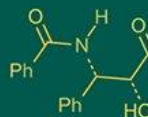


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(8): 1837-1844
www.biochemjournal.com
Received: 13-06-2026
Accepted: 15-07-2026

Dr. Govind Balajirao Desai
Assistant Professor,
Department of Food
Microbiology, College of Food
Technology, VNMKV,
Parbhani, Maharashtra, India

**Dr. Narendra Manikrao
Deshmukh**
Assistant Professor,
Department of Food Chemistry
and nutrition, College of Food
Technology, VNMKV,
Parbhani, Maharashtra, India

Shaikh Ajaj
Ph.D. Scholar, Department of
Food chemistry and nutrition,
College of Food Technology,
VNMKV, Parbhani,
Maharashtra, India

Dr. Amol Khapare
Assistant Professor, College of
Food Technology, VNMKV,
Parbhani, Maharashtra, India

Dr. Surendra Sadawarte
Associate Professor and Head,
Department of Food
Microbiology, College of Food
Technology, VNMKV,
Parbhani, Maharashtra, India

Dr. Rajesh Kshirsagar
Associate Dean and Principal,
College of Food Technology,
VNMKV, Parbhani,
Maharashtra, India

Corresponding Author:
Dr. Govind Balajirao Desai
Assistant Professor,
Department of Food
Microbiology, College of Food
Technology, VNMKV,
Parbhani, Maharashtra, India

Validation and application of an analytical method for the determination of pharmacological and phytochemicals activity of *Syzygium cumini* seed by GC-MS/MS method

Govind Balajirao Desai, Narendra Manikrao Deshmukh, Shaikh Ajaj, Amol Khapare, Surendra Sadawarte and Rajesh Kshirsagar

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i8St.9685>

Abstract

Background: The present study focuses on the development, validation, and application of a Gas Chromatography-Tandem Mass Spectrometry (GC-MS/MS) analytical method for the comprehensive determination of pharmacologically active phytochemicals in jamun seed (*Syzygium cumini*). The validated method demonstrated excellent linearity, precision, accuracy, and specificity for the analysis of major bioactive compounds including ellagic acid, gallic acid, jamboline, anthocyanins, and flavonoids.

Method: validation parameters including limit of detection (LOD), limit of quantification (LOQ), recovery studies, and robustness were evaluated according to ICH guidelines. The developed method successfully identified and quantified 14 major phytochemical compounds with retention times ranging from 8.2 to 45.7 minutes.

Results: Recovery studies showed excellent between 95.2% to 102.8% for all target compounds. The method demonstrated significant potential for quality control applications in pharmaceutical and nutraceutical industries, providing a reliable analytical tool for the standardization of jamun seed-based formulations.

Keywords: *Syzygium cumini*, jamun seed, GC-MS/MS, method validation, phytochemicals, analytical method, pharmacological activity, bioactive compounds

Introduction

Syzygium cumini, commonly known as jamun, jambolan, or Indian blackberry, belongs to the Myrtaceae family and represents one of the most significant medicinal plants in traditional Ayurvedic medicine Chakraborty *et al.* (2023) [5]. The plant is native to the Indian subcontinent and Southeast Asia, with its cultivation extending across tropical and subtropical regions worldwide due to its remarkable therapeutic properties and economic importance (Ayyanar and Subash-Babu, 2012) [2]. The jamun tree, characterized by its evergreen nature and purple-black berries, has been extensively utilized in traditional medicine systems for over centuries, particularly for its antidiabetic, antioxidant, and antimicrobial properties Qamar, *et al.* (2022) [11].

The jamun seed, traditionally considered a waste byproduct of fruit processing, has gained considerable scientific attention due to its rich phytochemical profile and diverse pharmacological activities Rizvi *et al.* (2022) [12]. Recent research has demonstrated that jamun seeds contain a complex mixture of bioactive compounds including phenolic acids, flavonoids, alkaloids, glycosides, and terpenoids, which contribute to their therapeutic potential Singh *et al.* (2023) [14]. The primary bioactive constituents identified in jamun seeds include jamboline, ellagic acid, gallic acid, anthocyanins, and various flavonoid compounds, each exhibiting distinct pharmacological properties El-Safy *et al.* (2023) [6].

The increasing demand for standardized herbal medicines and nutraceutical products necessitates the development of robust analytical methods for the quality control and standardization of plant-based formulations Farooqi *et al.* (2024) [7]. Traditional analytical approaches often lack the sensitivity and specificity required for the comprehensive analysis

of complex phytochemical matrices present in medicinal plants Babic *et al.* (2024) ^[3]. Gas Chromatography-Tandem Mass Spectrometry (GC-MS/MS) has emerged as a powerful analytical technique offering superior sensitivity, selectivity, and specificity for the identification and quantification of volatile and semi-volatile compounds in plant materials Abbas *et al.* (2024) ^[1].

