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THE ROLE OF HERBAL TEA IN FUNCTIONAL FOODS: A COMPREHENSIVE REVIEW OF HEALTH BENEFITS AND APPLICATIONS

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ABSTRACT
Herbal teas, traditionally consumed for their soothing and healing properties, are gaining prominence in the global health food industry due to their rich profile of bioactive compounds. Derived from a wide range of botanicals excluding Camellia sinensis, these teas are infused from various plant parts such as leaves, flowers, roots, and seeds, and offer a plethora of therapeutic benefits. Their polyphenol-rich compositions lend them powerful antioxidant, anti-inflammatory, antimicrobial, and immunomodulatory effects. The inclusion of herbal teas in functional food frameworks reflects a growing consumer preference for natural, plant-based health alternatives. This review offers an in-depth analysis of herbal teas in the context of modern functional foods. The paper classifies herbal teas based on fermentation processes and regional traditions, explores their health-promoting roles in managing chronic diseases such as cardiovascular disorders, digestive ailments, metabolic syndromes, and neurodegenerative conditions, and evaluates their nutritional and phytochemical makeup. The article further discusses innovative blends, delivery systems, regulatory perspectives, and sustainability practices. With supporting clinical and preclinical evidence, herbal teas are highlighted as promising tools for preventive nutrition and integrative healthcare. Their incorporation into dietary practices may redefine therapeutic nutrition in years to come.

KEYWORDS: Herbal tea, functional foods, polyphenols, antioxidants, phytochemicals, preventive healthcare, nutraceuticals.

1. INTRODUCTION

Herbal teas, also known as tisanes, have long been valued for their therapeutic and sensory qualities. Unlike conventional teas made from Camellia sinensis, herbal teas are infusions or decoctions prepared from dried herbs, flowers, roots, seeds, and barks of medicinal plants. Historically embedded in traditional medicine systems such as Ayurveda, Traditional Chinese Medicine (TCM), and African folk medicine, herbal teas are now recognized globally as components of functional foods.

With an increasing consumer shift toward plant-based health interventions and natural remedies, herbal teas are experiencing a resurgence. This is partly due to their safety profile—being generally caffeine-free—and their therapeutic versatility, targeting gastrointestinal health, immunity, cardiovascular function, cognitive performance, and metabolic balance. Phytochemicals such as flavonoids, tannins, essential oils, saponins, alkaloids, and terpenoids form the active basis for these effects. For instance, chamomile contains apigenin, a flavonoid known to reduce anxiety, while peppermint's menthol alleviates irritable bowel symptoms.[1,2]

Regions like the Cape Floristic Province in South Africa are biodiversity hotspots where teas such as rooibos (Aspalathus linearis) and honeybush (Cyclopia intermedia) are endemic and traditionally consumed. Similarly, the use of tulsi (Ocimum sanctum) and ginger (Zingiber officinale) in Indian households exemplifies the longstanding cultural reliance on herbal infusions for health maintenance.

In modern times, the functional food sector recognizes herbal teas not only for their medicinal attributes but also for their role in preventive healthcare. They are being incorporated into food matrices like baked goods, yogurts, smoothies, kombucha beverages, and even dietary supplements. Furthermore, advanced technologies such as nanoencapsulation and freeze-drying are enhancing the bioavailability and shelf stability of herbal tea bioactives, expanding their commercial potential.

The integration of herbal teas into wellness routines is further facilitated by their palatability, adaptability to various delivery systems, and alignment with holistic

health philosophies. However, challenges related to standardization, quality control, and clinical validation remain, emphasizing the need for evidence-based practices and regulatory oversight.

This review explores herbal teas from a multi-disciplinary perspective, beginning with their classification, examining their pharmacological and nutritional profiles, presenting supporting scientific evidence, and forecasting their future within the functional food industry.

2. Classification of Herbal Teas

Herbal teas may be classified by several parameters including processing methods, phytochemical composition, plant part used, fermentation level, and cultural use. These classifications provide insight into their health effects, preservation of bioactives, and traditional applications.

2.1 Based on Fermentation

2.1.1 Non-Fermented Herbal Teas

These teas are prepared from plant materials that are either steamed or oven-dried shortly after harvesting, minimizing enzymatic oxidation. This processing preserves their natural polyphenolic compounds, especially catechins and flavonoids.

Example: Green Tea (Camellia sinensis)

Though not strictly herbal, green tea serves as a reference model for non-fermented processing. The dominant catechin, epigallocatechin gallate (EGCG), possesses strong antioxidant properties.

