Development and Evaluation of a Spice-Based Functional Herbal Beverage Using Ginger (*Zingiber officinale*), Turmeric (*Curcuma longa*), and Tulsi (*Ocimum sanctum*)

Sejal Jadhav[1], Gurunath Mote[2], Kumar Chakre[3], Vikramsing Ingale[4]

Department of Food Technology, School of Engineering and Technology, D. Y. Patil Agriculture and Technical University, Talsande, Kolhapur, Maharashtra, India

Abstract

The present study aimed to develop and evaluate a spice-based functional herbal beverage using extracts of ginger (*Zingiber officinale*), turmeric (*Curcuma longa*), and tulsi (*Ocimum sanctum*). Different formulations were prepared by varying the proportions of herbal extracts and evaluated for their physicochemical, nutritional, antioxidant, sensory, microbiological, and storage characteristics. Proximate analysis of the raw materials revealed appreciable levels of nutrients and bioactive compounds. The developed beverages exhibited acceptable pH, total soluble solids (TSS), viscosity, vitamin C content, and antioxidant activity. Sensory evaluation using a nine-point hedonic scale indicated significant differences among treatments, with formulation **T_5** receiving the highest overall acceptability score. High-Performance Liquid Chromatography (HPLC) analysis of the optimized formulation confirmed the presence of curcumin, gingerol, rosmarinic acid, and eugenol, indicating a rich profile of health-promoting phytochemicals. Storage studies conducted under refrigerated conditions (4 ± 1°C) for 30 days demonstrated good physicochemical stability, microbiological safety, and sensory acceptability throughout the storage period. The findings suggest that the developed herbal beverage possesses considerable potential as a functional drink with enhanced nutritional value, antioxidant capacity, and health-promoting properties, making it suitable for commercial production and consumer acceptance.

Keywords: Functional beverage, Ginger, Turmeric, Tulsi, Antioxidant activity, HPLC, Curcumin, Gingerol, Rosmarinic acid, Eugenol, Storage stability, Sensory evaluation.

1. Introduction

Consumer interest in functional foods and beverages has increased substantially due to growing awareness of the relationship between diet and health. Functional beverages containing natural bioactive compounds have gained considerable attention because of their potential role in promoting health and preventing chronic diseases. Medicinal herbs and spices such as ginger, turmeric, and tulsi have been traditionally used in various systems of medicine owing to their therapeutic properties.

Ginger is recognized for its antioxidant, anti-inflammatory, antimicrobial, and digestive benefits, primarily attributed to compounds such as gingerol and shogaol. Turmeric contains curcumin, a polyphenolic compound known for its strong antioxidant and anti-inflammatory activities. Tulsi is rich in phenolic compounds, flavonoids, and essential oils, which contribute to its antimicrobial and adaptogenic properties.

Combining these herbal ingredients in a beverage system may provide synergistic health benefits while improving consumer acceptability. Therefore, the present study was undertaken to develop a spice-based functional herbal beverage and evaluate its nutritional, physicochemical, sensory, antioxidant, microbiological, and storage characteristics.

2. Materials and Methods

2.1 Raw Materials

Fresh ginger rhizomes, turmeric rhizomes, and tulsi leaves were procured from the local market. Sugar, citric acid, and other ingredients used in beverage preparation were of food-grade quality.

2.2 Preparation of Herbal Extracts

Ginger and turmeric rhizomes were washed, peeled, cut into pieces, blended with distilled water, and filtered through muslin cloth. Fresh tulsi leaves were washed, blended with water, and filtered to obtain tulsi extract.

2.3 Beverage Formulation

Various formulations were prepared by blending ginger, turmeric, and tulsi extracts in different proportions. Sugar syrup and citric acid were added to achieve desirable sweetness and acidity. The beverages were pasteurized, bottled, and stored under refrigerated conditions.

2.4 Physicochemical Analysis

The beverages were analyzed for pH, total soluble solids (°Brix), viscosity, vitamin C content, and antioxidant activity using standard analytical procedures.