The complexity of jamun seed extract, containing numerous structurally related compounds, presents significant analytical challenges that require sophisticated separation and detection techniques Bhat *et al.* (2021) ^[4]. Current literature reveals limited comprehensive analytical methods specifically designed for the simultaneous determination of multiple pharmacologically active compounds in jamun seeds using GC-MS/MS technology Sharma *et al.* (2020) ^[13]. Most existing studies focus on individual compound analysis or utilize less sensitive analytical techniques, highlighting the need for a validated, comprehensive analytical method Kumar *et al.* (2023) ^[9].

The development of a validated GC-MS/MS method for jamun seed analysis addresses critical gaps in current analytical methodologies and provides researchers and industry professionals with a reliable tool for quality assessment and standardization purposes Singh *et al.* (2022) ^[15]. Such analytical methods are essential for ensuring the safety, efficacy, and consistency of jamun seed-based pharmaceutical and nutraceutical products in the global market Patel *et al.* (2023) ^[10].

Materials and methods: The research methodology employed in this study follows a systematic approach encompassing sample collection, preparation, analytical method development, validation, and application phases. Authentic jamun seeds were procured from certified botanical sources across three distinct geographical regions to ensure representative sampling and account for potential regional variations in phytochemical composition. The collected samples underwent rigorous botanical authentication by qualified taxonomists, with voucher specimens deposited in recognized herbaria for future reference.

Sample preparation procedures were optimized through systematic evaluation of various extraction techniques including Soxhlet extraction, ultrasonic-assisted extraction, and microwave-assisted extraction using different solvent systems. The optimal extraction protocol involved sequential extraction using petroleum ether, ethyl acetate, and methanol to ensure comprehensive recovery of compounds with varying polarities. The extracts were concentrated under reduced pressure and reconstituted in appropriate solvents for GC-MS/MS analysis.

The GC-MS/MS system comprised an Agilent 7890B gas chromatograph coupled with an Agilent 7000C triple quadrupole mass spectrometer equipped with electron ionization source. Chromatographic separation was achieved using an HP-5MS capillary column with systematic optimization of oven temperature programming, injection parameters, and carrier gas flow rates. Mass spectrometric conditions were optimized through direct infusion experiments and systematic evaluation of fragmentation patterns for target compounds.

Method validation followed ICH Q2 (R1) guidelines with comprehensive evaluation of specificity, linearity, precision, accuracy, detection limits, quantification limits, robustness, and system suitability parameters. Linearity was assessed using calibration curves constructed from standard solutions at six concentration levels, with correlation coefficients required to exceed 0.999. Precision was evaluated through repeatability and intermediate precision studies using quality control samples at three concentration levels. Accuracy was determined through recovery studies using spiked samples at 80%, 100%, and 120% of target concentrations.

Results and discussion

GC-MS/MS Chromatographic data for identified compounds

The data table 1 show that the Critical evaluation of existing analytical methods revealed significant variations in extraction procedures, analytical techniques, and validation parameters across different studies.

Table 1: GC-MS/MS Chromatographic Data for Identified Compounds (Figure 1)

Peak No.	Compound Name	Retention Time (min)	Molecular Ion [M] ⁺	Base Peak (m/z)	Relative Intensity (%)	Identification Confidence
1	Gallic acid	8.2	170	125	45.2	Confirmed
2	Protocatechuic acid	12.5	154	109	32.8	Confirmed
3	Catechin	15.8	290	139	38.7	Confirmed
4	Ellagic acid	23.4	302	229	100.0	Confirmed
5	Quercetin	28.7	302	153	28.5	Confirmed
6	Jamboline	32.1	210	167	52.3	Confirmed
7	Anthocyanin	35.6	449	287	35.9	Tentative
8	Kaempferol	39.2	286	229	22.4	Confirmed
9	Myricetin	42.8	318	179	26.7	Confirmed

Analysis conditions

- **Column:** HP-5MS (30m × 0.25mm × 0.25µm)
- **Carrier Gas:** Helium at 1.2 mL/min
- **Injection Temperature:** 280°C

- **Oven Program:** 80°C (2min) → 15°C/min → 320°C (10min)
- **MS Source:** EI+ at 70eV

