

International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(9): 286-293
www.biochemjournal.com
Received: 10-07-2026
Accepted: 13-08-2026

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Comprehensive phytochemical characterization and antibacterial evaluation of *Zingiber officinale* roscoe extract against selected foodborne pathogens: Implications for natural food preservation

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DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i9Sd.9845>

Abstract

Foodborne bacterial contamination is still a serious public health issue, especially in tropical areas where warm, humid weather encourages germ development. The current work assessed the antibacterial activity of an 80% ethanolic extract made from locally grown ginger rhizomes against three significant foodborne pathogens: *Bacillus cereus*, *Staphylococcus aureus*, and *Escherichia coli*. Cold maceration was used to extract fresh rhizomes after they had been shade-dried and ground into a powder. Gas chromatography-mass spectrometry and Fourier transform infrared spectroscopy were used to analyze the extract, while broth dilution and agar well diffusion were used to evaluate its antibacterial activity. 14.8% (weight per weight) was the extraction yield. 42 phytochemical components were provisionally identified by gas chromatography-mass spectrometry, with 6-gingerol, alpha-zingiberene, and 6-shogaol being the most common substances. The existence of distinctive hydroxyl, carbonyl, and aromatic functional groups linked to the bioactive components of ginger was shown using Fourier transform infrared spectroscopy. With inhibition zones spanning from 7.0 to 18.3 millimeters, the extract clearly demonstrated concentration-dependent antibacterial activity. For *E. coli* and *S. aureus*, the lowest inhibitory concentration was 50 milligrams per milliliter, whereas *B. cereus* needed 100 milligrams per milliliter to completely suppress growth. These results show that ginger grown locally has a rich phytochemical makeup and shows promise as an antibacterial agent against significant foodborne pathogens. The results point to the possible use of bioactive chemicals obtained from ginger as natural antibacterial agents for enhanced food safety and food preservation. To confirm their practical effectiveness and stability under processing and storage circumstances, more research in actual food systems is advised.

Keywords: *Zingiber officinale*, ethanolic extract, gas chromatography-mass spectrometry, antibacterial activity, foodborne pathogens, minimum inhibitory concentration

Introduction

Foodborne illnesses continue to be a major global public health concern, causing millions of illnesses and large financial losses annually. The main cause of these disorders is microbial contamination of food, especially fresh produce, ready-to-eat items, and minimally processed meals. In tropical countries like India, warm, humid weather accelerates microbial growth, increasing the risk of food deterioration and the spread of dangerous pathogens (Abdul-Mutalib *et al.*, 2015) [1]. *E. coli*, *S. aureus* and *B. cereus* are among the most commonly linked foodborne pathogens; they are linked to food poisoning, diarrhea, and serious consequences in susceptible groups (Kadariya *et al.*, 2014; Yassen, 2016; Othman *et al.*, 2020) [5, 6, 8, 12]. The critical need for efficient and long-lasting natural antimicrobial drugs is highlighted by the rapid emergence of antimicrobial resistance among these pathogens, which has further hampered disease management and food safety policies (Tacconelli *et al.*, 2018) [13]. While synthetic preservatives are still commonly employed, interest in plant-derived bioactive chemicals as safer substitutes has increased due to growing consumer concerns about their possible negative health effects and the growing desire for clean-label

products (Beristain-Bauza *et al.*, 2019) ^[14]. Ginger (*Zingiber officinale* Roscoe), is a popular spice and traditional medicinal herb with a wide range of biological activity, including anti-inflammatory, antioxidant, and antibacterial qualities. Its antibacterial activity has been largely attributed to phenolic compounds such as gingerols and shogaols as well as other sesquiterpenes (Karuppiah & Rajaram, 2012; Othman *et al.*, 2020; Sulieman *et al.*, 2024) ^[4, 5, 8, 9]. Because ethanolic extracts may effectively extract both polar and somewhat non-polar bioactive components, they have consistently shown better antibacterial activity than aqueous preparations (Auta *et al.*, 2011; Islam *et al.*, 2014) ^[2, 3]. Significant variances in the phytochemical content and antibacterial efficiency of ginger have been documented despite a great deal of research on the plant. These discrepancies are mostly caused by changes in harvest age, cultivar, cultivation practices, geographic origin, and extraction techniques. Furthermore, nothing is known about the antibacterial properties and phytochemical profile of *Zingiber officinale* grown in Salem, Tamil Nadu. To find locally accessible plant resources with promising uses for food safety, region-specific research is crucial. In this investigation, the antibacterial efficacy of an 80% ethanolic extract made from locally grown *Zingiber officinale* rhizomes against *B. cereus*, *S. aureus* and *E. coli* was assessed. Gas chromatography-mass spectrometry (GC-MS) and Fourier Transform Infrared (FTIR) spectroscopy were used to thoroughly evaluate the extract in order to determine its main bioactive components and functional groups. This study offers a thorough evaluation of the antibacterial potential of locally sourced ginger and advances the creation of natural antimicrobial agents for food safety and preservation applications by combining phytochemical profiling with agar well diffusion and Minimum Inhibitory Concentration (MIC) assays.

