

Development of Herbal Lime Tea Based on Lemongrass, Ginger, and Peppermint: Formulation and Analysis

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Abstract

Herbal teas have gained significant attention as functional beverages combining sensory appeal with medicinal benefits. This study focuses on the development of a herbal lime tea formulated using three key botanicals: lemongrass (*Cymbopogon citratus*), ginger (*Zingiber officinale*), and peppermint (*Mentha piperita*). The primary objectives were to develop an organoleptically acceptable herbal tea blend and to evaluate its sensory, physicochemical, antimicrobial, and antioxidant properties. Sensory evaluation was conducted using a nine-point hedonic scale with a panel of five trained evaluators, assessing colour, aroma, flavour, and overall acceptability. Proximate analysis included determination of moisture content (7–10%), total ash (5%), water-soluble ash (50%), and alkalinity of water-soluble ash (0.5%). Antioxidant activity was assessed via the Folin-Ciocalteu colorimetric method, confirming the presence of polyphenolic compounds. Antimicrobial activity against *Staphylococcus aureus* was assessed using the disc diffusion method, yielding a negative result, potentially attributable to degradation of active compounds during preparation. The formulated herbal tea demonstrated acceptable sensory scores, confirmed polyphenol content, and offers a promising basis for further optimization as a functional health beverage.

Key words: Herbal tea, Lemongrass, Ginger, Peppermint, Antioxidant, Antimicrobial, Sensory evaluation, Polyphenols, Functional beverage

Herbal teas, commonly referred to as tisanes, are non-caffeinated beverages prepared from different plant parts such as leaves, flowers, roots, bark, seeds, fruits, and stems. These infusions have been consumed for centuries in traditional systems of medicine and as refreshing beverages due to their pleasant sensory attributes and therapeutic properties. In recent years, increasing consumer awareness regarding the adverse effects associated with synthetic additives, artificial flavouring agents, and chemically processed beverages has significantly accelerated the demand for natural, plant-based functional drinks. Functional beverages enriched with medicinal herbs are now recognized not only for their nutritional value but also for their role in promoting health and preventing chronic diseases through bioactive phytochemicals possessing antioxidant, antimicrobial, anti-inflammatory, and immunomodulatory activities [1-2]. In India, tea consumption forms an integral part of daily dietary habits, with a substantial proportion of households consuming tea regularly. This cultural acceptance provides an excellent platform for the development and commercialization of herbal tea formulations possessing enhanced nutraceutical value.

Among medicinal herbs, lemongrass (*Cymbopogon citratus* Stapf) has gained considerable scientific and commercial importance due to its distinctive lemon-like aroma and broad spectrum of pharmacological activities. Belonging to the family Poaceae, lemongrass is widely distributed in tropical

and subtropical regions including Southeast Asia, Africa, Australia, and India. The characteristic aroma of lemongrass is primarily attributed to essential oil constituents such as citral, geraniol, citronellal, limonene, and geranyl acetate. Numerous studies have demonstrated that lemongrass exhibits potent antioxidant, antimicrobial, antifungal, anti-inflammatory, anticancer, hepatoprotective, and antiviral activities owing to its rich phytochemical composition [3-4]. Lemongrass extracts and essential oils have also been reported to inhibit the growth of several food-borne pathogenic microorganisms, making them promising ingredients in functional food formulations and natural preservation systems.

Ginger (*Zingiber officinale* Roscoe), belonging to the family Zingiberaceae, is one of the oldest and most extensively used medicinal spices worldwide. Ginger rhizomes are rich in biologically active compounds including gingerols, shogaols, paradols, and zingerone, which are responsible for its characteristic pungency and medicinal properties. Traditionally, ginger has been utilized in Ayurvedic, Chinese, and Unani systems of medicine for the treatment of nausea, indigestion, arthritis, hypertension, colds, migraines, and inflammatory disorders. Modern pharmacological studies have validated its antioxidant, anti-inflammatory, antimicrobial, antidiabetic, cardioprotective, and gastroprotective activities [5-6]. The strong radical scavenging activity of ginger is associated with its ability to neutralize reactive oxygen species

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and reduce oxidative stress, thereby contributing to the prevention of chronic degenerative diseases.