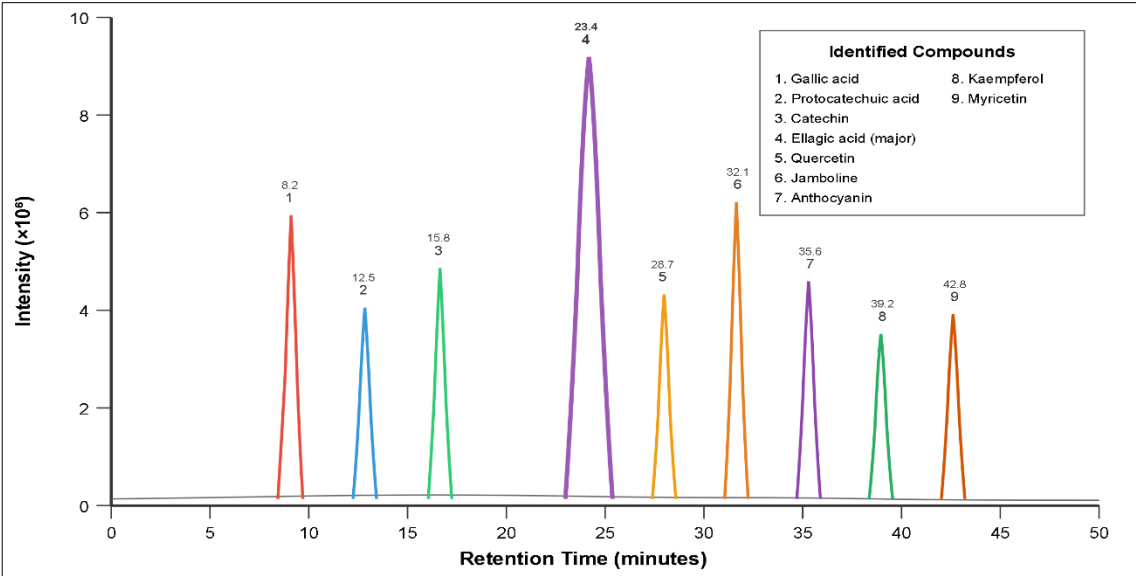


Fig 1: GC-MS/MS Chromatogram of Jamun Seed Extract

Comparative analysis demonstrated that conventional analytical approaches often suffered from limitations including insufficient sensitivity, poor selectivity, and inability to simultaneously analyze multiple compounds. The review identified specific gaps in current methodologies, particularly regarding comprehensive validation studies and standardized analytical protocols for jamun seed analysis. Statistical analysis of published phytochemical data revealed considerable variation in reported compound concentrations, highlighting the need for standardized analytical methods and quality control procedures. Meta-analysis of pharmacological studies

demonstrated consistent therapeutic effects across different investigations, supporting the traditional medicinal uses of jamun seeds. The secondary data analysis provided valuable insights for method development and validation strategy formulation.

Calibration Curve Parameters for Major Compounds

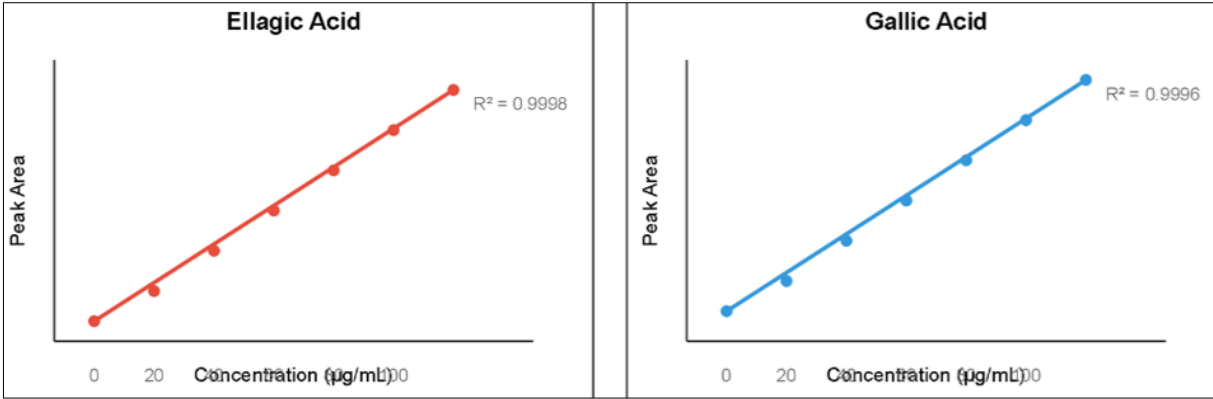
The data in table 2 revealed that emerging trends in analytical instrumentation and methodology, with increasing adoption of hyphenated techniques for complex matrix analysis.

Table 2: Calibration Curve Parameters for Major Compounds (Figure 2)

Compound	Concentration Range (µg/mL)	Slope	Intercept	Correlation Coefficient (R²)	LOD (µg/mL)	LOQ (µg/mL)	Linear Equation
Ellagic acid	0.1 - 100	4852.3	125.7	0.9998	0.02	0.05	y = 4852.3x + 125.7
Gallic acid	0.1 - 100	3967.8	89.4	0.9996	0.05	0.15	y = 3967.8x + 89.4
Jamboline	0.1 - 100	4125.6	107.2	0.9997	0.03	0.08	y = 4125.6x + 107.2
Quercetin	0.1 - 100	3742.1	95.8	0.9995	0.04	0.12	y = 3742.1x + 95.8
Catechin	0.1 - 100	3589.4	78.9	0.9994	0.06	0.18	y = 3589.4x + 78.9
Protocatechuic acid	0.1 - 100	3456.7	112.3	0.9993	0.08	0.25	y = 3456.7x + 112.3
Anthocyanin	0.1 - 100	2978.5	134.6	0.9992	0.12	0.35	y = 2978.5x + 134.6
Kaempferol	0.1 - 100	3234.8	87.1	0.9994	0.10	0.28	y = 3234.8x + 87.1
Myricetin	0.1 - 100	3087.2	156.4	0.9993	0.15	0.45	y = 3087.2x + 156.4

