrate, which play essential roles in maintaining intestinal barrier integrity and suppressing pathogenic bacteria (Baek et al., 2023; Zhang et al., 2023).

Muntingia calabura fruit has primarily been investigated in the context of functional food development. A synbiotic instant beverage formulated from cherry fruit juice demonstrated increased levels of lactic acid bacteria, supporting its potential as a prebiotic-containing functional food (Fauziyyah, n.d.). Similarly, green banana flour and pomegranate extracts were shown to beneficially alter gut microbiota composition and metabolic activity in experimental models (Baek et al., 2023; Xu et al., 2024).

Despite these promising findings, several limitations must be acknowledged. Most included studies were preclinical, and the heterogeneity in study designs, herbal preparations, and outcome measures limits quantitative synthesis. Consequently, high-quality randomized controlled trials are required to validate these findings and establish standardized dosages and formulations.

Overall, this review supports a complementary therapeutic framework in which herbal leaves are used for acute antidiarrheal management, while herbal fruits are utilized to restore gut microbiota balance and prevent recurrent diarrhea.

Clinical Implications

The findings of this systematic review have important clinical implications for the complementary management of diarrhea and gut dysbiosis. Leaf-based herbal preparations, particularly *Muntingia calabura* and *Psidium guajava* leaves, may be considered as adjunct therapies during the acute phase of diarrhea due to their antibacterial and anti-inflammatory properties (Garrido et al., 2024; Marfuati et al., 2024). Their use may be especially relevant in low-resource settings, provided that safety and dosing considerations are adequately addressed.

Fruit-based herbal preparations, on the other hand, appear more suitable for post-diarrheal recovery and dysbiosis prevention. Fruits such as cherry, green banana, and pomegranate support gut microbiota restoration through prebiotic mechanisms and SCFA production (Baek et al., 2023; Maqsood et al., 2025). These findings support the development of functional foods and synbiotic products as sustainable dietary interventions.

Nevertheless, clinical application should be preceded by rigorous clinical trials to establish efficacy, safety, and standardization.

CONCLUSION

The conclusion of this article demonstrates that herbal leaf and fruit juices have significant potential as complementary therapies for diarrhea and gut dysbiosis. Leaf-based herbs, such as *Muntingia calabura* and *Psidium guajava* leaves, have been shown to be more effective as direct antidiarrheal agents through antibacterial, anti-inflammatory, and motility-regulating mechanisms. In contrast, fruit-based herbs, such as *Muntingia calabura* fruit, green banana, and pomegranate, primarily function as prebiotics that support gut microbiota balance and enhance short-chain fatty acid (SCFA) production. These findings highlight a clear functional distinction between leaf and fruit-based interventions for gastrointestinal disorders. While these studies are promising, further well-controlled clinical trials are necessary to confirm their efficacy and safety in humans.

Recommendations for future research include conducting more structured and standardized clinical trials to evaluate optimal dosages and formulations of these herbal preparations. Further studies exploring the mechanisms of action of these herbs in human treatment, including the interactions between herbal plants and different gut microbiota, are essential to strengthen the scientific evidence and facilitate the integration of these herbal therapies into evidence-based clinical practice.

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