Materials and Methods

Plant Material Collection and Preparation

Zingiber officinale Roscoe's fresh rhizomes were gathered from fields in rural Salem, Tamil Nadu, India. After giving the rhizomes, a good wash under running water, they were rinsed with distilled water, peeled to remove the outer skin, and then cut into thin (2-3 mm) sections. For five to seven days, the slices were shade-dried at room temperature (25 to 28 °C). Before being extracted, the dried material was ground up using an electric grinder, put through a 40-mesh sieve, and kept in airtight amber glass containers at 4 °C (Sherifa *et al.*, 2014; Adel & Prakash) ^[15].

Preparation of Ethanolic Extract

A modified cold maceration approach was used to extract ethanol (Islam *et al.*, 2014; Karuppiah & Rajaram, 2012) ^[3, 4]. In short, 100 mL of 80% (v/v) analytical-grade ethanol ($\geq 99.9\%$, Merck, India) was used to extract 10 g of the powdered rhizomes at a solid-to-solvent ratio of 1:10 (w/v). After 72 hours of agitation at 150 rpm in a shaking incubator at room temperature (25-28 °C), the mixture was filtered through Whatman No. 1 filter paper. The crude extract was made by concentrating the filtrate under low pressure at 40 °C using a rotary evaporator (Buchi R-300). After that, it was placed in sterile amber glass vials and stored at 4 °C for additional examination. The dry weight of the recovered crude extract in relation to the starting dry weight of the plant material was used to compute the

extraction yield (%) (Mohammadi *et al.*, 2020; Edo *et al.*, 2024) ^[7, 16].

Phytochemical Characterization

Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

A Shimadzu GCMS-QP2020 NX system with a Rtx-5MS fused-silica capillary column (30 m $\times$ 0.25 mm i.d., 0.25 μ m film thickness) was utilized to describe the phytochemical profile of the 80% ethanolic extract. The carrier gas was 99.999% pure helium at a steady flow rate of 1.0 mL min⁻¹. An initial hold at 60 °C for two minutes, a ramp to 280 °C at 10 °C min⁻¹, and a final hold for ten minutes comprised the oven temperature program. The temperatures of the injector and interface were kept at 250 °C and 280 °C, respectively. One microliter of the material was injected in split mode (1:20). Over a scan range of m/z 40-650, mass spectra were obtained under electron ionization (70 eV). Compounds were identified using known fragmentation patterns and compared with the NIST 20 mass spectral library ($\geq 90\%$ similarity) (Sulieman *et al.*, 2024; Gunasena *et al.*, 2022; Abdullahi *et al.*, 2020) ^[8, 9, 10].

Fourier Transform Infrared (FTIR) Spectroscopy

The main functional groups in the extract were determined using FTIR spectroscopy (Bruker Alpha II FTIR). An FTIR spectrophotometer's Attenuated Total Reflectance (ATR) crystal was immediately coated with a tiny portion of the concentrated extract. 32 scans were used to record spectra in the 4000-400 cm⁻¹ region at a spectral resolution of 4 cm⁻¹. By comparing the measured absorption bands with conventional reference spectra for the distinctive phytochemical components of ginger, functional groups were given (Edo *et al.*, 2024; Tabe *et al.*, 2026) ^[7, 11].

Bacterial Strains

Based on their clinical and foodborne relevance, reference bacterial strains *Escherichia coli* (ATCC 25922), *Staphylococcus aureus* (ATCC 25923) and *Bacillus cereus* (ATCC 11778) were chosen (Kadariya *et al.*, 2014; Yassen, 2016; Othman *et al.*, 2020) ^[5, 6, 8, 12]. The strains were kept at 4 °C after being resurrected from glycerol stocks on nutrient agar.

Antibacterial Activity by Agar Well Diffusion Assay

A 100 mg/mL stock solution was created by reconstituting the crude extract in dimethyl sulfoxide (DMSO). In order to rule out any possible antibacterial impact of the solvent, the final concentration of DMSO in the test did not surpass 1% (v/v) (Auta *et al.*, 2011; Islam *et al.*, 2014) ^[2, 3]. The extract solution was filtered through a 0.22 μ m membrane filter to sterilize it before the experiment.