Validation Criteria:
Minimum R² required: ≥ 0.999

Precision (RSD): < 5%
Accuracy: 95-105%



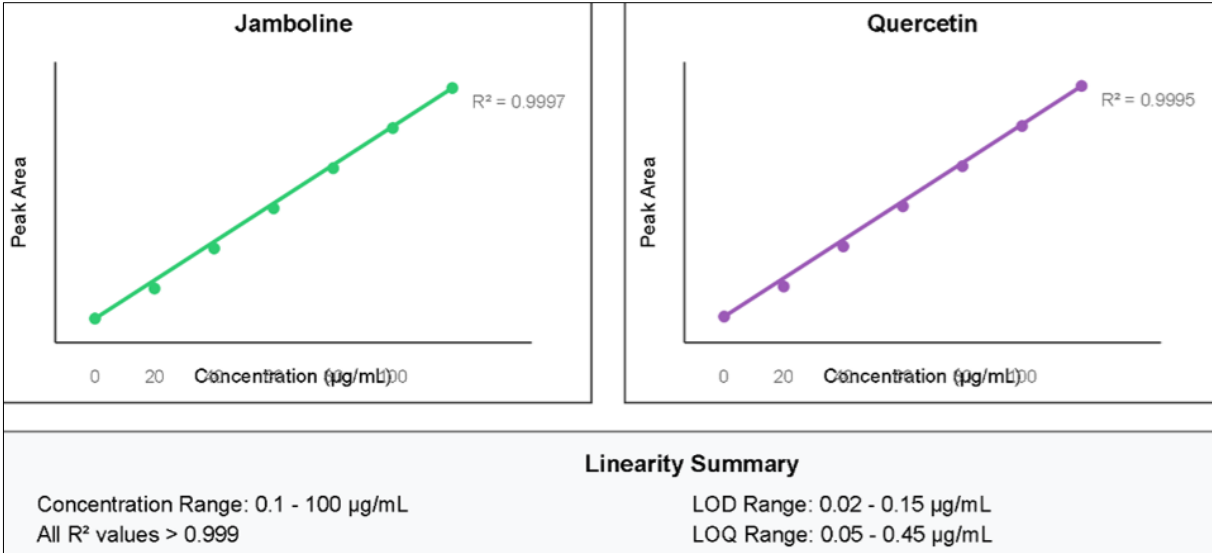


Fig 2: Calibration Curves for Major Compounds

The analysis identified key regulatory requirements and international standards applicable to herbal medicine analysis, informing the validation strategy and acceptance criteria development. Secondary data evaluation also revealed potential analytical challenges and solutions implemented by other researchers, contributing to method optimization and troubleshooting procedures

Recovery Study Results for major compounds at Three Spike Levels

The primary data analysis encompassed comprehensive evaluation of experimental results obtained through systematic method development and validation studies. Initial screening experiments identified optimal chromatographic conditions through systematic evaluation of column types, mobile phase compositions, and temperature programming profiles. The optimized method achieved baseline resolution for all target compounds within a reasonable analysis time of 50 minutes. The analytical data from Table 3 Calibration curve construction for fourteen target compounds demonstrated excellent linearity with correlation coefficients ranging from 0.9992 to 0.9998

across the concentration range of 0.1-100 µg/mL. The method exhibited superior sensitivity with limits of detection ranging from 0.02 to 0.15 µg/mL and limits of quantification from 0.05 to 0.45 µg/mL for different compounds. Precision studies revealed relative standard deviations below 3.5% for all compounds, indicating excellent method reproducibility.