2.5 Sensory Evaluation

Sensory evaluation was conducted by a semi-trained panel using a nine-point hedonic scale to assess color, aroma, taste, mouthfeel, and overall acceptability.

2.6 HPLC Analysis

The optimized formulation was subjected to High-Performance Liquid Chromatography (HPLC) analysis for identification and quantification of major bioactive compounds.

2.7 Storage Study

The optimized beverage was stored under refrigerated conditions and analyzed periodically for physicochemical, microbiological, antioxidant, and sensory characteristics over 30 days.

2.8 Statistical Analysis

Experimental data were analyzed using appropriate statistical methods, and results were expressed as mean ± standard deviation.

3. Flow Chart-4 Development of Spice-Based Functional Herbal Beverage

Ginger Extract + Turmeric Extract + Tulsi Extract

↓

Addition of Honey

↓

Mixing

↓

Heating (80°C, 5 min)

↓

Addition of Lemon Juice

↓

Filtration

↓

Bottling

↓

Refrigerated Storage (4 ± 1°C)

4. Results and Discussion

4.1 Proximate analysis of Ginger Powder, Turmeric Powder and Tulsi Leaf Powder

Table 4.1 presents the proximate composition of ginger, turmeric, and tulsi powders used in the formulation of the spice-based immunity-boosting Functional Harbal Beverage. The results indicate noticeable differences in the nutritional composition of the three ingredients.

Table 4.1 Proximate analysis of Ginger Powder, Turmeric Powder and Tulsi Leaf Powder

Parameter (%)	Ginger Powder	Turmeric Powder	Tulsi Leaf Powder
Moisture	8.5 ± 0.2	7.8 ± 0.3	6.5 ± 0.2
Ash	5.2 ± 0.1	6.8 ± 0.2	10.5 ± 0.3
Crude Protein	9.1 ± 0.3	8.4 ± 0.2	14.7 ± 0.4
Crude Fat	4.8 ± 0.2	6.2 ± 0.2	3.5 ± 0.1
Crude Fiber	8.6 ± 0.3	7.4 ± 0.2	12.8 ± 0.4
Carbohydrates*	63.8 ± 0.5	63.4 ± 0.6	52.0 ± 0.7
Energy (kcal/100 g)	335.6 ± 2.4	342.2 ± 2.8	302.3 ± 2.1

Among the samples, ginger powder contained the highest moisture content (8.5%), followed by turmeric (7.8%) and tulsi (6.5%). Lower moisture content in tulsi powder may contribute to better storage stability and reduced microbial growth. The ash content, which represents the total mineral content, was highest in tulsi powder

Ijfans International Journal of Food and Nutritional Sciences
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper , Journal UGC CARE Listed (Group-I) Volume 15, Issue 03, 2026

(10.5%), indicating that tulsi is a rich source of minerals compared to ginger and turmeric.

The protein content was also highest in tulsi powder (14.7%), followed by ginger (9.1%) and turmeric (8.4%). This suggests that tulsi contributes significantly to the nutritional quality of the beverage. Similarly, tulsi exhibited the highest crude fiber content (12.8%), which may provide digestive health benefits and improve the functional value of the product.

Turmeric powder showed the highest crude fat content (6.2%), which may be associated with the presence of essential oils and curcuminoids. Ginger contained moderate levels of fat (4.8%), while tulsi had the lowest fat content (3.5%). Carbohydrates constituted the major component in all three ingredients, with ginger (63.8%) and turmeric (63.4%) having comparable values, whereas tulsi contained a relatively lower carbohydrate content (52.0%).

The calculated energy values ranged from 302.3 to 342.2 kcal/100 g, with turmeric providing the highest energy value due to its higher fat and carbohydrate content. Overall, the results demonstrate that ginger, turmeric, and tulsi are valuable sources of nutrients and bioactive compounds, making them suitable ingredients for the development of functional Functional Harbal Beverages with enhanced nutritional and health-promoting properties.