Peppermint (*Mentha piperita* L.), a hybrid of *Mentha aquatica* and *Mentha spicata* belonging to the family Lamiaceae, is another medicinal herb widely valued for its aromatic and therapeutic properties. Peppermint contains high concentrations of menthol, menthone, pulegone, carvone, rosmarinic acid, and various flavonoids that contribute to its cooling sensation and medicinal efficacy. Scientific investigations have reported that peppermint possesses antioxidant, antimicrobial, antiviral, antiallergenic, antispasmodic, analgesic, and immunomodulatory activities [7-8]. Peppermint essential oil and extracts are extensively used in food products, pharmaceuticals, oral hygiene formulations, cosmetics, and herbal beverages because of their refreshing flavour and health-promoting properties.

The incorporation of medicinal herbs into functional beverages has emerged as an important area of research in food science and nutraceutical development. Herbal tea formulations combining multiple botanicals may produce synergistic effects resulting in enhanced therapeutic potential and improved sensory acceptability. The combination of lemongrass, ginger, and peppermint is particularly promising because these herbs collectively contribute desirable aroma, flavour, antioxidant capacity, and antimicrobial activity while also providing digestive and immunomodulatory benefits. Furthermore, the addition of lime can improve flavour complexity and increase vitamin C content, thereby enhancing the overall nutritional and sensory quality of the beverage.

Despite the increasing popularity of herbal teas, there remains limited scientific information regarding the combined formulation and comprehensive evaluation of lemongrass–ginger–peppermint herbal lime tea with respect to sensory quality, physicochemical characteristics, antimicrobial efficacy, and antioxidant potential. Therefore, the present investigation was undertaken to develop a functional herbal tea formulation using *Cymbopogon citratus*, *Zingiber officinale*, and *Mentha piperita* and to evaluate its quality attributes through sensory, proximate, antimicrobial, and antioxidant analyses. The study aimed to explore the potential of these medicinal herbs as functional ingredients in the preparation of a health-promoting herbal beverage with desirable consumer acceptability and therapeutic benefits. The specific objectives of the study were:

- To formulate an herbal lime tea using lemongrass, ginger, and peppermint in suitable proportions for optimum sensory and functional quality.
- To conduct sensory evaluation of the formulated herbal tea using a nine-point hedonic scale for assessing colour, aroma, taste, flavour, and overall acceptability.
- To evaluate the antimicrobial activity of the formulated herbal tea against *Staphylococcus aureus* using the disc diffusion method.
- To determine the antioxidant potential of the herbal tea through estimation of total polyphenol content using the Folin–Ciocalteu method.
- To perform proximate analysis of the formulated herbal tea, including moisture content, total ash, water-soluble ash, and alkalinity of water-soluble ash, in order to assess its physicochemical quality characteristics.

Herbal teas as functional beverages

Herbal tea has gained considerable attention worldwide due to their nutritional, medicinal, and therapeutic properties. Traditionally, herbal teas have been used not only as refreshing beverages but also as natural remedies for the prevention and

management of various health disorders. Unlike conventional tea derived from *Camellia sinensis*, most herbal teas are naturally caffeine-free, making them suitable for individuals of all age groups and for consumers seeking healthier beverage alternatives. The increasing preference for plant-based functional foods and beverages has further enhanced the popularity of herbal teas in both traditional and modern healthcare systems.

Ravikumar [9] comprehensively reviewed the composition and health-promoting benefits of various herbal teas and reported that these beverages are generally prepared either from a single medicinal herb or from carefully formulated proprietary blends. According to the author, the selection of herbs is primarily based on their intended physiological and therapeutic effects, including relaxation, detoxification, digestive support, immune enhancement, and stress reduction. The study further highlighted that herbal teas are rich sources of bioactive phytochemicals such as polyphenols, flavonoids, tannins, alkaloids, and essential oils, which contribute significantly to their antioxidant, antimicrobial, anti-inflammatory, and adaptogenic activities.