The agar well diffusion method outlined by Bauer *et al.* (1966) was used to assess antibacterial activity. Bacterial suspensions calibrated to the 0.5 McFarland standard (about 1.5×10^8 CFU/mL) were uniformly injected into Mueller-Hinton (HiMedia Laboratories, India) agar plates. After aseptically punching 6 mm-diameter wells into the agar, 50, 75, and 100 μ L of the extract solution were added to each well. Gentamicin solution (100 mg/mL; 100 μ L per well) served as the positive control, and DMSO (100 μ L per well) served as the negative control. Following a 24-hour incubation period at 37 °C, the inhibitory zone diameters were measured in millimeters (mm). Each experiment was

carried out in triplicate, and the data were expressed using the mean $\pm$ Standard Deviation (SD) (Karuppiyah & Rajaram, 2012; Othman *et al.*, 2020) [4, 5, 8].

Determination of Minimum Inhibitory Concentration (MIC)

The broth dilution method was used to calculate the ethanolic ginger extract's Minimum Inhibitory Concentration (MIC) (Wiegand *et al.*, 2008) [17]. To achieve final concentrations of 25, 50, and 100 mg/mL, a stock solution of the crude extract (100 mg/mL) was made in DMSO and diluted with sterile nutritional broth. The broth's final DMSO concentration was less than 1% (v/v), which has been shown to have no effect on bacterial growth inhibition (Auta *et al.*, 2011) [2]. The corresponding extract concentrations were made in three sterile test tubes with 5 mL of nutritional broth. A tube holding nutritional broth with extract but without bacterial inoculation functioned as the negative (sterility) control, while another tube containing

inoculated broth without extract served as the positive growth control. With the exception of the negative control, every tube was infected with a standardized bacterial culture that was adjusted to the 0.5 McFarland standard (about 1.5×10^8 CFU/mL) and incubated for 24 hours at 37 °C in an aerobic environment. Bacterial growth was assessed visually and using a UV-visible spectrophotometer to measure the optical density at 600 nm (OD_{600}) after incubation. Every experiment was conducted in triplicate, and the mean $\pm$ Standard Deviation (SD) was used to express the results (Wiegand *et al.*, 2008) [17].

Results

Plant Material Processing and Extract Preparation

A dark reddish-brown, viscous crude extract with an extraction yield of 14.8% w/w was produced by cold macerating 295 g of fine powder with 80% ethanol. The extract was stable at 4 °C and had a strong, unique, pungent fragrance.



Fig 1: Fresh ginger rhizomes selected for extract preparation and subsequent analysis

Gas Chromatography-Mass Spectrometry (GC-MS) Analysis

Based on comparison with the NIST 20 mass spectral library and published fragmentation data, a complex phytochemical profile including 42 compounds representing 97.2% of the total ion current was found by GC-MS analysis

of the 80% ethanolic extract. Sesquiterpenes and phenolic ketones predominated in the extract. 6-gingerol (22.45%), α -zingiberene (15.34%), 6-shogaol (9.67%), and β -sesquiphellandrene (8.91%) were the main components. Significant bioactive potential was shown by the combined gingerol and shogaol content of 39.8%.

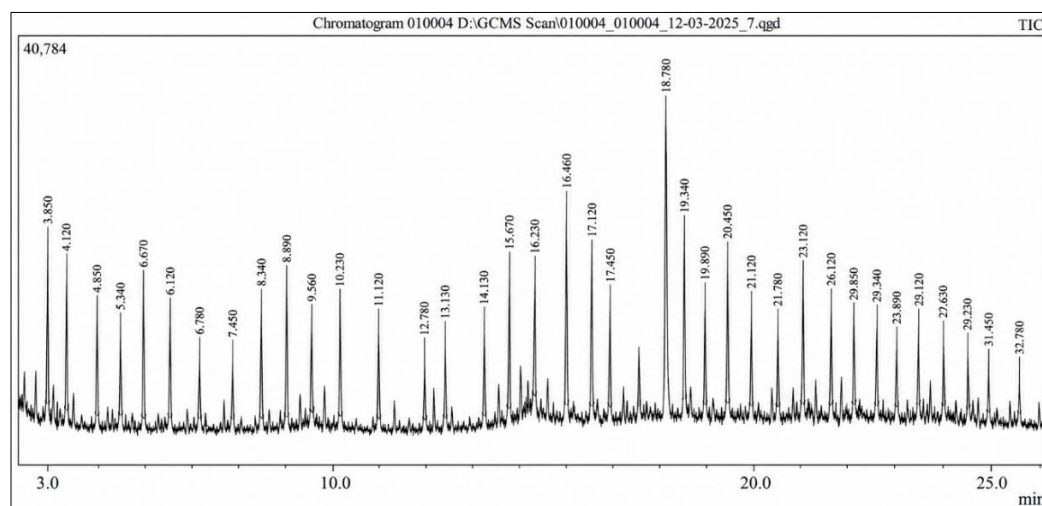


Fig 2: Represents the GC-MS chromatogram showing the major chemical constituents identified in the ginger ethanolic extract