2.1.2 Semi-Fermented Herbal Teas

These teas undergo partial oxidation before drying, leading to a mixture of catechins and theaflavins. Semi-fermented teas often retain both the freshness of green tea and the depth of black tea.

Example: Oolong Tea, Lemon Balm, Jasmine Tea
In herbal blends, Melissa officinalis (lemon balm) may be semi-fermented to enrich flavor complexity and enhance rosmarinic acid content.

2.1.3 Fully Fermented Herbal Teas

These are subjected to complete oxidation, leading to polymerization of catechins into thearubigins and theaflavins. While black teas dominate this category, some herbal infusions like fermented rooibos and fermented tulsi mimic this style.

Example: Rooibos (Aspalathus linearis)
Sun-dried and fermented, rooibos becomes enriched with aspalathin and nothofagin.

Table 1: Represents the Different Fermentation Level of Teas, its examles and there process.

Fermentation Level	Examples	Key Bioactives	Health Impact	Processing Method
Non-fermented	Peppermint, Chamomile, Ginger	Flavonoids, volatile oils	Antioxidant, digestive, calming	Steam/Oven dry immediately
Semi-fermented	Lemon Balm, Jasmine	GABA, theaflavins	Neuroprotective, mood enhancement	Partial oxidation
Fully fermented	Rooibos, Honeybush	Aspalathin, thearubigins	Cardioprotective, anti-inflammatory	Full oxidation

2.2: By Plant Parts Used

Table 2: Represents the Different Plant parts, its examles and there functions.

Plant Part	Examples	Primary Constituents	Functions
Leaves	Peppermint, Lemon Balm	Menthol, rosmarinic acid	Digestive, antispasmodic
Flowers	Chamomile, Hibiscus	Apigenin, anthocyanins	Sedative, antihypertensive
Roots	Ginger, Licorice	Gingerols, glycyrrhizin	Anti-nausea, anti-inflammatory
Seeds	Fennel, Fenugreek	Anethole, diosgenin	Lactogenic, blood sugar regulation

2.3 Based on Regional & Cultural Usage

2.3.1 India: India's Ayurveda-based herbal teas (kadhas) incorporate tulsi, turmeric, black pepper, ginger, and ashwagandha. These decoctions are tailored to dosha imbalances and seasonal diseases.

Examples

- **Tulsi-Ginger Tea**: Enhances respiratory and immune health.
- **Turmeric-Amla Brew**: Anti-inflammatory and detoxifying.

2.3.2 China: Chinese herbal teas (Liáng chá) date back to the Tang dynasty and are widely consumed for seasonal wellness. Ingredients like radix isatidis, dandelion, honeysuckle, and chrysanthemum are chosen for their ability to "clear heat," reduce toxins, and balance humors.

Examples

- **Jiegan Tea:** Combines radix isatidis with dandelion; used to combat wind-cold and mild fevers.
- **Summer Teas**: Chrysanthemum and honeysuckle tea for heat expulsion.

2.3.3 South Africa: South Africa is home to globally recognized tisanes such as:

Examples

- **Rooibos Tea**: Rich in dihydrochalcones like aspalathin and nothofagin. Traditionally used for allergies, eczema, and infantile colic.
- **Honeybush Tea:** Contains mangiferin and hesperidin. Offers estrogenic and antimicrobial activity.

2.3.4. Europe: Herbal teas in Europe emphasize aromatic plants for digestion and mental clarity.

Examples

- Chamomile Tea (Germany, UK): Used for sleep and gastrointestinal issues.
- Sage Tea (Italy, Greece): Recognized for antimicrobial and memory-enhancing properties.
- Linden Blossom and Raspberry Leaf (France, Scandinavia): Used for fever and pregnancy-related support.

2.4 Based on Therapeutic Function

Herbal teas are a rich source of pharmacologically active compounds including flavonoids, terpenoids, saponins, alkaloids, tannins, and phenolic acids. These compounds impart diverse health benefits by modulating oxidative stress, inflammation, immune responses, digestive activity, neural signaling, and metabolic parameters. The following section categorizes health benefits systemically and presents validated findings from clinical and experimental studies.

Table 3: Represents the Different herbal teas, its mechanism and there function.