The therapeutic effectiveness of herbal teas has been associated with their ability to provide natural bioactive compounds in a readily consumable form. Regular consumption of herbal infusions has been linked with improved metabolic functions, enhanced immunity, and reduced oxidative stress. Furthermore, the incorporation of medicinal herbs such as lemongrass, peppermint, ginger, chamomile, and Tulsi into tea formulations has broadened the functional beverage market by offering products with both sensory appeal and health benefits. The growing scientific validation of herbal teas supports their potential application as nutraceutical beverages and natural alternatives to synthetic health supplements.

Lemongrass (Cymbopogon citratus)

Cymbopogon citratus has attracted considerable scientific attention due to its wide spectrum of pharmacological and antimicrobial properties. Several studies have demonstrated its traditional and therapeutic significance in the management of various ailments. Manvitha and Bidya [10] conducted a comprehensive review on the pharmacological activities of *C. citratus* and reported its traditional use in the treatment of diarrhea, fever, inflammation, and microbial infections. The authors emphasized that the medicinal efficacy of lemongrass is mainly associated with the presence of bioactive constituents such as citral, flavonoids, and phenolic compounds. In traditional medicine systems, decoctions prepared from the stalks and leaves of lemongrass have long been utilized as effective remedies against gastrointestinal disorders and infectious diseases.

Further investigations into the phytochemical composition of *C. citratus* have revealed the presence of several antioxidant compounds. Figueirinha *et al.* [11], as cited by Sousa *et al.* [12], identified tannins, phenolic acids, and flavone glycosides, particularly derivatives of apigenin and luteolin, in lemongrass leaves. These compounds exhibited significant antioxidant activity against the DPPH free radical, indicating the plant's potential role in reducing oxidative stress and preventing cellular damage. The antioxidant capacity of lemongrass has been associated with its therapeutic applications in health promotion and disease prevention.

The antimicrobial activity of lemongrass essential oil has also been extensively documented. Naik *et al.* [13] evaluated the antibacterial efficacy of lemongrass oil against six pathogenic bacterial species using agar diffusion and broth

dilution techniques. The study demonstrated inhibitory effects against all tested bacteria except *Pseudomonas aeruginosa*. Gram-positive bacteria were found to be more susceptible than gram-negative bacteria, suggesting that the structural composition of bacterial cell walls may influence sensitivity to lemongrass oil. The findings further support the potential application of lemongrass essential oil as a natural antimicrobial agent in pharmaceutical and food preservation industries.

Ginger (Zingiber officinale)

Zingiber officinale is one of the most extensively studied medicinal plants due to its diverse pharmacological activities, including antimicrobial, anti-inflammatory, antiviral, and anticancer properties. The therapeutic potential of ginger is primarily attributed to its rich composition of bioactive compounds such as gingerols, shogaols, and sesquiterpenes. Numerous investigations have confirmed the significant medicinal value of ginger extracts and essential oils in traditional as well as modern healthcare systems.

Malu *et al.* [14] evaluated the antibacterial activity of different ginger extracts and reported that all extracts except aqueous preparations exhibited considerable dose-dependent antibacterial effects. Among the extraction methods employed, Soxhlet-prepared extracts demonstrated the highest antimicrobial potency against tested bacterial pathogens. The study suggested that organic solvents enhance the extraction of active phytochemicals responsible for the antimicrobial efficacy of ginger.

The anti-inflammatory properties of ginger have also been widely documented. Kumar *et al.* [15] identified 6-gingerol as one of the principal bioactive constituents responsible for the anti-inflammatory activity of ginger. The authors demonstrated that 6-gingerol inhibits the activation of nuclear factor-kappa B (NF- κ B), which subsequently downregulates the expression of inflammatory mediators such as cyclooxygenase-2 (COX-2), 5-lipoxygenase (5-LOX), and inducible nitric oxide synthase (iNOS). This mechanism highlights the therapeutic potential of ginger in the management of inflammatory disorders.

In addition to its antibacterial and anti-inflammatory effects, ginger possesses notable antiviral properties. Malhotra and Singh [16] reviewed the sesquiterpene constituents of ginger and identified β -sesquiphellandrene as one of the most potent anti-rhinoviral compounds through bioassay-guided fractionation techniques. The study emphasized the role of ginger-derived sesquiterpenes in inhibiting viral replication and supporting respiratory health.