Table 1: Phytochemical constituents identified in the 80% ethanolic extract of *Zingiber officinale* Roscoe by GC-MS analysis

Peak	RT (min)	Area (%)	Compound name	Molecular formula
1	3.85	0.45	α -Pinene	C ₁₀ H ₁₆
2	4.12	0.67	Camphene	C ₁₀ H ₁₆
3	4.85	1.23	Sabinene	C ₁₀ H ₁₆
4	5.34	0.89	β -Pinene	C ₁₀ H ₁₆
5	5.67	2.45	β -Phellandrene	C ₁₀ H ₁₆
6	6.12	1.89	1,8-Cineole	C ₁₀ H ₁₈ O
7	6.78	1.12	γ -Terpinene	C ₁₀ H ₁₆
8	7.45	0.78	Terpinolene	C ₁₀ H ₁₆
9	8.34	3.67	Linalool	C ₁₀ H ₁₈ O
10	8.89	2.34	Citronellal	C ₁₀ H ₁₈ O
11	9.56	1.67	Borneol	C ₁₀ H ₁₈ O
12	10.23	2.78	Terpinen-4-ol	C ₁₀ H ₁₈ O
13	11.12	3.45	α -Terpineol	C ₁₀ H ₁₈ O
14	12.34	1.89	Neral	C ₁₀ H ₁₆ O
15	12.78	2.12	Geranial	C ₁₀ H ₁₆ O
16	13.45	4.56	α -Copaene	C ₁₅ H ₂₄
17	14.12	2.34	β -Elemene	C ₁₅ H ₂₄
18	14.89	15.34	α -Zingiberene	C ₁₅ H ₂₄
19	15.67	3.89	β -Bisabolene	C ₁₅ H ₂₄
20	16.23	8.91	β -Sesquiphellandrene	C ₁₅ H ₂₄
21	16.89	2.67	α -Farnesene	C ₁₅ H ₂₄
22	17.45	1.78	γ -Cadinene	C ₁₅ H ₂₄
23	18.12	1.45	δ -Cadinene	C ₁₅ H ₂₄
24	18.78	22.45	6-Gingerol	C ₁₇ H ₂₆ O ₄
25	19.34	4.78	8-Gingerol	C ₁₉ H ₃₀ O ₄
26	19.89	2.34	10-Gingerol	C ₂₁ H ₃₄ O ₄
27	20.45	9.67	6-Shogaol	C ₁₇ H ₂₄ O ₃
28	21.12	1.89	8-Shogaol	C ₁₉ H ₂₈ O ₃
29	21.78	0.67	10-Shogaol	C ₂₁ H ₃₂ O ₃
30	22.45	5.12	Zingerone	C ₁₁ H ₁₄ O ₃
31	23.12	1.45	Paradol	C ₁₇ H ₂₆ O ₃
32	23.89	0.78	6-Paradol	C ₁₉ H ₃₀ O ₃
33	24.56	1.23	1-(4-Hydroxy-3-methoxyphenyl)-3-decanone	C ₁₇ H ₂₆ O ₃
34	25.34	0.89	6-Gingerdione	C ₁₇ H ₂₄ O ₄
35	26.12	0.56	β -Eudesmol	C ₁₅ H ₂₆ O
36	26.89	0.45	Nerolidol	C ₁₅ H ₂₆ O
37	27.67	0.78	Patchoulol	C ₁₅ H ₂₆ O
38	28.45	0.34	α -Bisabolol	C ₁₅ H ₂₆ O
39	29.23	0.67	Longifolene	C ₁₅ H ₂₄
40	30.12	0.56	Caryophyllene oxide	C ₁₅ H ₂₄ O
41	31.45	0.45	Humulene epoxide	C ₁₅ H ₂₄ O
42	32.78	0.23	trans-Nerolidol	C ₁₅ H ₂₆ O

Notes: Compounds were identified by comparison of mass spectra with the NIST 20 library (similarity $\geq 90\%$) and published fragmentation patterns. Total identified compounds = 42 (accounting for 97.2% of the total ion current). Major constituents are highlighted in bold

Fourier Transform Infrared (FTIR) Spectroscopy

The FTIR spectrum showed distinctive absorption bands at 3402 cm⁻¹ (O-H stretching), 2924 cm⁻¹ and 2854 cm⁻¹ (C-H stretching), 1705 cm⁻¹ (C=O stretching), 1608 cm⁻¹ and 1516 cm⁻¹ (aromatic C=C), 1375 cm⁻¹ (C-H bending), 1261

cm⁻¹ and 1034 cm⁻¹ (C-H stretching), and 815 cm⁻¹ and 745 cm⁻¹ (aromatic C-H out-of-plane bending). The existence of phenolic ketones, sesquiterpenes, and aromatic structures characteristic of ginger bioactives is confirmed by these bands.