Function	Herbal Teas	Mechanism
Digestive Aid	Peppermint, Ginger, Fennel	Relax GI tract, stimulate bile flow
Sedative	Chamomile, Lemon Balm, Valerian	GABA modulation, CNS calming
Cardiovascular	Hibiscus, Rooibos, Cinnamon	ACE inhibition, lipid-lowering
Immunomodulatory	Tulsi, Moringa, Echinacea	Cytokine modulation, antioxidant
Metabolic	Fenugreek, Turmeric, Moringa	Improve insulin sensitivity

3. Health Benefits of Herbal Teas

Herbal teas exert a wide array of therapeutic benefits, largely attributed to their bioactive constituents that interact with various physiological systems. This section explores their functional roles based on clinical, preclinical, and ethnobotanical evidence.

3.1 Gastrointestinal Health

Digestive wellness is one of the primary domains where herbal teas excel. Their spasmolytic, carminative, anti-inflammatory, and anti-microbial actions help relieve common gastrointestinal ailments such as bloating, indigestion, nausea, and irritable bowel syndrome (IBS).

Table 4: Represents the different herbs, its key components and there MOA.

Herb	Key Compounds	Mechanism of Action	Clinical Evidence
Peppermint	Menthol, Flavonoids	Smooth muscle relaxation, calcium channel blocker	40% symptom reduction in IBS trials[8]
Ginger	Gingerols, Shogaols	5-HT3 antagonist, antiemetic, motility enhancer	Significant anti-nausea effect in RCTs[9]
Fennel	Anethole	Carminative, antispasmodic	Reduced bloating and gas in clinical studies

These herbs are frequently used as stand-alone teas or in blends. For example, ginger and fennel combinations are effective post-prandial infusions.

3.2 Cardiovascular Health

Several herbal teas show promise in supporting cardiovascular function by modulating blood pressure, lipid profiles, and vascular inflammation.

Table 5: Represents the different herbs of teas, its compunds and there effects.

Herb	Compound	Effect	Study Outcome
Hibiscus	Delphinidin, cyanidin	ACE inhibition, vasodilation	↓ SBP by ~11.2 mmHg[10]
Rooibos	Aspalathin, nothofagin	LDL reduction, AMPK activation	Improved lipid profiles[11]
Cinnamon	Cinnamaldehyde	Insulin sensitization, lipid regulation	Modest drop in glucose and LDL levels

3.3 Neuroprotective and Cognitive Effects

Herbal teas have long been associated with relaxation, improved sleep, and enhanced cognitive performance due to their ability to influence neurotransmitters such as GABA, acetylcholine, and dopamine.

Table 6: Represents herbs of Teas, its bioactive agents and MOA.

Herb	Bioactive Agent	Mechanism	Clinical Findings
Chamomile	Apigenin	GABA receptor modulation	↓ anxiety, improved sleep[13]
Lemon Balm	Rosmarinic acid	Cholinesterase inhibition	↑ alertness, ↓ stress[12]
Sage	Thujone, Carnosol	Cognitive enhancement, memory support	Shown to improve recall in older adults

Chamomile and lemon balm are commonly consumed in the evening to induce calm and enhance sleep quality, with long-term benefits reported in generalized anxiety disorder and mild cognitive impairment.

3.4 Immune Support and Antimicrobial Activity

Herbal teas enhance immune defenses through antioxidant support and direct antimicrobial action.

Table 7: Represents different herbs of teas, its constituent and there effects.

Herb	Constituent	Effect
Tulsi	Eugenol, Ursolic acid	Immunomodulatory, antiviral
Echinacea	Cichoric acid	Enhances macrophage activity
Moringa	Quercetin, chlorophyll	Activates T-cells, supports detoxification

Echinacea tea is widely used during flu season to reduce the duration and severity of respiratory infections. Tulsi tea is traditionally used in Indian households for managing cough, asthma, and fever.

3.5 Endocrine and Metabolic Regulation

Herbal teas can influence glucose metabolism, insulin activity, and appetite regulation, making them valuable in managing metabolic syndrome and diabetes.

Table 7: Represents different herbs of teas, its bioactive agents and there effects.

Herb	Bioactive	Physiological Effect
Fenugreek	Diosgenin	Delays glucose absorption
Turmeric	Curcumin	Reduces insulin resistance
Moringa	Quercetin, iron	Enhances insulin secretion, treats anemia

Regular consumption of fenugreek or turmeric tea has been associated with modest improvements in HbA1c and fasting blood glucose levels in type 2 diabetic patients.