Furthermore, Shukla and Singh [17] summarized the cancer-preventive potential of ginger and reported that its bioactive compounds exhibit antioxidant, anti-inflammatory, anti-proliferative, and apoptosis-inducing activities. The review highlighted the ability of ginger constituents to suppress tumour initiation, promotion, and progression through modulation of multiple cellular signalling pathways. These findings collectively demonstrate the immense pharmaceutical and therapeutic potential of ginger as a natural source of antimicrobial and health-promoting agents.

Peppermint (Mentha piperita)

Mentha piperita is widely recognized for its medicinal, antimicrobial, and antioxidant properties, owing to the presence of bioactive compounds such as menthol, menthone, and various phenolic constituents. Numerous studies have highlighted its therapeutic significance in traditional and modern medicine. Balakrishnan [18] reviewed the medicinal applications of peppermint and reported its extensive use as a

spasmolytic, antispasmodic, analgesic, and diaphoretic agent. The study emphasized that peppermint has traditionally been employed in the treatment of digestive disorders, respiratory ailments, and musculoskeletal conditions due to its soothing and anti-inflammatory effects.

The antimicrobial potential of peppermint essential oil has also been extensively investigated. Kang *et al.* [19] demonstrated that peppermint essential oil (PEO) effectively disrupted biofilms of *Staphylococcus aureus* by causing irreversible damage to the bacterial cell membrane. The study reported increased membrane permeability accompanied by leakage of nucleic acids and proteins, indicating strong bactericidal activity of peppermint oil. These findings suggest the possible application of peppermint essential oil as a natural antimicrobial agent against biofilm-forming pathogenic bacteria.

In addition to its antibacterial properties, peppermint has shown remarkable antioxidant activity. Pramila *et al.* [20] evaluated the methanolic extract of peppermint and observed significant dose-dependent free radical scavenging activity. The authors further reported inhibitory effects against several bacterial and fungal pathogens based on zone-of-inhibition assays. Among the tested organisms, *Escherichia coli* exhibited greater susceptibility to peppermint extract compared to *Staphylococcus* species, indicating variable sensitivity among microbial groups.

Supporting these observations, Wu *et al.* [21] assessed the antioxidant potential of different mint essential oils and reported that peppermint essential oil exhibited the lowest EC50 value for DPPH radical scavenging activity. This finding confirmed the superior antioxidant efficacy of peppermint compared to other mint species. The strong antioxidant and antimicrobial properties of peppermint indicate its promising potential for pharmaceutical, nutraceutical, and food preservation applications.

MATERIALS AND METHODS

Sample collection and preparation

Fresh and dried samples of lemongrass, ginger, and peppermint were procured from the fields and stores of the Aromatic and Medicinal Plants Research Station (AMPRS), Odakkali, Ernakulam, Kerala. Both fresh and dried forms were weighed and prepared for analysis. The herbal tea blend was formulated by combining measured proportions of dried lemongrass, dried ginger, and dried peppermint, and infused in hot water to produce the test beverage.

Sensory evaluation

Sensory evaluation was conducted at AMPRS, Odakkali, using a panel of five trained staff members aged between 21 and 50 years. A nine-point hedonic scale was employed to assess four sensory attributes: colour, aroma, flavour, and overall acceptability. Hedonic rating test forms were distributed, and individual scores were tabulated and represented graphically using a radar/spider chart.

Proximate analysis

Moisture determination

Approximately 5 g of the sample was accurately weighed into a tared aluminium dish and dried in an air oven at $100 \pm 2^\circ\text{C}$ for 5–6 hours. The dish was cooled in a desiccator and reweighed at 30-minute intervals until the difference between successive weighings was less than 1 mg. Moisture content was calculated on a dry weight basis.

$$\text{Moisture (\%)} = [(W_1 - W_2) \times 100] / (W_1 - W)$$

Total ash determination

Approximately 5 g of the sample was charred in a silica dish using a Bunsen burner, then transferred to a muffle furnace and ashed at $550 \pm 10^\circ\text{C}$ until carbon-free. The dish was cooled in a desiccator and weighed repeatedly until a stable mass was achieved. Total ash was calculated on a dry weight basis. Water-soluble ash and alkalinity

The total ash was transferred with approximately 25 mL of distilled water into a beaker and boiled for 5 minutes. The solution was filtered through an ashless filter paper (Whatman No. 42). The water-insoluble residue was re-ashed at 550°C and weighed. Water-soluble ash was calculated as the difference between total ash and water-insoluble ash. Alkalinity of the soluble ash was determined by titrating the filtrate against 0.1 N hydrochloric acid using methyl orange indicator, noting the volume at the orange endpoint.