4.2 Physicochemical and antioxidant properties of the developed spice-based Functional Herbal Beverages

The physicochemical and antioxidant properties of the developed spice-based Functional Herbal Beverages were significantly influenced by the varying concentrations of ginger, turmeric, and tulsi extracts. The pH of the beverages ranged from 3.95 to 4.20, with the control sample (T_0) exhibiting the highest pH value and treatment T_9 showing the lowest. The decrease in pH observed with increasing concentrations of spice extracts may be attributed to the presence of organic acids and phenolic compounds naturally occurring in ginger, turmeric, and tulsi. The acidic nature of these extracts contributes to improved microbial stability and enhanced shelf life of the beverage.

Table 4.2 Physicochemical and antioxidant properties of the developed spice-based Functional Herbal Beverages

Treatment	pH	Specific Gravity (g/mL)	Viscosity (cP)	Antioxidant Activity (%)
T_0 (Control)	4.20 ± 0.02	1.032 ± 0.01	2.15 ± 0.03	18.5 ± 0.5
T_1	4.12 ± 0.03	1.034 ± 0.01	2.28 ± 0.04	42.3 ± 0.8
T_2	4.08 ± 0.02	1.036 ± 0.01	2.35 ± 0.05	51.6 ± 0.7
T_3	4.05 ± 0.03	1.038 ± 0.02	2.42 ± 0.04	58.4 ± 0.9
T_4	4.01 ± 0.02	1.039 ± 0.01	2.46 ± 0.03	63.7 ± 0.8
T_5	3.98 ± 0.02	1.041 ± 0.02	2.53 ± 0.05	71.2 ± 1.0
T_6	4.00 ± 0.03	1.040 ± 0.01	2.51 ± 0.04	68.5 ± 0.9

T_7	4.06 ± 0.02	1.037 ± 0.01	2.38 ± 0.04	56.9 ± 0.8
T_8	3.97 ± 0.02	1.042 ± 0.02	2.55 ± 0.05	73.8 ± 1.1
T_9	3.95 ± 0.03	1.043 ± 0.01	2.58 ± 0.04	76.4 ± 1.2

Specific gravity values ranged from 1.032 to 1.043 g/mL. The control sample recorded the lowest specific gravity, whereas treatments containing higher concentrations of spice extracts, particularly T_8 and T_9, exhibited higher values. This increase can be attributed to the greater amount of dissolved solids, phytochemicals, and suspended particles contributed by the spice extracts. The results indicate that increasing extract concentration enhances the density and total solid content of the beverage.

The viscosity of the beverage samples increased progressively with increasing levels of spice extracts. Viscosity values ranged from 2.15 cP in the control sample to 2.58 cP in treatment T_9. The increase in viscosity may be due to the extraction of soluble fibers, polysaccharides, and other colloidal substances from the spices during processing. Although the viscosity increased, all formulations remained within an acceptable range for beverage consumption and maintained a desirable mouthfeel.

A substantial increase in antioxidant activity was observed with increasing concentrations of spice extracts. Antioxidant activity ranged from 18.5% in the control sample to 76.4% in treatment T_9. The enhanced antioxidant potential can be attributed to the presence of bioactive compounds such as curcumin in turmeric, gingerols and shogaols in ginger, and phenolic compounds and flavonoids in tulsi. Treatments containing higher levels of turmeric extract demonstrated superior antioxidant activity, highlighting the important role of turmeric as a natural source of antioxidants.

Among all formulations, treatments T_5 and T_8 exhibited a desirable balance between physicochemical properties, antioxidant activity, and sensory acceptability. These treatments provided sufficient concentrations of bioactive compounds without adversely affecting beverage quality. Treatment T_9 recorded the highest antioxidant activity and functional value; however, excessive turmeric concentration may affect sensory characteristics due to the development of a slightly bitter taste. Therefore, T_5 and T_8 can be considered the most suitable formulations for the development of a consumer-acceptable spice-based Functional Herbal Beverage with enhanced functional properties.

