Chemical Science Review and Letters ISSN 2278-6783

www.chesci.com Research Article

GC–MS Identification of Active Pharmaceutical Ingredients in Seized Drug Formulations: A Multidisciplinary Forensic Investigation

Bhvimane Sanna Jilani*

Department of Chemistry/ Forensic Science, Regional Forensic Science Laboratory, Kalaburagi-585102,

Karnataka, India

Abstract

Forensic science integrates analytical chemistry, toxicology, and forensic medicine to generate objective scientific evidence for criminal investigations. The identification of pharmaceutical substances recovered during investigations is particularly important in medico-legal cases involving alleged illegal confinement, physical assault, coercion, or suspected drug administration. Gas Chromatography–Mass Spectrometry (GC–MS) is a widely established analytical technique for identifying volatile and semi-volatile organic compounds by combining efficient chromatographic separation with mass spectral characterization. Its sensitivity, selectivity, reproducibility, and compatibility with spectral databases, particularly the National Institute of Standards and Technology (NIST) Mass Spectral Library, make it valuable for forensic drug analysis. The present study demonstrates the application of GC–MS for the qualitative identification of active pharmaceutical ingredients (APIs) in seized therapeutic drug formulations recovered during the investigation of an alleged case involving prolonged illegal confinement and repeated physical assault. The analytical findings provide objective evidence regarding the chemical composition of the seized exhibits. Although chemical identification alone cannot establish drug misuse or criminal intent, its correlation with medico-legal findings and other corroborative evidence can strengthen forensic interpretation. The study focuses exclusively on qualitative API identification, without quantitative estimation or dosage verification.

Keywords: Gas Chromatography–Mass Spectrometry (GC–MS); Forensic Toxicology; Forensic Chemistry; Pharmaceutical Identification; Flunarizine; tromethamine and ketorolac methyl ester ; Sertraline; Medico-Legal Investigation; Physical Assault; Analytical Toxicology; Criminal Investigation.

***Correspondence**

Author: Bhvimane Sanna Jilani

Introduction

The application of analytical chemistry in forensic science has become increasingly important for the identification and characterization of pharmaceutical substances encountered during criminal investigations. Therapeutic drugs recovered from crime scenes or seized during medico-legal investigations often provide valuable scientific evidence that assists in reconstructing events, establishing the nature of offences, and corroborating witness statements. Accurate identification of active pharmaceutical ingredients (APIs) is particularly significant in cases involving illegal confinement, poisoning, drug-facilitated crimes, and suspected administration of medications intended to incapacitate or influence victims [1,2].

Modern forensic toxicology integrates advanced analytical instrumentation with medico-legal investigation to provide objective and scientifically defensible evidence for judicial proceedings. Among the available analytical techniques, Gas Chromatography–Mass Spectrometry (GC–MS) remains one of the most reliable and widely accepted methods for qualitative identification of volatile and semi-volatile organic compounds. The technique combines high chromatographic separation efficiency with mass spectral fingerprinting, enabling definitive compound identification through comparison with validated spectral libraries such as the National Institute of Standards and Technology (NIST) Mass Spectral Library [3, 4]. Owing to its high specificity, sensitivity, reproducibility, and international acceptance, GC–MS continues to serve as a reference analytical technique in forensic laboratories worldwide [5].

Pharmaceutical preparations encountered in forensic casework frequently include analgesics, antidepressants, anxiolytics, sedatives, antihistamines, and neurological medications. Although these drugs are intended for legitimate

therapeutic use, they may also be encountered during criminal investigations involving unlawful restraint, prolonged confinement, coercion, domestic violence, or physical assault. Scientific identification of such pharmaceutical formulations enables investigators to verify the authenticity of seized materials, determine their pharmacologically active constituents [6, 7]. Consequently, reliable laboratory confirmation of APIs contributes substantially to the evidentiary value of pharmaceutical exhibits.

GC–MS has been extensively applied for the identification of pharmaceutical compounds in complex forensic matrices because of its excellent analytical performance and ability to distinguish chemically similar compounds. Mass spectral matching against validated reference databases provides highly reliable compound confirmation, while retention time information further strengthens analytical confidence. The technique has been successfully employed for forensic identification of analgesics, antidepressants, antiepileptic drugs, antihistamines, psychotropic substances, and numerous other pharmaceutical agents recovered from seized exhibits and biological samples [4, 8].