Fig 1 Weighed sample containing lemongrass, ginger and peppermint (dried)



Fig 2 Weighed sample (fresh)



Fig 3 Lemongrass, ginger and peppermint based herbal tea

Total phenolic content (Folin–Ciocalteu method)

Total phenolic content was determined spectrophotometrically using a modified Folin–Ciocalteu colorimetric method. Extracts at a dilution of 1:10 g/mL were prepared in test tubes. Folin–Ciocalteu reagent was added and the mixture was allowed to react for 6 minutes, followed by addition of 1.25 mL of 7.5% sodium carbonate solution and 3 mL of water. The mixture was heated to boiling. After colour development, absorbance was measured at 625 nm using a UV-Visible spectrophotometer (Shimadzu UV-1900i). A standard curve was prepared using gallic acid (GA) through serial dilution, and phenolic content was expressed as gallic acid equivalents.

Antimicrobial analysis — Disc diffusion method

Antimicrobial activity against *Staphylococcus aureus* was evaluated using the disc diffusion method on Mueller–Hinton Agar (MHA). The herbal extract was concentrated using a rotary evaporator. MHA plates were inoculated with a

standardized bacterial suspension inside a Laminar Air Flow (LAF) cabinet. Sterile paper discs impregnated with the test extract were placed on the inoculated plates. Plates were incubated at 37°C for 24 hours, after which zones of inhibition (if any) were measured.

RESULTS AND DISCUSSION

Sensory evaluation

The herbal lime tea was found to be organoleptically acceptable by the panel of five evaluators. Scores across aroma, colour, flavour, and overall acceptability were above average on the nine-point hedonic scale. The lemongrass contributed a fresh, citrus-like aroma; ginger imparted a characteristic warm pungency; and peppermint provided a cooling finish, resulting in a complex, well-rounded flavour profile. Results are summarized in (Table 1) and graphically depicted in (Fig 4) as a radar chart.

Table 1 Sensory evaluation results (Nine-point hedonic scale)

Panelist	Aroma	Colour	Flavour	Overall acceptability
Panelist 1	8	8	7	8
Panelist 2	7	8	8	8
Panelist 3	6	5	6	6
Panelist 4	4	3	4	4
Panelist 5	7	6	6	7
Mean \pm SD	6.4 ± 1.5	6.0 ± 2.0	6.2 ± 1.5	6.6 ± 1.5

Proximate analysis

The proximate analysis results for the formulated herbal tea blend are summarized in (Table 2). The moisture content of 7–10% is within the acceptable range for dried herbal products, indicating adequate drying and good storage potential. A moisture content below 12% is generally considered safe for

preventing microbial spoilage in dried botanicals. The total ash content of 5% reflects the inorganic mineral residue of the blend, within accepted limits for herbal preparations. Water-soluble ash constituting 50% of total ash indicates a moderate mineral content in soluble form. The alkalinity of water-soluble ash (0.5%) is an indicator of the carbonate content, within safe limits.