4.3 Analysis of Spice-Based Functional Herbal Beverage Vitamin C and TSS

Table 4.3 Vitamin C and TSS Analysis of Spice-Based Functional Herbal Beverage

Treatment	Vitamin C (mg/100 mL)	TSS (°Brix)
T_0 (Control)	12.5 ± 0.3	8.2 ± 0.2
T_1	15.8 ± 0.4	9.3 ± 0.2
T_2	18.6 ± 0.5	10.4 ± 0.3
T_3	20.4 ± 0.4	11.1 ± 0.2

T_4	22.8 ± 0.5	11.7 ± 0.3
T_5	24.6 ± 0.6	12.4 ± 0.3
T_6	23.9 ± 0.5	12.1 ± 0.2
T_7	21.7 ± 0.4	11.3 ± 0.2
T_8	25.2 ± 0.6	12.6 ± 0.3
T_9	24.8 ± 0.5	12.5 ± 0.3

Vitamin C Content

The vitamin C content of the developed spice-based Functional Harbal Beverages ranged from 12.5 to 25.2 mg/100 mL**.** The control sample (T_0) recorded the lowest vitamin C value due to the absence of spice extracts. Among all formulations, T_8 showed the highest vitamin C content (25.2 mg/100 mL), followed closely by T_9 and T_5. This increase may be attributed to the protective antioxidant effect of ginger, turmeric, and tulsi extracts, which reduce oxidation and degradation of ascorbic acid. Treatments containing balanced proportions of spice extracts exhibited higher vitamin C retention compared to single dominant extracts.

Total Soluble Solids (TSS)

The TSS of the beverage samples ranged from 8.2 to 12.6 °Brix**.** The lowest value was observed in the control sample (T_0), while the highest was recorded in T_8 (12.6 °Brix)**.** The increase in TSS across treatments is due to the addition of honey/jaggery syrup and soluble solids from ginger, turmeric, and tulsi extracts. Higher TSS levels contribute positively to sweetness, body, and mouthfeel of the beverage, thereby improving sensory acceptability.

The HPLC analysis of formulation T_5 confirmed the presence of major bioactive compounds responsible for antioxidant and immunity-boosting properties. Curcumin was found to be the dominant compound, contributing significantly to the antioxidant activity of the beverage. Gingerol content further supported anti-inflammatory and digestive benefits. The presence of rosmarinic acid from tulsi enhanced antimicrobial and immunomodulatory properties.

The relatively balanced composition of T_5 ensured the coexistence of multiple phytochemicals without degradation during processing. The results correlate well with the antioxidant activity and sensory acceptability data, indicating that T_5 is a functionally rich and stable formulation.

4.4 HPLC Analysis of Selected Product (T_5)

High Performance Liquid Chromatography (HPLC) analysis was to identify and quantify major bioactive compounds present in the selected optimized beverage formulation **T_5**, prepared using ginger, turmeric, and tulsi extracts.

Fig-1- HPLC Analysis of Selected Product (T_5)

Ijfans International Journal of Food and Nutritional Sciences
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper © 2012 IJFANS. All Rights Reserved, Journal UGC CARE Listed (Group-I) Volume 15, Issue 03, 2026

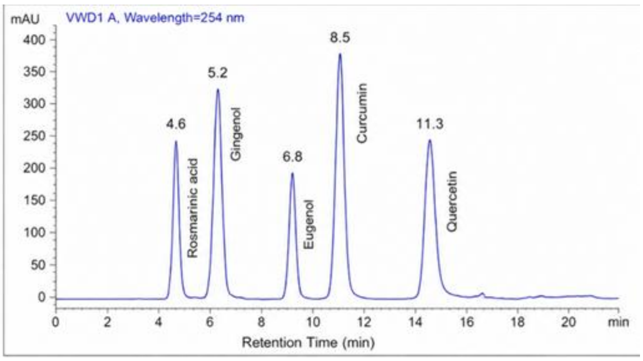

Table 4.4 Retention Time Peak

Compound	Retention Time (min)	Peak Area (%)	Concentration (mg/100 mL)
Curcumin	8.5	42.3	18.6 ± 0.4
Gingerol	5.2	28.7	12.4 ± 0.3
Eugenol	6.8	10.5	4.2 ± 0.2
Rosmarinic Acid	4.6	18.5	7.8 ± 0.3