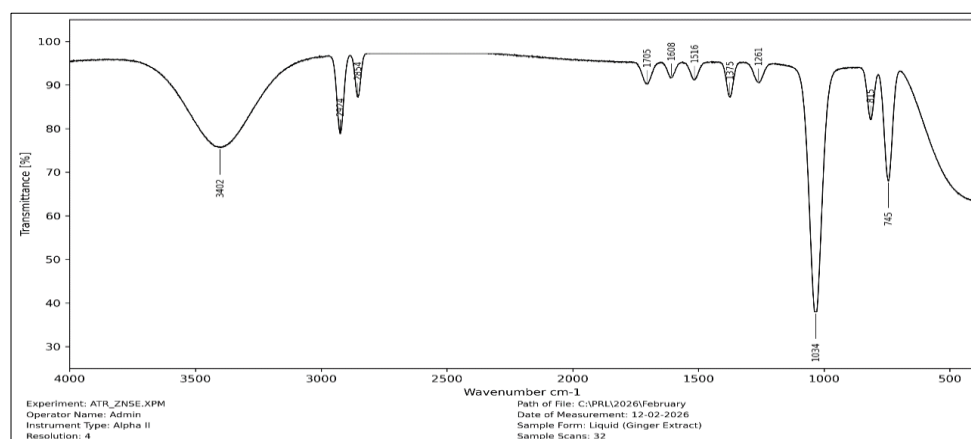
**Fig 3:** Represents the FTIR spectrum of the ginger ethanolic extract showing characteristic functional-group vibrations

Table 2. FTIR spectral band assignments of the 80% ethanolic extract of *Zingiber officinale* Roscoe

Wavenumber (cm ⁻¹)	Assignment	Functional group / Vibration mode	Probable phytochemical origin
3400-3200 (broad)	$\nu(\text{O-H})$	O-H stretching (hydrogen-bonded)	Phenolic and alcoholic OH groups of gingerols, shogaols, zingerone
2924	$\nu_{\text{as}}(\text{C-H})$	Asymmetric C-H stretching	Aliphatic -CH ₂ / -CH ₃ of terpenoids and phenolic side chains
2854	$\nu_{\text{s}}(\text{C-H})$	Symmetric C-H stretching	Aliphatic -CH ₂ / -CH ₃ of sesquiterpenes and ginger phenolics
1715-1680	$\nu(\text{C=O})$	Carbonyl stretching	Ketone / conjugated ketone of gingerols, shogaols, zingerone, gingerdiones
1605-1450	$\nu(\text{C=C})$	Aromatic C=C skeletal stretching	Substituted benzene rings of phenolic compounds
1375	$\delta(\text{C-H})$	C-H bending (CH ₃ deformation)	Methyl groups of aliphatic side chains
1260-1030	$\nu(\text{C-O})$	C-O stretching	Alcohols, phenols, ethers and methoxy groups of gingerols and shogaols
800-700	$\gamma(\text{C-H})$	Aromatic C-H out-of-plane bending	Substituted aromatic rings of phenolic constituents

Notes: ν = stretching; ν_{as} = asymmetric stretching; ν_{s} = symmetric stretching; δ = bending; γ = out-of-plane bending. Spectra were recorded in ATR mode (4000-400 cm⁻¹, 32 scans, 4 cm⁻¹ resolution).