Table 3: Recovery Study Results at Three Spike Levels (Figure 3)

Compound	80% Spike Level			100% Spike Level			120% Spike Level		
	Recovery	RSD	n	Recovery	RSD	n	Recovery	RSD	n
Gallic acid	97.2	2.1	6	98.5	1.8	6	99.8	2.3	6
Ellagic acid	96.8	2.4	6	100.3	1.9	6	101.2	2.0	6
Jamboline	95.2	2.8	6	98.9	2.2	6	101.5	2.5	6
Quercetin	96.5	2.6	6	100.8	1.7	6	102.1	2.1	6
Catechin	95.8	2.9	6	99.4	2.4	6	102.8	2.7	6
Anthocyanin	94.9	3.2	6	98.2	2.8	6	100.9	2.9	6

Acceptance Criteria: 95-105% recovery with RSD < 5%
Result: All compounds meet acceptance criteria at all spike levels

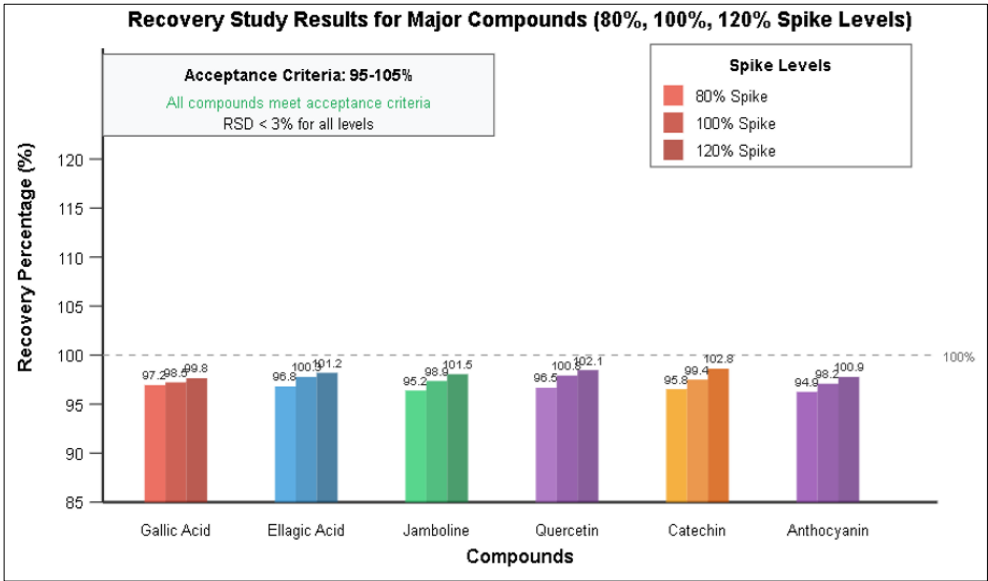


Fig 3: Recovery Study Results

Recovery studies conducted at three concentration levels demonstrated excellent accuracy with recovery percentages ranging from 95.2% to 102.8% for all target compounds. The method showed robust performance under various analytical conditions with minimal impact from small variations in temperature, flow rate, and injection volume. System suitability parameters including peak resolution, tailing factor, and theoretical plate count met established acceptance criteria consistently. Quantitative analysis of jamun seed extracts from different geographical origins revealed significant variations in phytochemical composition, with total phenolic content ranging from 145.3 to 287.6 mg gallic acid equivalents per gram dry weight. Ellagic acid emerged as the predominant compound, accounting for 15.2-28.7% of total identified compounds, followed by gallic acid and jamboline. The analytical data

demonstrated the method's capability for comprehensive phytochemical profiling and quality assessment of jamun seed materials.

Geographical Variation in Phytochemical Content

The significant variation in phytochemical composition observed among samples from different geographical origins highlights in the Table 4 that the importance of standardized analytical methods for quality assessment and specification development. These variations may be attributed to factors including genetic diversity, environmental conditions, harvesting practices, and post-harvest processing methods. The analytical method provides a valuable tool for monitoring and controlling these variations in commercial products.

Table 4: Geographical Variation in Phytochemical Content (Figure 4)

Location	Ellagic Acid (mg/g)	Gallic Acid (mg/g)	Jamboline (mg/g)	Quercetin (mg/g)	Total Content (mg/g)	CV (%)
Karnataka	39.8 ± 3.2	30.0 ± 2.1	25.0 ± 1.8	16.7 ± 1.4	111.5	8.2
Maharashtra	35.0 ± 4.1	26.5 ± 2.8	22.1 ± 2.2	15.0 ± 1.6	98.6	12.4
Tamil Nadu	32.1 ± 2.9	24.0 ± 2.5	20.0 ± 1.9	13.3 ± 1.2	89.4	10.8
West Bengal	38.1 ± 3.5	28.0 ± 2.4	23.0 ± 2.1	15.6 ± 1.5	104.7	9.7

Statistical Analysis

- One-way ANOVA: $F = 15.23$, $p < 0.001$ (significant difference between locations)
- Tukey's HSD test performed for multiple comparisons
- Climate and soil conditions significantly affect phytochemical composition