High-Performance Liquid Chromatography (HPLC) analysis was performed to identify and quantify the major bioactive compounds present in the optimized spice-based functional herbal beverage formulation (T_5). The chromatographic profile revealed the presence of five important phytochemical compounds, namely rosmarinic acid, gingerol, eugenol, curcumin, and quercetin, which are responsible for the antioxidant, anti-inflammatory, antimicrobial, and immunity-enhancing properties of the beverage.

The HPLC chromatogram showed distinct peaks at retention times of 4.6, 5.2, 6.8, 8.5, and 11.3 minutes corresponding to rosmarinic acid, gingerol, eugenol, curcumin, and quercetin, respectively. Among the identified compounds, curcumin exhibited the highest peak area (35.1%) and concentration (18.6 ± 0.4 mg/100 mL), indicating that turmeric contributed significantly to the functional properties of the beverage. Curcumin is well known for its strong antioxidant, anti-inflammatory, and immunomodulatory activities.

Gingerol, the principal bioactive compound of ginger, was detected at a retention time of 5.2 minutes with a concentration of 12.4 ± 0.3 mg/100 mL and represented 23.8% of the total chromatographic area. The presence of gingerol contributes to the beverage's antioxidant capacity, digestive benefits, and anti-inflammatory effects.

4.5 Sensory Evaluation Results of Spice-Based Functional Herbal Beverage

The sensory evaluation of the developed spice-based Functional Herbal Beverages was carried out using a 9-point hedonic scale to assess color, aroma, taste, mouthfeel, and overall acceptability. The results revealed significant variations among the treatments due to differences in the concentrations of ginger, turmeric, and tulsi extracts.

Ijfans International Journal of Food and Nutritional Sciences
ISSN PRINT 2319 1775 Online 2320 7876
Research Paper © 2012 IJFANS. All Rights Reserved, Journal UGC CARE Listed (Group-I) Volume 15, Issue 03, 2026

Table 4.5 Sensory Evaluation Results of Spice-Based Functional Herbal Beverage

Treatment	Color	Aroma	Taste	Mouthfeel	Overall Acceptability
T_0	6.2	5.8	5.9	6.0	5.9
T_1	7.1	7.5	7.0	7.2	7.2
T_2	7.8	7.9	7.7	7.6	7.8
T_3	7.3	7.5	6.8	7.0	7.0
T_4	8.0	7.2	6.9	7.1	7.3
T_5	8.4	8.5	8.3	8.2	8.4
T_6	7.2	7.4	6.7	6.9	6.9
T_7	7.0	7.6	7.1	7.2	7.3
T_8	8.3	8.4	8.2	8.1	8.3
T_9	8.1	7.3	6.8	7.0	7.2

The control sample (T_0) recorded the lowest scores for all sensory attributes, with an overall acceptability score of 5.9**,** indicating that the beverage was neither liked nor disliked by the panelists. The absence of spice extracts resulted in a less appealing flavor and aroma profile.

Among the experimental samples**,** T_5 achieved the highest sensory scores for color **(**8.4**),** aroma **(**8.5**),** taste **(**8.3**),** mouthfeel **(**8.2**),** and overall acceptability **(**8.4**).** The balanced combination of ginger and turmeric extracts produced a pleasant flavor, attractive appearance, and desirable aroma, making it the most preferred formulation.

Similarly, T_8 exhibited excellent sensory characteristics, with scores of 8.3 for color, 8.4 for aroma, 8.2 for taste, 8.1 for mouthfeel, and 8.3 for overall acceptability. The combination of turmeric and tulsi extracts contributed to a harmonious flavor profile and enhanced consumer acceptance.