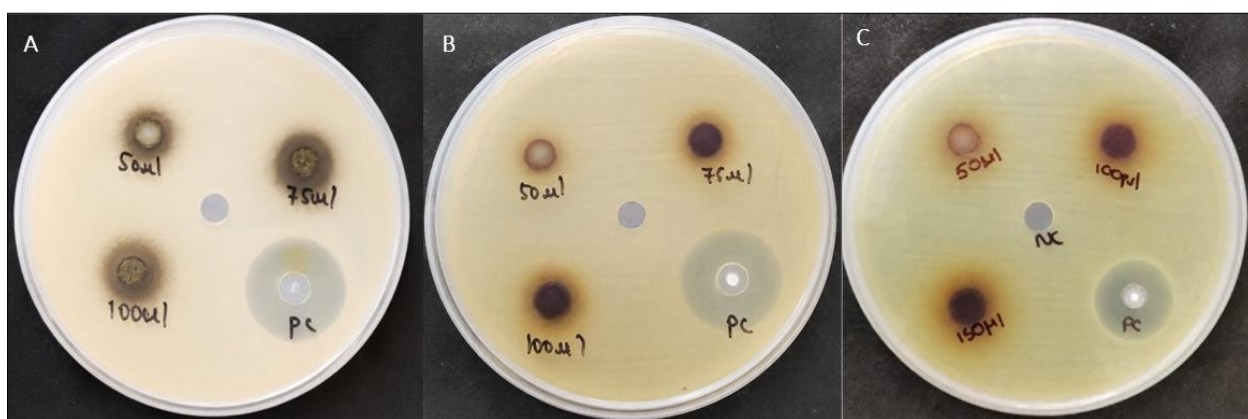
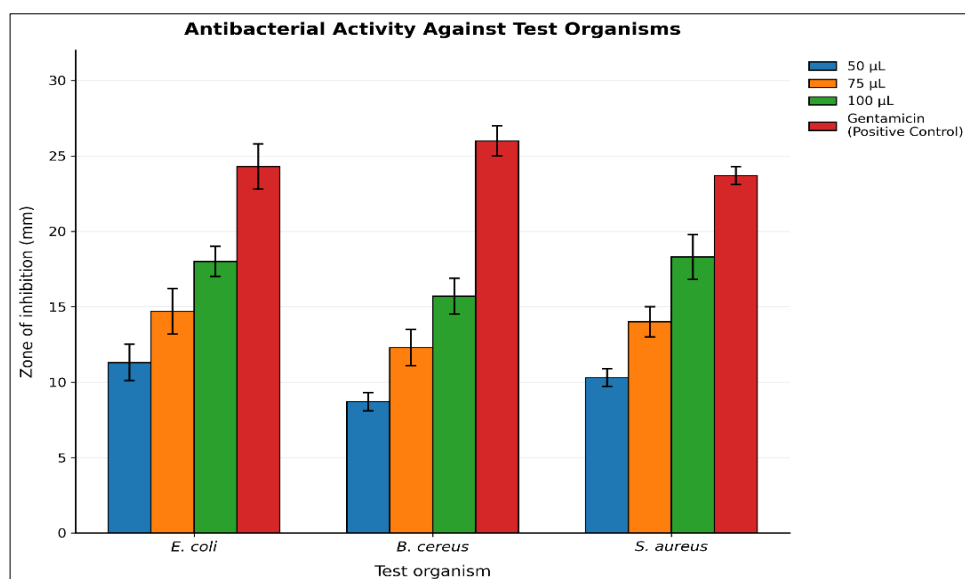
Antibacterial Activity by Agar Well Diffusion Assay

Zingiber officinale's 80% ethanolic extract clearly showed concentration-dependent antibacterial activity against the

foodborne pathogens that were tested. Zones of inhibition were seen after a 24-hour incubation period at 37 °C. The DMSO negative control showed no inhibitory zone.

Table 3. Mean zones of inhibition (mm) produced by the ginger ethanolic extract against foodborne bacterial strains (mean± SD, n=3)

Test Organism	50 μL (mm)	75 μL (mm)	100 μL (mm)	Gentamicin (Positive Control, mm)
<i>E. coli</i>	11.3±1.2	14.7±1.5	18.0±1.0	24.3±1.5
<i>B. cereus</i>	8.7±0.6	12.3±1.2	15.7±1.2	26.0±1.0
<i>S. aureus</i>	10.3±0.6	14.0±1.0	18.3±1.5	23.7±0.6

**Fig 4:** Agar well diffusion assay showing the antibacterial activity of ginger ethanolic extract against the test bacteria**Fig 5:** Antibacterial activity of the ginger extract against test pathogens Bars represent mean± SD (n = 3) of the inhibition zone diameter (mm) at different extract concentrations

The inhibition zones grew as the extract concentration rose, indicating a concentration-dependent antibacterial activity against every strain of bacteria examined. At 100 μ L, the extract generated the highest mean inhibition zone (18.3 ± 1.5 mm) against *Staphylococcus aureus*. Additionally, moderate antibacterial activity against *Bacillus cereus* and *Escherichia coli* was noted. The assay's validity was confirmed by the gentamicin positive control, which generated inhibition zones between 23 and 26 mm, while the DMSO negative control showed no inhibition zone.

Determination of Minimum Inhibitory Concentration (MIC)

The broth dilution method was used to calculate the minimum inhibitory concentration (MIC) of the 80% ethanolic ginger extract. Following a 24-hour incubation period, bacterial growth was evaluated both visually and by measuring optical density at 600 nm (OD_{600}). Bacterial growth was clearly inhibited by the extract in a dose-dependent manner.