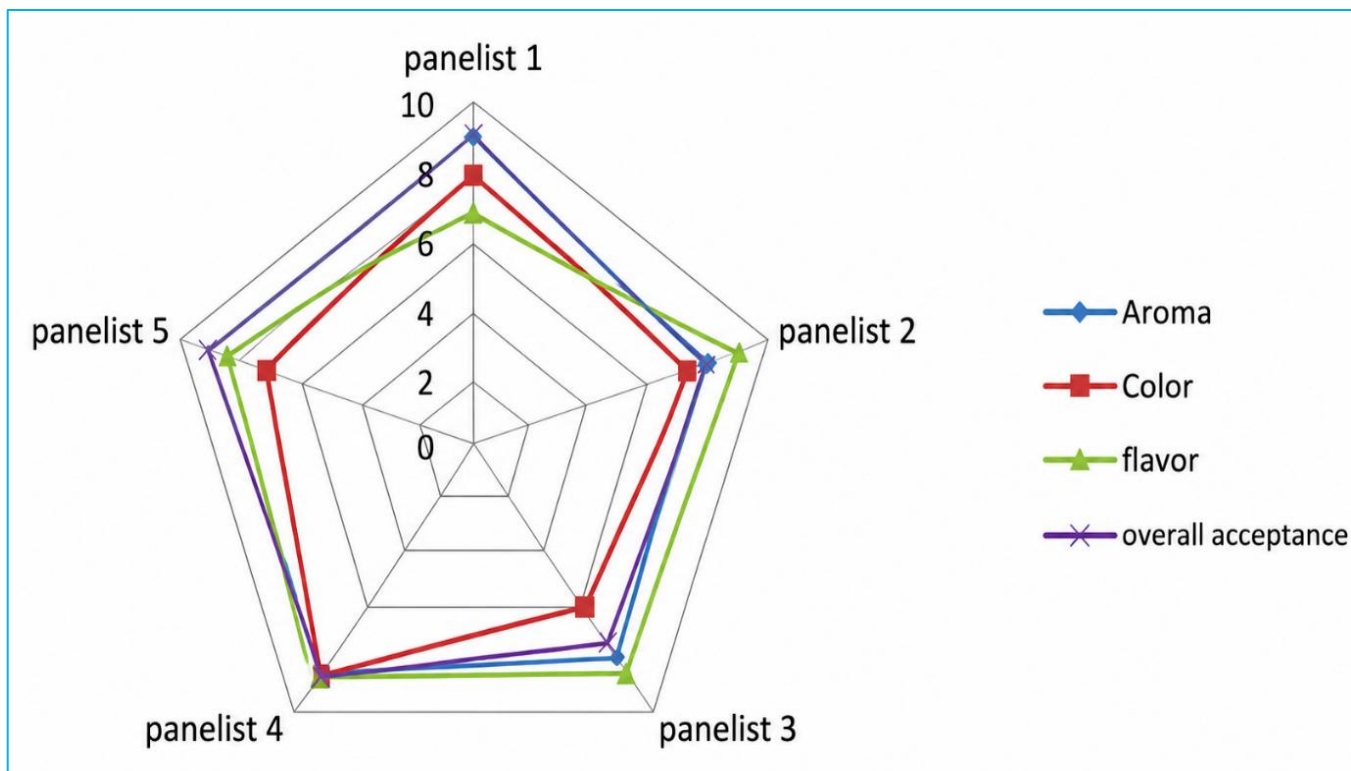


Fig 4 Sensory evaluation result graph

Table 2 Proximate analysis results

Parameter	Result / Value
Moisture content (Dry basis)	7–10%
Total ash	5%
Water-soluble ash	50% of total ash
Alkalinity of water-soluble ash	0.5%
Polyphenol test (Folin–Ciocalteu)	Positive
Antimicrobial test (Disc Diffusion, <i>S. aureus</i>)	Negative

Antioxidant analysis — Total phenolic content

The Folin–Ciocalteu colorimetric assay confirmed the presence of polyphenolic compounds in the herbal tea extract (Table 2). Serial dilutions of gallic acid were used to construct a calibration curve, and sample absorbance was measured at 625 nm on a Shimadzu UV-1900i spectrophotometer. Lemon grass extract showed an absorbance of 0.001 ($K \times \text{Abs} = 0.0014$), whereas other reference standards (STD11–STD14) ranged from 0.153 to 0.405, confirming baseline polyphenol content.

The presence of phenolic compounds — including flavonoids, tannins, and phenolic acids — in these three botanicals is well established in the literature, and their antioxidant activity is attributed primarily to hydrogen-donating capacity and free radical scavenging.

Compounds such as citral and luteolin derivatives in lemongrass, gingerols and shogaols in ginger, and menthol and rosmarinic acid in peppermint all contribute to the overall antioxidant profile. The positive result confirms the functional beverage potential of this formulation.