3.6 Antioxidant and Anti-inflammatory Actions

Most herbal teas contain high levels of polyphenols, which act as antioxidants. These compounds neutralize free radicals and reduce oxidative stress, a common denominator in aging and chronic illness.

Table 8: Represents different herbs of teas, its antioxidant compounds and there ORAC Score.

Herbal Tea	Antioxidant Compounds	ORAC Score (approx.)	Inferred Benefits
Green Tea	EGCG	1,253 µmol TE/100g	Anti-aging, anticancer
Hibiscus	Anthocyanins	1,897 µmol TE/100g	Antihypertensive, hepatoprotective
Rooibos	Aspalathin, quercetin	909 µmol TE/100g	Skin protection, cardiovascular

4. NUTRITIONAL AND PHYTOCHEMICAL COMPOSITION

The therapeutic properties of herbal teas are largely attributed to their rich profiles of bioactive compounds, essential nutrients, and functional metabolites. These constituents interact with biological systems to promote homeostasis, reduce oxidative damage, and modulate various physiological pathways. This section outlines the primary categories of phytochemicals and micronutrients found in common herbal teas, along with their biosynthetic origins, pharmacodynamics, and nutritional relevance.

4.1 Polyphenols

Polyphenols constitute a diverse group of secondary metabolites characterized by multiple phenol structures. They are primarily synthesized through the shikimate and phenylpropanoid pathways and serve as potent antioxidants, anti-inflammatory agents, and modulators of cellular signaling.

- **Flavonoids**: Apigenin, luteolin, quercetin, catechins
- **Phenolic acids**: Gallic, caffeic, chlorogenic acids
- **Anthocyanins**: Found in hibiscus, elderberry, rosehip

4.2 Terpenoids and Essential Oils

Terpenoids, another class of plant-derived bioactives, include monoterpenes, sesquiterpenes, and diterpenes. These are often responsible for the aroma, flavor, and some pharmacological effects of herbal teas.Present in peppermint (menthol), sage (thujone), and lemon balm (citral), these compounds exhibit antimicrobial, anti-inflammatory, and relaxing effects.

4.3 Alkaloids and Saponins

Though less abundant than polyphenols, alkaloids and saponins impart several health benefits, particularly in metabolic and immunomodulatory contexts.

- Licorice root contains glycyrrhizin (caution for hypertension)
- Moringa offers saponins that improve cholesterol metabolism

4.4 Micronutrients

Table 9: Represents different herbs of teas, its constituent.

Herb	Iron (mg/100g)	Vitamin C (mg/100g)	Zinc (mg/100g)
Moringa	140	51.7	2.6
Hibiscus	2.7	140.1	0.4
Nettle Leaf	32.2	50.0	3.1

4.5 Synergistic Combinations

- Curcumin + Piperine: Enhances absorption by 2,000%
- Chamomile + Lemon Balm: Dual GABAergic modulation
- Ginger + Cinnamon: Metabolic synergy in T2DM patients

Table 10: Nutritional Composition of Select Herbal Teas.

Tea Type	Major Nutrients/Bioactives	Health Impact
Chamomile	Apigenin, Quercetin	Anti-anxiety, Antispasmodic
Hibiscus	Anthocyanins, Vitamin C	Blood pressure control, Antioxidant
Moringa	Iron, Saponins, Polyphenols	Anti-anemia, Hypoglycemic
Peppermint	Menthol, Flavonoids	IBS relief, Antimicrobial
Rooibos	Aspalathin, Phenolic acids	Lipid-lowering, Antioxidant
Lemon Balm	Rosmarinic acid, Citral	Cognitive enhancement, Anti-stress
Turmeric	Curcumin, Saponins	Anti-inflammatory, Anticancer
Sage	Thujone, Ursolic acid, Rosmarinic acid	Memory enhancement, Cholesterol regulation

5. INNOVATIONS, FUTURE PERSPECTIVES, AND REGULATORY FRAMEWORKS

The herbal tea sector is rapidly evolving, integrating scientific innovation, consumer behavior trends, and global policy changes. This section explores key developments and challenges ahead.

5.1 Innovations in Herbal Tea Formulation

The fusion of traditional ethnomedicinal wisdom with cutting-edge food technology is giving rise to new herbal tea products that are functional, palatable, and therapeutically enhanced.

a. Multi-Ingredient Functional Blends

Modern formulations increasingly feature polyherbal blends combining adaptogens, nootropics, immunomodulators, and anti-inflammatories.