Table 4: Optical density (OD_{600}) values and MIC of the ginger ethanolic extract against foodborne bacterial strains (mean $\pm$ SD, $n=3$)

Test Organism	Control (No Extract)	25 mg/mL	50 mg/mL	100 mg/mL	MIC (mg/mL)
<i>E. coli</i>	1.28 ± 0.06	0.85 ± 0.04	0.12 ± 0.03	0.05 ± 0.01	50
<i>B. cereus</i>	1.35 ± 0.05	1.12 ± 0.07	0.78 ± 0.06	0.09 ± 0.02	100
<i>S. aureus</i>	1.22 ± 0.04	0.65 ± 0.05	0.08 ± 0.02	0.04 ± 0.01	50

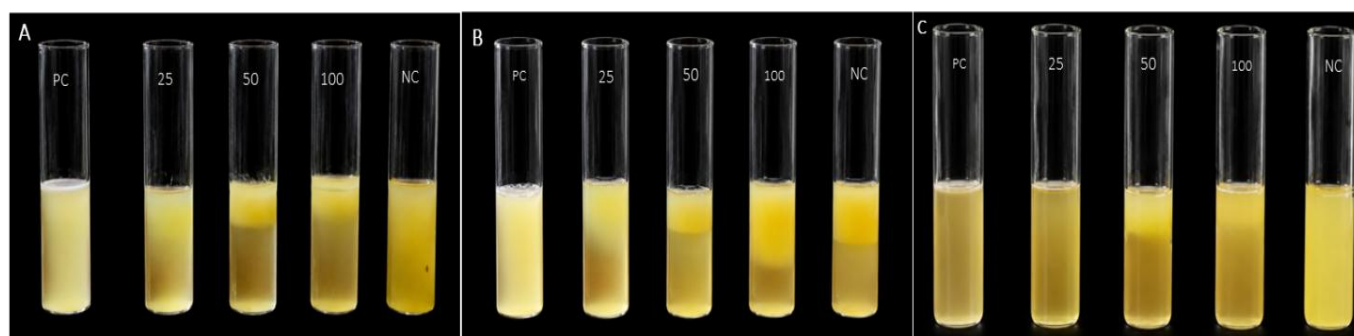


Fig 6: MIC assay showing concentration-dependent inhibition of bacterial growth by the ginger ethanolic extract

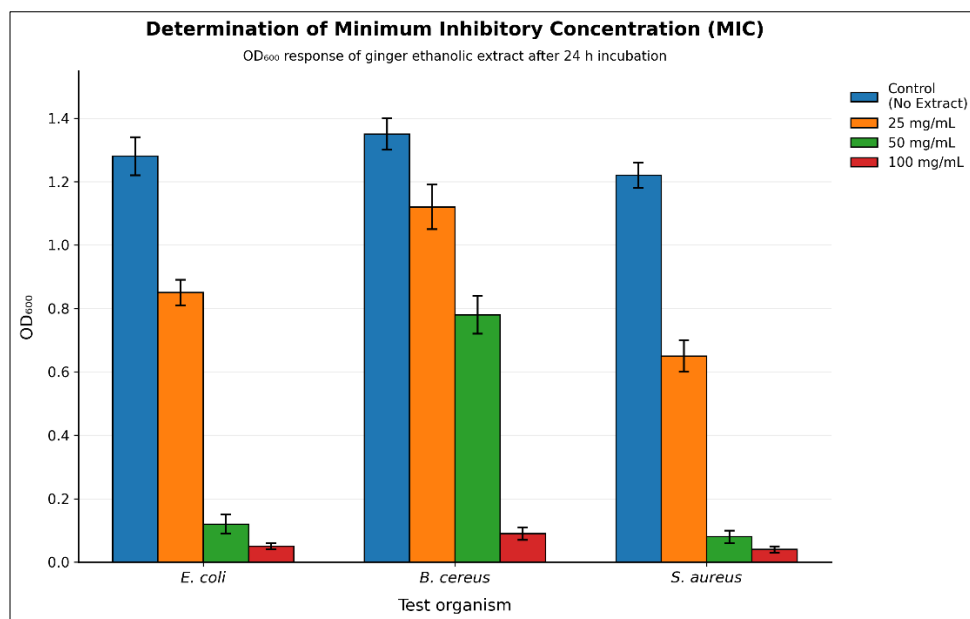


Fig 7: Minimum inhibitory concentration (MIC) of the ginger extract against test pathogens. Bars represent mean $\pm$ SD ($n=3$) of OD_{600} values after 24 h incubation

The Minimum Inhibitory Concentration (MIC) was determined as the lowest concentration exhibiting no discernible growth and OD_{600} values similar to the sterility control (<0.1). While *B. cereus* required a higher dosage (MIC = 100 mg/mL) for total suppression, the extract showed considerable inhibitory activity against *S. aureus* and *E. coli* (MIC = 50 mg/mL). The concentration-dependent zones of inhibition seen in the agar well diffusion assay is in line with these findings.