Among the pharmaceutical compounds investigated in the present study, Flunarizine is a selective calcium channel blocker widely prescribed for migraine prophylaxis and vestibular disorders. Tromethamine is an organic amine commonly used as a buffering and salt-forming agent in pharmaceutical formulations, whereas ketorolac methyl ester is the methyl ester derivative of ketorolac, an NSAID widely used for the short-term management of moderate to severe pain, whereas Sertraline is a selective serotonin reuptake inhibitor (SSRI) extensively used for depression, anxiety disorders, obsessive-compulsive disorder, and post-traumatic stress disorder. Although these medications are routinely prescribed in clinical practice, their forensic significance increases considerably when recovered during criminal investigations, where their identification may provide important contextual evidence regarding the circumstances surrounding the alleged offence [9–11].

In addition to laboratory identification, forensic interpretation requires integration of analytical findings with medico-legal examination, injury documentation, investigative information and chain-of-custody procedures. Such multidisciplinary evaluation strengthens the scientific validity of forensic conclusions by correlating physical evidence with clinical observations and investigative findings. Recent advances in forensic science increasingly emphasize collaborative interpretation involving analytical chemists, forensic toxicologists, forensic physicians, and investigating agencies to improve the reliability, transparency, and admissibility of scientific evidence presented before courts of law [2, 12].

The present study describes the qualitative identification of active pharmaceutical ingredients in three seized therapeutic drug formulations recovered during an alleged case of prolonged illegal confinement and physical assault. Using GC–MS with NIST Mass Spectral Library matching, Flunarizine was identified in Sibelium® 5 mg Tablets, Tromethamine and Ketorolac methyl ester in Ketrol-DT® 10 mg Tablets and Sertraline in Sertagess® 50 mg Tablets. The analytical findings were subsequently interpreted in conjunction with detailed medico-legal examination results, demonstrating the importance of integrating forensic analytical chemistry with forensic medicine to provide comprehensive, objective, and scientifically robust evidence that supports criminal investigations and the administration of justice.

Objectives of the Study

Primary Objective

- To qualitatively identify the active pharmaceutical ingredients (APIs) present in seized therapeutic drug formulations associated with an alleged case of prolonged illegal confinement and physical assault using Gas Chromatography–Mass Spectrometry (GC–MS).

Specific Objectives

- To analyze the seized Sibelium® 5 mg, Ketrol-DT® 10 mg, and Sertagess® 50 mg tablet formulations using GC–MS.
- To identify the APIs in the seized pharmaceutical formulations by comparing the obtained mass spectra with the National Institute of Standards and Technology (NIST) Mass Spectral Library.
- To evaluate the applicability of GC–MS as a reliable analytical technique for the forensic characterization of seized therapeutic drug formulations.
- To evaluate the qualitative chemical identity of the recovered pharmaceutical exhibits within the analytical scope of forensic laboratory testing.
- To demonstrate the value of integrating forensic analytical chemistry, forensic toxicology, and forensic medicine in strengthening scientific evidence during complex criminal investigations.

- To highlight the importance of standardized GC–MS methodologies for generating accurate, reproducible, and legally defensible analytical results that support medico-legal opinions and the administration of justice.

Materials and Methods

Case Background

The present study was conducted as part of a medico-legal investigation involving an alleged case of prolonged illegal confinement and physical assault. During the investigation, three therapeutic drug formulations were recovered by the investigating agency and submitted to the Regional Forensic Science Laboratory for chemical examination. The exhibits consisted of Sibelium® 5 mg tablets, Ketrol-DT® 10 mg tablets, and Sertagess® 50 mg tablets. All exhibits were received in sealed condition with proper documentation, and the integrity of the chain of custody was maintained throughout the examination in accordance with standard forensic laboratory procedures and international recommendations for handling physical evidence [3].

The present study was conducted as part of an forensic investigation involving seized pharmaceutical exhibits recovered by law enforcement agencies during a criminal case. The chemical examination was performed at the Regional Forensic Science Laboratory under administrative authorization and strictly following standard operating procedures for physical evidence examination.

Because the investigation was strictly limited to the qualitative chemical analysis of solid-dose pharmaceutical exhibits, no human biological specimens, clinical trials or direct animal/human subject testing were involved. All case background details have been completely anonymized to protect case confidentiality and ongoing judicial proceedings. Formal ethical clearance for human subject research was not required as no human biological materials or patient personal data were collected or analyzed; laboratory analysis was performed solely on physical drug exhibits submitted through standard legal chain-of-custody protocols.

Materials

Three seized pharmaceutical formulations were analyzed:

- Article 1: Sibelium® 5 mg Tablets
- Article 2: Ketrol-DT® 10 mg Tablets
- Article 3: Sertagess® 50 mg Tablets

Analytical-grade methanol (HPLC/GC grade) was used as the extraction solvent. Helium (99.999% purity) served as the carrier gas during GC–MS analysis. Mass spectral identification was performed using the National Institute of Standards and Technology (NIST) Mass Spectral Library, which provides authenticated reference spectra for compound identification.