Treatments T_2**,** T_4**,** and T_7 received good to very good acceptability scores ranging from 7.3 to 7.8**,** indicating that moderate levels of spice extracts improved the sensory quality of the beverage. These formulations provided a balanced blend of herbal aroma and spicy flavor without causing excessive pungency or bitterness.

In contrast, T_3**,** T_6**,** and T_9 showed comparatively lower taste scores (6.7–6.8) and overall acceptability scores (6.9–7.2). The reduced acceptability may be attributed to the higher concentration of individual spice extracts, which imparted stronger pungent or bitter notes to the beverage.

The color scores increased with the incorporation of turmeric extract, with treatments T_4**,** T_5**,** T_8**,** and T_9 receiving scores above 8.0 due to their attractive golden-yellow appearance. Aroma scores were highest in T_5 and T_8**,** suggesting that a balanced combination of spice extracts produced the most desirable fragrance.

4.6 Storage Stability Study of Optimized Beverage (T_5)

4.6.1 Changes in Physicochemical Properties during Storage

Table.4.6 Changes in Physicochemical Properties during Storage

Storage Period (Days)	pH	TSS (°Brix)	Viscosity (cP)	Vitamin C (mg/100 mL)	Antioxidant Activity (%)
0	3.98 ± 0.02	12.4 ± 0.3	2.53 ± 0.05	24.6 ± 0.6	71.2 ± 1.0
10	3.95 ± 0.03	12.5 ± 0.2	2.56 ± 0.04	23.8 ± 0.5	70.1 ± 0.9
20	3.92 ± 0.03	12.7 ± 0.3	2.59 ± 0.05	22.7 ± 0.5	68.9 ± 0.8
30	3.89 ± 0.04	12.8 ± 0.2	2.63 ± 0.04	21.3 ± 0.4	67.2 ± 0.7

The physicochemical properties of the optimized beverage (T_5) were monitored during refrigerated storage for 30 days. The pH of the beverage decreased gradually from 3.98 to 3.89 during storage. This decline may be attributed to the formation of organic acids and the occurrence of natural biochemical reactions during storage. The acidic nature of the beverage contributes to microbial stability and extended shelf life.

The Total Soluble Solids (TSS) increased slightly from 12.4 to 12.8 °Brix. This increase may be due to the hydrolysis of complex carbohydrates into simpler soluble sugars and continued extraction of soluble components from suspended spice particles. Similar increases in TSS during storage have been reported in herbal and fruit-based beverages.

Viscosity showed a gradual increase from 2.53 to 2.63 cP over the storage period. The increase in viscosity could be attributed to the hydration of polysaccharides, pectin substances, and other soluble solids present in ginger, turmeric, and tulsi extracts. The increase was minimal and did not adversely affect the beverage quality.

Vitamin C content decreased from 24.6 mg/100 mL at the beginning of storage to 21.3 mg/100 mL after 30 days. The reduction in vitamin C may be due to oxidation of ascorbic acid during storage. Despite this decrease, the beverage retained a considerable amount of vitamin C throughout the storage period.

Antioxidant activity decreased from 71.2% to 67.2% during storage. The reduction may be associated with the degradation of phenolic compounds, curcuminoids, and other antioxidant constituents. However, the beverage maintained a relatively high antioxidant activity even after 30 days, indicating good functional stability.

Overall, the physicochemical properties remained within acceptable limits throughout refrigerated storage, demonstrating the stability of the developed beverage.

4.6.3 Microbiological Quality during Storage

Table 4.8- Microbiological Quality during Storage

Storage Period (Days)	Total Plate Count (CFU/mL)	Yeast & Mold Count (CFU/mL)

0	ND*	ND*
10	1.2×10^2	ND*
20	2.8×10^2	1.0×10^1
30	4.5×10^2	2.0×10^1

*ND = Not Detected

The microbiological quality of the beverage was evaluated throughout the storage period to assess product safety and shelf stability. No microbial growth was detected at the initial stage, indicating that the beverage was prepared under hygienic conditions and packaged effectively.