Polyphenol content by spectrophotometer



Fig 5 Serial dilution using GA for obtaining standard curve



Fig 6 UV visible spectrophotometer



Fig 7 Results of spectrophotometry for variable samples



Fig 8 Weighed MHA agar

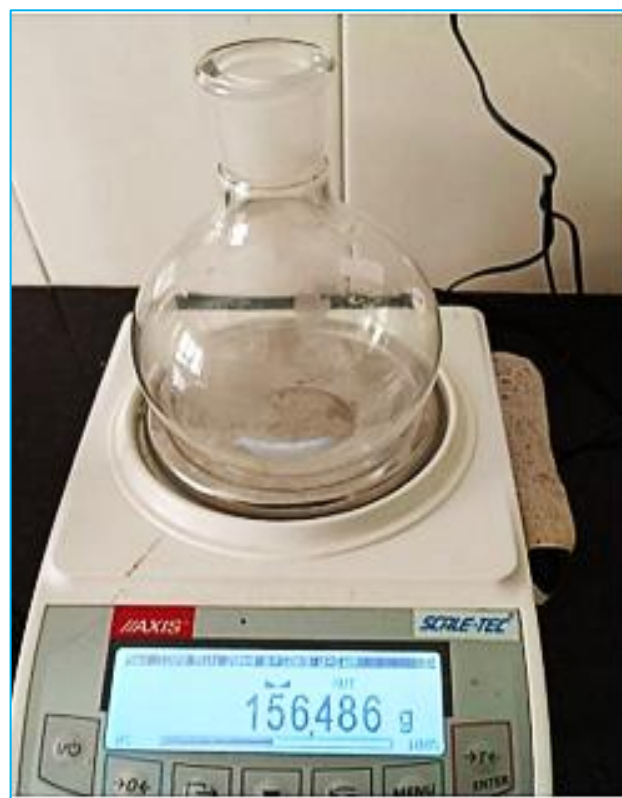


Fig 9 Round bottom flask containing sample prepared using rotary evaporator



Fig 10 Plates prepared inside LAF for disc diffusion method



Fig 11 Resultant plate obtained after incubation

Antimicrobial analysis

The disc diffusion method against *Staphylococcus aureus* yielded a negative result, with no observable zone of inhibition around the test discs. This outcome diverges from previously reported antibacterial activity of lemongrass oil and peppermint essential oil against *S. aureus* in the literature. Several explanations are plausible:

- Degradation of thermolabile antimicrobial compounds (e.g., citral, menthol, and gingerols) during hot water infusion and rotary evaporation.
- The extract concentration achieved may have been below the Minimum Inhibitory Concentration (MIC) required for observable inhibition in the disc diffusion system.
- The aqueous extraction method employed may not have been optimal for capturing lipophilic antimicrobial constituents that partition poorly in water.

Further studies using organic solvent extractions (e.g., ethanol, methanol) and optimized concentration protocols may yield positive antimicrobial results consistent with literature precedent.

CONCLUSION

This study successfully developed a herbal lime tea formulated from lemongrass, ginger, and peppermint with satisfactory sensory attributes. Sensory evaluation confirmed above-average acceptability across aroma, colour, flavour, and overall acceptance parameters on a nine-point hedonic scale. Proximate analysis demonstrated a moisture content of 7–10%, total ash of 5%, and water-soluble ash of 50%, all within acceptable limits for dried herbal preparations. Antioxidant analysis via the Folin–Ciocalteu method confirmed the presence of phenolic compounds, validating the antioxidant

potential of the blend. Although the disc diffusion test against *Staphylococcus aureus* yielded a negative result in this study, this is likely attributable to inadequate extract concentration or degradation of antimicrobial constituents during processing, rather than a true absence of antimicrobial activity a conclusion supported by extensive prior literature on the component herbs. Future research should explore: (1) optimized solvent extraction protocols; (2) MIC determination using broth

microdilution; (3) advanced antioxidant assays such as DPPH, FRAP, and ABTS; (4) accelerated shelf-life and stability testing; and (5) scale-up formulation studies for commercial viability. Overall, the formulated herbal lime tea presents a promising functional beverage candidate with confirmed polyphenol content and good organoleptic acceptability, warranting further investigation into its full therapeutic and commercial potential.

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