Experimental conditions of GC-MS

GC conditions:

Column: 30 m × 0.25 m I.D, 0.25 µm film thickness, SH-Rxi-5Sil MS stationary phase. Injector temperature: 275 ºC, Injection mode: Split, Split ratio: 10:0, Oven temperature program: 200 ºC for 2 min, raised by 15 ºC /min to 260 ºC, and then raised by 25 ºC /min to 320 ºC where it was kept constant for 1 min, Total run time: 9.4 min, Injection volume: 1 µL.

Mass spectrometry conditions:

Mode: Electron impact ionization mode using energy of 70 eV, ion source temperature: 220 ºC, interface temperature: 250 ºC. Full scan mode using the mass range of 40–600 amu with a scan speed of 2000.

Sample Preparation

One tablet from each pharmaceutical formulation was separately pulverized using a clean mortar and pestle to obtain a homogeneous powder. Approximately 20–50 mg of each powdered sample was transferred into separate glass extraction vials. The powder was extracted with 1–2 mL of methanol, followed by vortex mixing and sonication for approximately 10–15 minutes to facilitate dissolution of the active pharmaceutical ingredients.

The extracts were centrifuged to remove insoluble excipients, and the clear supernatant was filtered through a 0.22 µm PTFE syringe filter into clean GC autosampler vials. Fresh disposable laboratory consumables were used during sample preparation to minimize the possibility of cross-contamination.

Quality Assurance

All analyses were performed following established forensic laboratory quality-assurance practices. Laboratory glassware and analytical instruments were cleaned and verified before analysis. Fresh extraction solvents were used for each sample, and appropriate procedural precautions were adopted to avoid contamination or analytical bias. The analytical workflow complied with internationally accepted forensic laboratory practices to ensure the reliability, reproducibility, and scientific validity of the reported findings [3, 13].

Chemicals and Reagents

Analytical-grade methanol (≥99.9%, GC grade) was used as the extraction solvent for the preparation of tablet extracts prior to GC–MS analysis. Helium (99.999% purity) was employed as the carrier gas for chromatographic separation. The purity of all reagents complied with the requirements for chromatographic analysis to minimize background interference and ensure reliable analytical performance. No derivatization reagents were required, as the pharmaceutical formulations were analyzed directly following solvent extraction.

For compound identification, the acquired mass spectra were compared with the National Institute of Standards and Technology (NIST) Mass Spectral Library, which provides validated reference spectra for qualitative identification of organic compounds. Instrument calibration, routine performance verification, and analytical quality assurance were carried out according to the laboratory's standard operating procedures and internationally accepted quality management practices to ensure the accuracy, precision, and reproducibility of the analytical results [14, 15].

Results and Discussion

GC–MS analysis of the three seized pharmaceutical formulations resulted in the successful qualitative identification of their respective active pharmaceutical ingredients (APIs). The chromatographic separation produced well-resolved peaks, and the corresponding electron ionization (EI) mass spectra exhibited characteristic fragmentation patterns. Comparison of the acquired spectra with the National Institute of Standards and Technology (NIST) Mass Spectral Library (NIST 23) provided high-confidence identification of the detected compounds. The analytical findings were consistent with the labeled therapeutic compositions of the seized formulations and provided objective scientific evidence regarding the identity of the recovered pharmaceutical exhibits [4, 7].

Identification of Flunarizine in Sibelium® 5 mg Tablets

GC–MS analysis of **Sibelium® 5 mg Tablets** confirmed the presence of **Flunarizine**, a selective calcium channel blocker widely prescribed for migraine prophylaxis and vestibular disorders. The chromatographic peak corresponding to flunarizine generated a characteristic EI mass spectrum that matched the reference spectrum in the NIST library, confirming its identity.

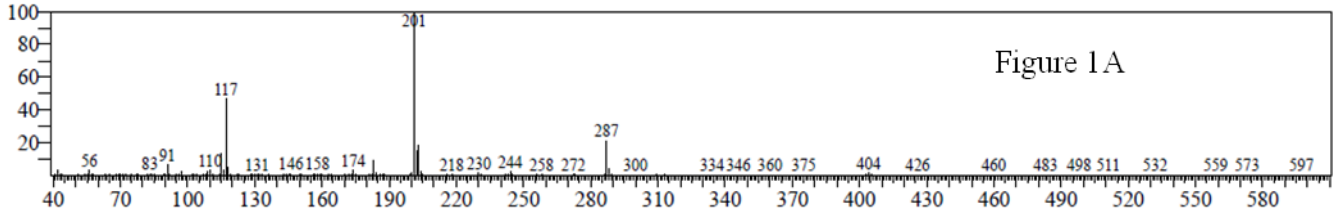


Figure 1A GC-MS Spectrum of Flunarizine.