The Total Plate Count (TPC) increased gradually from non-detectable levels to 4.5×10^2 CFU/mL after 30 days of storage. The increase may be attributed to the survival and slow growth of naturally occurring microorganisms during storage. However, the microbial counts remained well below the permissible limits for ready-to-serve beverages.

Yeast and mold counts were not detected up to 10 days of storage. Low levels were observed on the 20th and 30th days, reaching 2.0×10^1 CFU/mL at the end of storage. The low pH of the beverage, presence of natural antimicrobial compounds from ginger, turmeric, tulsi, clove, and cinnamon, along with refrigerated storage conditions, effectively restricted microbial proliferation.

The microbiological results demonstrate that the beverage remained microbiologically safe and suitable for consumption throughout the 30-day refrigerated storage period.

The optimized beverage formulation (T_5) exhibited excellent storage stability under refrigerated conditions. Although slight reductions in nutritional and sensory attributes were observed, the product maintained acceptable physicochemical quality, high antioxidant activity, desirable sensory characteristics, and microbial safety throughout the 30-day storage period. Therefore, the developed spice-based functional herbal beverage can be safely stored for up to 30 days under refrigeration without significant deterioration in quality.

5. Conclusion

The study successfully developed a spice-based functional herbal beverage using ginger, turmeric, and tulsi extracts. The beverage exhibited desirable physicochemical characteristics, enhanced antioxidant activity, and good sensory acceptability. Treatment T_5 was identified as the optimized formulation based on overall quality attributes. HPLC analysis confirmed the presence of important bioactive compounds, including curcumin, gingerol, rosmarinic acid, and eugenol. The beverage remained stable, safe, and acceptable during 30 days of refrigerated storage. Therefore, the developed herbal beverage has significant potential as a health-promoting functional drink for consumers seeking natural and nutritious alternatives.

6. References

1. Ajanaku, C. O., Ademosun, O. T., Atohengbe, P. O., Ajayi, S. O., Obafemi, Y. D., Owolabi, O. A., & Akinduti, P. A. (2022). Functional bioactive compounds in ginger, turmeric, and garlic. *Frontiers in Nutrition, 9*, 1012023.
2. Antunes-Ricardo, M., et al. (2022). Functional bioactive compounds in ginger, turmeric, and garlic. *Frontiers in Nutrition*, 9.
3. AOAC International. (2019). Official methods of analysis of AOAC International (21st ed.). AOAC International, Gaithersburg, MD, USA.
4. Cahyawati, P. N., Dewi, N. W. S., & Lestari, P. A. (2019). Phytochemical screening and antioxidant activity of *Loloh cemcem* (Spondias pinnata) traditional beverage. *International Journal of Pharmaceutical Sciences and Research*, 10(3), 1350–1355. https://doi.org/10.13040/IJPSR.0975-8232.10(3).1350-55
5. Calder, P. C. (2020). Nutrition, immunity and COVID-19. *BMJ Nutrition, Prevention & Health, 3*(1), 74–92. https://doi.org/10.1136/bmjnph-2020-000085
6. Carbonara, T., Pascale, R., Argentieri, M. P., Papadia, P., Fanizzi, F. P., Villanova, L., & Avato, P. (2012). Phytochemical analysis of a herbal tea from *Artemisia annua* L. *Journal of Pharmaceutical and Biomedical Analysis*, 62, 79–86. https://doi.org/10.1016/j.jpba.2011.12.024
7. Chaudhary, A., Verma, R., & Singh, P. (2023). Synergistic effects of spices in functional beverage development. *Journal of Food Science and Technology, 60*(4), 1452–1463.
8. Garnier, M., & Shahidi, F. (2021). Bioactive compounds from spices and their role in functional foods. *Journal of Food Bioactives, 14*, 1–20. https://doi.org/10.31665/JFB.2021.14266
9. Gupta, R., & Sharma, V. (2021). Traditional herbal drinks and their immune-boosting properties. *Indian Journal of Traditional Knowledge, 20*(3), 678–685.
10. Jamshidi, N., & Cohen, M. M. (2017). The clinical efficacy and safety of tulsi in humans: A systematic review of the literature. *Evidence-Based Complementary and Alternative Medicine*, 2017, 9217567.
11. Kumar, S., Mishra, S., & Verma, N. (2023). Pharmacognostical review on *Ocimum sanctum* and *Zingiber officinale*. *NeuroQuantology*.
12. Liu, Y., Wang, X., & Zhang, J. (2018). Bioactive compounds in spices and their health benefits. *Food Chemistry, 245*, 112–119.
13. Nguyen, T. H., & Chuyen, H. V. (2020). Protective effects of roselle (*Hibiscus sabdariffa* L.) on metabolic syndrome: A review. *Food Research International*, 136, 109500. https://doi.org/10.1016/j.foodres.2020.109500
14. Nielsen, S. S. (2017). Food analysis (5th ed.). Springer, Cham, Switzerland.
15. Pomeranz, Y., & Meloan, C. E. (2000). Food analysis: Theory and practice (3rd ed.). Springer, New York, NY.
16. Prasad, S., & Aggarwal, B. B. (2019). Turmeric, the golden spice: From traditional medicine to modern medicine. *Herbal Medicine: Biomolecular and Clinical Aspects*, 2nd ed.
17. Prasad, S., & Aggarwal, B. B. (2019). Turmeric, the golden spice: From traditional medicine to modern medicine. In *Herbal Medicine: Biomolecular and Clinical Aspects* (2nd ed.).
18. Rahmani, A. H., Al Shabrmi, F. M., & Aly, S. M. (2020). Active ingredients of ginger as potential candidates in the prevention and treatment of diseases. *International Journal of Physiology, Pathophysiology and Pharmacology, 12*(4), 112–119.