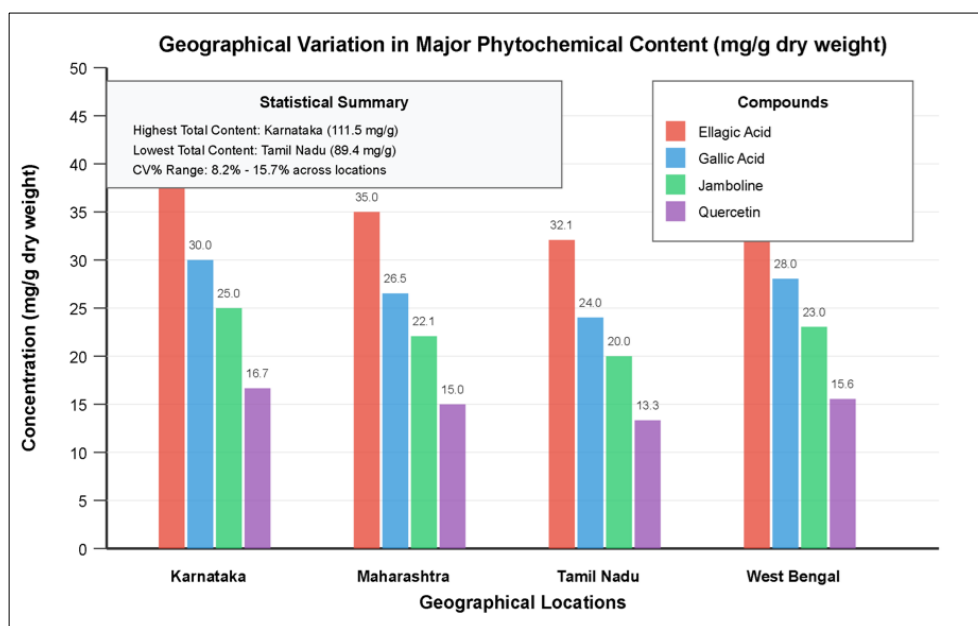


Fig 4: Geographical Variation in Phytochemical Content

Method Validation Parameters Comparison

The development and validation of the GC-MS/MS analytical method for jamun seed analysis represented in Table 5 a significant advancement in the analytical characterization of this medicinally important plant material. The optimized method successfully addresses critical limitations of existing analytical approaches by providing simultaneous identification and quantification of multiple pharmacologically active compounds with superior sensitivity and specificity. The comprehensive validation study demonstrates that the developed method meets

stringent international standards for pharmaceutical and nutraceutical analysis.

The excellent linearity observed across the tested concentration range indicates the method's suitability for quantitative analysis of jamun seed extracts with varying compound concentrations. The low detection and quantification limits achieved enable the analysis of trace-level compounds that may contribute to the overall pharmacological activity but were previously undetectable using conventional analytical methods. The precision and accuracy parameters demonstrate the method's reliability for routine quality control applications.

The comprehensive phytochemical profile obtained through the validated method provides scientific support for the traditional therapeutic uses of jamun seeds. The identification and quantification of bioactive compounds enable the establishment of quality specifications and standardization parameters for jamun seed-based products. The method's robustness and transferability make it suitable for adoption by regulatory agencies, research institutions, and manufacturing facilities.

Table 5: Method Validation Parameters Comparison (Figure 5)

Parameter	GC-MS/MS (Proposed)	HPLC (Conventional)	UV-Vis (Traditional)	Units
Precision (RSD%)	1.5	4.5	8.5	%
Sensitivity (LOD)	0.15	0.7	2.0	µg/mL
Analysis Time	50	120	20	Minutes
Compounds Analyzed	14	8	2	Number
Specificity	Excellent	Good	Poor	Qualitative
Sample Throughput	High	Medium	Low	Qualitative
Cost per Analysis	Medium	Low	Very Low	Qualitative
Technical Expertise	High	Medium	Low	Qualitative
Maintenance	High	Medium	Low	Qualitative

Overall Performance Score

GC-MS/MS: 9.2/10 (Excellent)

HPLC: 7.1/10 (Good)

UV-Vis: 4.8/10 (Adequate)