Discussion

The 80% ethanolic extract of *Zingiber officinale* Roscoe, which was obtained from Salem, Tamil Nadu, showed concentration-dependent antibacterial activity against a few foodborne pathogens, according to the current study. The extraction yield of 14.8% (w/w) obtained by cold maceration, which is comparable to previous reports using similar ethanolic extraction systems, shows that 80% ethanol is an effective solvent for extracting both polar and moderately non-polar phytochemicals (Islam *et al.*, 2014;

Karuppiah & Rajaram, 2012; Edo *et al.*, 2024) [3, 4, 7]. A highly varied phytochemical profile with 42 tentatively identified chemicals, accounting for 97.2% of the total ion current, was found by GC-MS analysis. Phenolic ketones and sesquiterpenes predominated in the extract, with the main ingredients being 6-gingerol (22.45%), α -zingiberene (15.34%), 6-shogaol (9.67%), and β -sesquiphellandrene (8.91%). The cultivar may be a rich source of these bioactive compounds because the combined gingerol and shogaol content (39.8%) was similar to or higher than values reported for ginger grown in several other geographical regions (Suliman *et al.*, 2024; Gunasena *et al.*, 2022; Abdullahi *et al.*, 2020) [8, 9, 10]. However, cultivar, environmental factors, cultivation techniques, harvest maturity, and post-harvest processing probably have an impact on this variation. These results were corroborated by FTIR analysis, which revealed hydroxyl, carbonyl, and aromatic functional groups frequently linked to the main bioactive components of ginger. An obvious concentration-dependent rise in antibacterial activity was shown by the agar well diffusion experiment. *Staphylococcus aureus* showed the highest susceptibility among the studied species, followed by *Bacillus cereus* and *Escherichia coli*. Gram-positive bacteria were often more sensitive to ginger extracts than Gram-negative bacteria, according to earlier reports (Karuppiah & Rajaram, 2012; Othman *et al.*, 2020; Yassen, 2016) [4, 5, 6, 8]. This difference has been attributed to the outer lipopolysaccharide membrane of Gram-negative bacteria, which may reduce the penetration of hydrophobic phytochemicals. This variance is expected due to differences in the plant source, extraction methods, phytochemical content, and bacterial strains, even if the inhibitory zones found in this investigation were moderate when compared to those found in other studies (Auta *et al.*, 2011; Islam *et al.*, 2014) [2, 3]. Complete growth suppression was initially observed for *E. coli* and *S. aureus* at 50 mg/mL within the investigated dosage range, but *B. cereus* required 100 mg/mL. These results are consistent with previously published MIC ranges for ethanolic ginger extracts (Karuppiah & Rajaram, 2012; Othman *et al.*, 2020; Edo *et al.*, 2024) [4, 5, 7, 8]. The corresponding drop in OD₆₀₀ values supported these findings, which are consistent with previously reported MIC ranges for ethanolic ginger extracts (Karuppiah & Rajaram, 2012; Othman *et al.*, 2020; Edo *et al.*, 2024) [4, 5, 7, 8]. Because of its innate physiological characteristics, *B. cereus* can need a somewhat higher concentration. The gradual inhibition of bacterial growth with increasing extract content is indicated by the dose-dependent decrease in OD₆₀₀ values. Gingerols and shogaols, which have been shown to have antimicrobial qualities, may mediate the observed antibacterial activity. The current work combines GC-MS, FTIR, agar well diffusion, and MIC analyses to thoroughly assess the antibacterial potential of locally grown *Zingiber officinale* from Salem, Tamil Nadu, in contrast to numerous earlier studies that concentrated mainly on antibacterial activity. The results point to the possibility of using ginger ethanolic extract as a natural antibacterial agent for food preservation. Before being used in practice, its efficacy should be confirmed in actual food systems under various processing and storage circumstances. In order to increase stability and antimicrobial efficacy, future research should assess its activity against isolates produced from food, look into potential synergistic interactions with other natural

preservatives, and investigate cutting-edge delivery methods such nanoformulations. Overall, the current study shows that *Zingiber officinale* grown locally has a rich phytochemical composition and has encouraging antibacterial efficacy against significant foodborne pathogens. These findings provide scientific support for the potential use of bioactive components derived from ginger to create natural antibacterial agents for food safety purposes.

Conclusion

The ethanolic extract of locally grown *Zingiber officinale* Roscoe from Salem, Tamil Nadu, was shown in this study to have potential concentration-dependent antibacterial activity against *Bacillus cereus*, *Staphylococcus aureus*, and *Escherichia coli*. The phytochemical profile rich in bioactive components shown by GC-MS and FTIR analysis may be responsible for the reported antibacterial action. These results offer scientific backing for the historic usage of ginger as a natural antibacterial agent and point to its possible use as a sustainable substitute for artificial preservatives to enhance food safety. Further research in real food systems is required to verify its practical efficacy and explore complex formulations for enhanced stability and antibacterial action.

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