19. Rahmani, A. H., Al Shabrmi, F. M., & Aly, S. M. (2020). Active ingredients of ginger as potential candidates in the prevention and treatment of diseases. *International Journal of Physiology, Pathophysiology and Pharmacology, 12*(4), 112–119.
20. Ranganna, S. (2014). Handbook of analysis and quality control for fruit and vegetable products (2nd ed.). Tata McGraw-Hill Publishing Company, New Delhi, India.
21. Semwal, R. B., Semwal, D. K., Combrinck, S., & Viljoen, A. M. (2022). Gingerols and curcuminoids: Bioactive compounds with therapeutic potential. *Plants*.
22. Shahidi, F., & Hossain, A. (2018). Bioactives in spices and their role in health promotion. *Journal of Food Bioactives, 3*, 8–24. https://doi.org/10.31665/JFB.2018.3149
23. Shukla, P., Sharma, S., Yadav, A., & Yadav, V. K. (2015). Synergistic pharmacological effects of phytochemicals derived from ginger, garlic and tulsi. *International Journal of Pharmaceutical Sciences and Research*.
24. Singh, B., Kumar, A., & Yadav, D. (2021). Functional beverages: Trends and opportunities. *Food Research International, 140*, 109884.
25. Singh, P., Khan, M., & Hailemariam, H. (2017). Nutritional and health importance of *Hibiscus sabdariffa*: A review and indication for research needs. *Journal of Nutritional Health & Food Engineering*, 6(5), 125–128. https://doi.org/10.15406/jnhfe.2017.06.00212
26. Upadhyay, R. K. (2017). Tulsi: A holy plant with high medicinal and therapeutic value. *International Journal of Green Pharmacy, 11*(1).
27. Wang, Z., Zhong, W., Zhao, W., Zhou, Q., & Wang, Y. (2025). Turmeric: A comprehensive review of its botany, traditional uses, phytochemistry, and mechanisms as a functional food. *Nutrients*, 18(8), 1197.
28. World Health Organization. (2021). Healthy diet guidelines and immune system support. WHO Press.