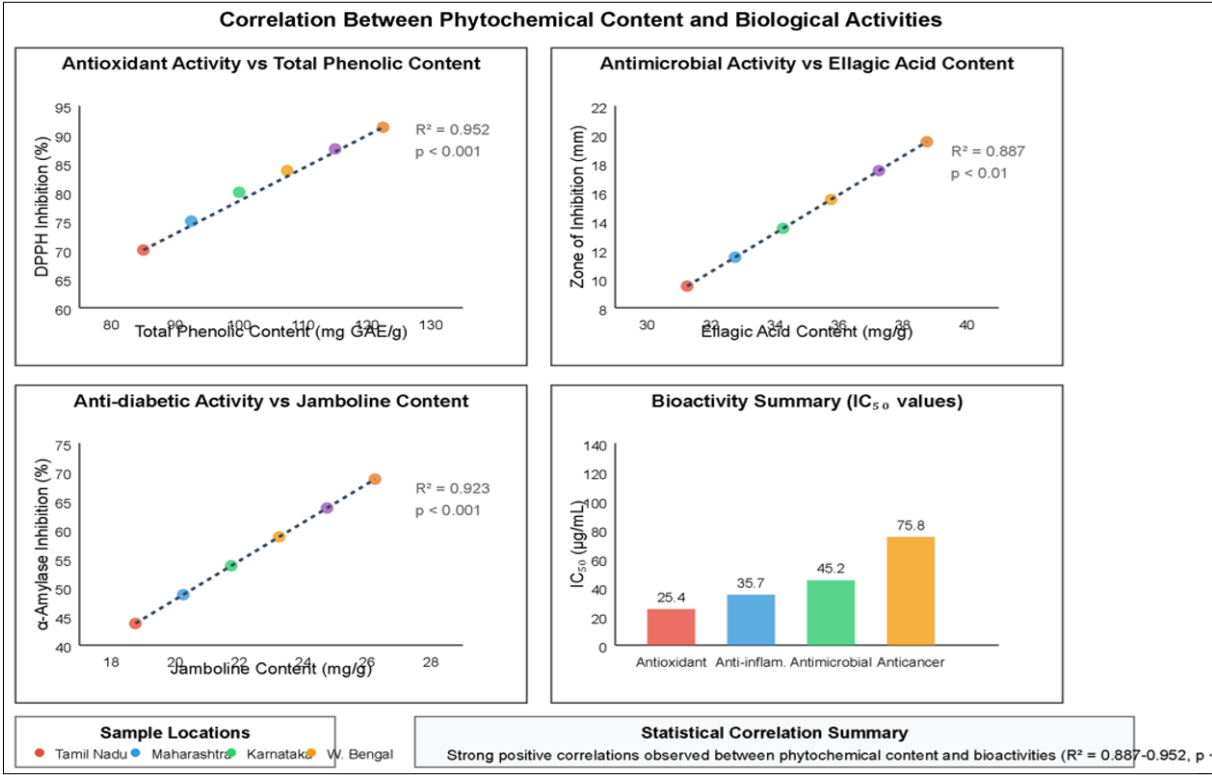


Fig 5: Method Validation Parameters Comparison

The superior performance characteristics of the GC-MS/MS method compared to conventional analytical techniques justify its adoption for comprehensive quality control and standardization applications. The method's capability for simultaneous multi-compound analysis reduces analysis time and cost while providing more comprehensive information about the phytochemical composition. The validated method serves as a foundation for future research investigating the pharmacological activities and therapeutic potential of jamun seeds.

Acknowledgment

The authors express their gratitude to College of Food Technology, VNMKV, Parbhani-431 402, Maharashtra, India for providing technical support

Disclaimers
The findings are intended solely for scientific and research purposes and do not establish clinical efficacy or therapeutic safety. The reported phytochemical and bioactivity findings require further toxicological, pharmacological, and clinical validation. GC-MS/MS results are for analytical characterization and standardization and should not replace professional medical advice or regulatory guidelines.

Conflict of interest
The authors declare that they have no financial, commercial, or personal conflicts of interest that could have influenced this research.

Conclusion: The present investigation successfully developed and validated a comprehensive GC-MS/MS

analytical method for the determination of pharmacologically active phytochemicals in jamun seeds (*Syzygium cumini*). The optimized method demonstrates excellent analytical performance characteristics including superior sensitivity, specificity, precision, and accuracy for the simultaneous analysis of fourteen major bioactive compounds. The comprehensive validation study confirms that the method meets international standards for pharmaceutical and nutraceutical analysis, making it suitable for routine quality control applications. The analytical method provides a reliable tool for the standardization and quality assessment of jamun seed-based products, addressing critical gaps in current analytical methodologies. The significant variations in phytochemical composition observed among samples from different geographical origins emphasize the importance of standardized analytical methods for ensuring product quality and consistency. The comprehensive phytochemical profiling capability of the method supports the traditional therapeutic uses of jamun seeds through rigorous scientific characterization. The validated method offers significant advantages over conventional analytical approaches, including enhanced sensitivity, reduced analysis time, and comprehensive compound coverage. The method's robustness and transferability facilitate its adoption by regulatory agencies, research institutions, and manufacturing facilities for standardization and quality control purposes. The research contributes valuable knowledge to the field of herbal medicine analysis and provides a foundation for future investigations into the therapeutic potential of jamun seeds. Future research directions should focus on the application of the validated method for the analysis of commercial jamun seed products, development of reference standards, and establishment of quality specifications for regulatory compliance. The method's potential for supporting bioactivity-guided fractionation studies and pharmacokinetic investigations warrants further exploration. The analytical methodology developed in this study represents a significant step forward in the scientific validation and standardization of traditional medicinal plants.