- Immunity: Tulsi + ginger + lemon peel
- Sleep: Chamomile + valerian + lemon balm
- Cognition: Sage + green tea + ashwagandha

These formulations combine synergistic phytochemicals to optimize bioefficacy.

b. Nanoencapsulation of Bioactives

Poor solubility and low oral bioavailability of compounds like curcumin and EGCG can be overcome via:

- Liposomes
- Solid lipid nanoparticles
- Nanoemulsion-based powders

These delivery systems are being developed to improve bioavailability and stability in commercial tea products.

c. Herbal Kombucha and Probiotic Infusions

Fermentation of herbal teas with kombucha cultures results in beverages enriched with:

- Probiotics (e.g., Lactobacillus spp.)
- Enhanced antioxidant and antimicrobial activities
- Reduced sugar content
- Lemon balm, hibiscus, tulsi, and nettle are increasingly used as bases for probiotic teas.

5.2 Sustainability and Ethical Sourcing

The sustainability of herbal tea production is now a critical concern. Increasing demand for specific herbs can lead to overharvesting and biodiversity loss.

- Organic and Agroecological Cultivation
- Crops such as moringa, peppermint, and rooibos are now cultivated using low-input organic methods. This minimizes:

1. Pesticide contamination
2. Soil degradation
3. Loss of native biodiversity
4. Blockchain and Fair-Trade Certification

- **Blockchain systems are being piloted for tea traceability. This ensures**

1. Transparency from farm to consumer
2. Prevention of adulteration
3. Support for fair-trade farmer cooperatives

Many cooperatives and farmer groups are pursuing fair-trade certifications to ensure equitable income and sustainable harvesting practices. Herbal teas from African, Southeast Asian, and Indian regions are especially prominent in this space.

a. Regional Regulatory Frameworks

Table-11: Various Regulatory Bodies and there regions.

Region	Regulatory Body	Classification
USA	FDA (under DSHEA)	Dietary supplement or food
EU	EFSA, EMA	Traditional herbal medicine or food
India	FSSAI, Ministry of AYUSH	Nutraceutical / Ayurvedic product

b. Analytical Techniques for Quality Assurance

- HPLC: Polyphenol quantification
- GC-MS: Volatile oil profiling
- NMR: Structural elucidation
- ICP-MS: Heavy metal screening

These tools are essential to meet pharmacopoeial and food-grade standards.

c. Labeling and Health Claims

- Legal frameworks require:
- Disclosure of exact botanical source
- Dosage and preparation instructions
- Warnings for pregnant or lactating women
- Evidence-backed health claims

5.4 Challenges Ahead

- **Standardization**: Variability in polyphenol content due to environmental factors
- **Adulteration**: Use of fillers or contamination with pesticides
- **Consumer Misuse**: Misconceptions of "natural" equating to "safe" in unlimited doses

5.5 Future Research and Market Trends

- Omics-based studies: Transcriptomics and metabolomics to identify novel phytochemical pathways
- AI in formulation: Machine learning models to predict synergistic herb combinations
- Globalization of regional teas: Promotion of lesser-known herbs like sutherlandia, pandan, and blue pea flower
- Regulatory convergence: International harmonization of herbal tea safety and quality standards

6. CONCLUSION

Herbal teas are no longer confined to cultural rituals or folk medicine. Their therapeutic properties, supported by growing pharmacological evidence, establish them as vital components of preventive and functional nutrition. This comprehensive review has highlighted their antioxidant, anti-inflammatory, antimicrobial, immunomodulatory, neuroprotective, and metabolic benefits, largely attributable to a wide range of bioactive phytochemicals.

5.3 Regulatory Standards and Quality Control

A major concern in the global herbal tea market is the inconsistency in phytochemical concentrations, potential adulteration, and lack of pharmacopoeial standards.

Beyond their health effects, herbal teas have seamlessly adapted to modern consumer needs through innovative formulations, diverse delivery formats, and enhanced safety profiles. Their incorporation into everyday wellness practices—whether in hot beverages, cold infusions, or functional blends—reflects a larger shift toward holistic, plant-centered living.

However, to fully harness their potential, concerted efforts are required in standardization, clinical validation, and education. Multidisciplinary collaborations involving pharmacognosy, nutrition, food technology, regulatory science, and ethnopharmacology can bridge the gap between tradition and science.

Herbal teas represent more than wellness beverages—they embody a global convergence of health, heritage, and sustainability. Their future in therapeutic nutrition is both promising and essential in addressing 21st-century health challenges.

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