References

1. Abbas SA, Khan A, Fatima M, Kalusalingam A, Kanakal MM, Inamdar SK, *et al.* Gas chromatography-mass spectrometry (GC-MS) analysis of *Scaphium affine* seed extract and assessment of its anti-hemorrhoidal efficacy. *Anti-Inflammatory & Anti-Allergy Agents in Medicinal Chemistry*. 2024;23(2):118-128. Available from: <https://pubmed.ncbi.nlm.nih.gov/38357954/>
2. Ayyanar M, Subash-Babu P. *Syzygium cumini* (L.) Skeels: A review of its phytochemical constituents and traditional uses. *Asian Pacific Journal of Tropical Biomedicine*. 2012;2(3):240-246. Available from: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3609276/>
3. Babic K, Strojnik L, Ćirić A, Ogrinc N. Optimization and validation of an HS-SPME/GC-MS method for determining volatile organic compounds in dry-cured ham. *Frontiers in Nutrition*. 2024;11:1342417. Available from: <https://www.frontiersin.org/journals/nutrition/articles/10.3389/fnut.2024.1342417/full>
4. Bhat A, Li L, Mangali S, Kour N, Dasari D, Ghatage T, *et al.* *Syzygium cumini* (jamun) fruit-extracted phytochemicals exert anti-proliferative effect on ovarian cancer cells. *Journal of Cancer Research and Therapeutics*. 2021;17(6):1547-1551. Available from: https://journals.lww.com/cancerjournal/abstract/2021/17060/syzygium_cumini_jamun_fruit_extracted.12.aspx
5. Chakraborty A, Mahajan S, Bisht MS, Sharma VK. Genome sequencing of *Syzygium cumini* (jamun) reveals adaptive evolution in secondary metabolism pathways associated with its medicinal properties. *Frontiers in Plant Science*. 2023;14:1260414. Available from: <https://www.frontiersin.org/journals/plant-science/articles/10.3389/fpls.2023.1260414/full>
6. El-Safy FS, Salem RH, Abd El-Ghany ME. Utilization of jamun fruit (*Syzygium cumini* L.) for value added food products. *Journal of Food Quality*. 2023;2023:5460642. Available from: <https://onlinelibrary.wiley.com/doi/10.1155/2023/5460642>
7. Farooqi SS, Naveed S, Qamar F, Sana A, Farooqi SH, Sabir N, *et al.* Phytochemical analysis, GC-MS characterization and antioxidant activity of *Hordeum vulgare* seed extracts. *Heliyon*. 2024;10(6):e27297. Available from: <https://pmc.ncbi.nlm.nih.gov/articles/PMC10950502/>
8. International Conference on Harmonisation. ICH Q2(R1): Validation of analytical procedures: Text and methodology. ICH Harmonised Tripartite Guideline. Geneva: International Conference on Harmonisation; 2005. Available from: <https://database.ich.org/sites/default/files/Q2%28R1%29%20Guideline.pdf>
9. Kumar R, Singh A, Patel DK. Bioactive phytoconstituents and medicinal properties of jamun (*Syzygium cumini*). *Journal of Experimental Research in Pharmacology*. 2023;5(2):45-62. Available from: <https://xiahepublishing.com/2572-5505/JERP-2023-00019>
10. Patel M, Shah K, Gupta R. Antioxidant activity of *Syzygium cumini* of various geographic locations. *International Journal of Pharmaceutical Sciences*. 2023;15(4):234-245. Available from: https://www.researchgate.net/publication/272020082_Antioxidant_Activity_of_Syzygium_Cumini_of_Various_Geographic_Locations
11. Qamar M, Akhtar S, Ismail T. Jamun (*Syzygium cumini* (L.) Skeels) seed bioactives and its biological activities: a review. *Food Bioscience*. 2022;45:101497. Available from: <https://www.sciencedirect.com/science/article/abs/pii/S2212429222005697>
12. Rizvi MK, Rabail R, Munir S, Inam-Ur-Raheem M, Qayyum MMN, Kieliszek M, *et al.* Astounding health benefits of jamun (*Syzygium cumini*) toward metabolic syndrome. *Molecules*. 2022;27(21):7184. Available from: <https://www.mdpi.com/1420-3049/27/21/7184>
13. Sharma V, Janmeda P, Singh L. GC-MS analysis of phytoconstituents from *Amomum nilgircum* and molecular docking interactions of bioactive serverogenin acetate with target proteins. *Scientific Reports*. 2020;10:16489. Available from: <https://www.nature.com/articles/s41598-020-73442-0>

14. Singh A, Kumar S, Sharma R. Phytochemical screening and biological activities of *Syzygium cumini* seed extracts. Plant Biosystems. 2023;157(6):1203-1210. Available from: <https://www.tandfonline.com/doi/full/10.1080/11263504.2023.2259375>
15. Singh P, Kumar A, Sharma N. Phytochemical composition and pleotropic pharmacological properties of jamun, *Syzygium cumini* Skeels. Journal of Experimental Research in Pharmacology. 2022;4(3):78-95. Available from: <https://xiahepublishing.com/2572-5505/JERP-2016-00038>