Flunarizine possesses antihistaminic and calcium-channel-blocking properties and acts by reducing excessive calcium influx into neuronal cells. Although the drug is primarily prescribed for prophylactic treatment of migraine and vertigo, it may also produce adverse effects such as drowsiness, fatigue, dizziness, impaired psychomotor performance, and sedation in susceptible individuals. Consequently, forensic identification of flunarizine becomes important whenever the medication is recovered in criminal investigations involving allegations of unlawful confinement, coercion, or physical assault, where documentation of pharmaceutical evidence contributes to reconstructing the sequence of events. The present findings demonstrate the capability of GC–MS to accurately identify flunarizine in seized pharmaceutical

formulations with high analytical specificity [9–11]. GC-MS Spectrum of Flunarizine and its corresponding NIST library match is shown in **Figures 1 (A, B).**

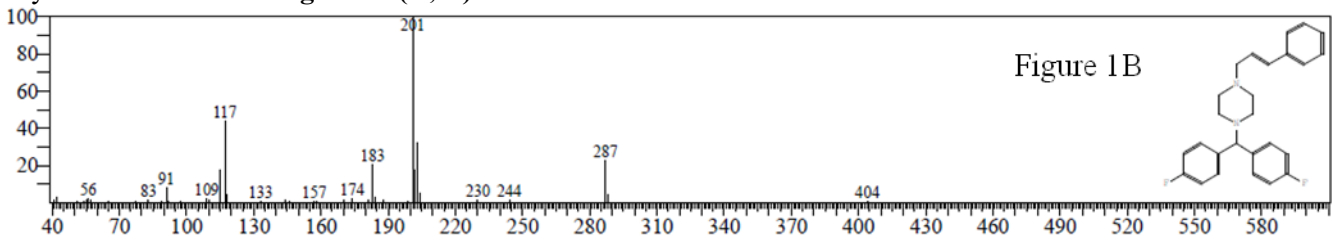


Figure 1B. Corresponding GC-MS NIST library match of Flunarizine.

Identification of Tromethamine and Ketorolac Methyl Ester in Ketrol-DT® 10 mg Tablets

Analysis of Ketrol-DT® 10 mg Tablets revealed the presence of Tromethamine and Ketorolac methyl ester. Ketorolac is formulated as a salt with tromethamine. The detection of ketorolac methyl ester rather than unchanged ketorolac is attributed to in situ thermal transesterification/esterification with the extraction solvent (methanol) under un-derivatized GC–MS conditions. Therefore, these detected species confirm the presence of the parent formulation, ketorolac tromethamine.

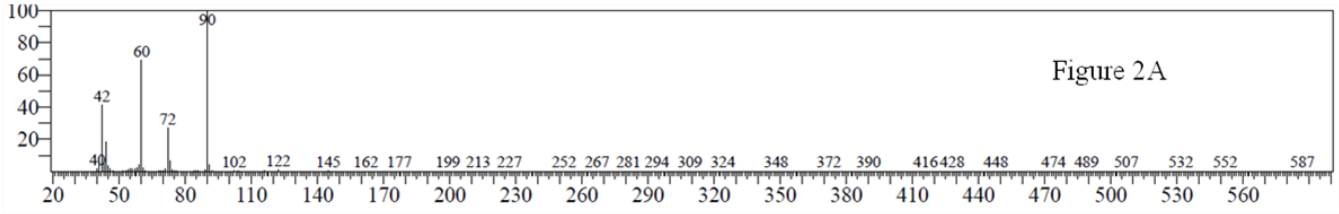


Figure 2A GC-MS Spectrum of Tromethamine

Mass spectral matching with the NIST library confirmed the identity of both detected compounds. The presence of ketorolac-related compounds is consistent with the pharmaceutical formulation intended for analgesic therapy. In medico-legal investigations involving physical assault, identification of analgesic medications may assist investigators in evaluating whether pain management drugs were available or administered during or after the alleged incident. Although the analytical findings alone cannot establish drug administration, they objectively confirm the identity of the seized pharmaceutical evidence submitted for forensic examination. Similar applications of GC–MS for identification of analgesic drugs have been reported in forensic pharmaceutical investigations because of the technique's excellent selectivity, reproducibility, and spectral reliability [6, 16-17]. GC-MS Spectrum of Tromethamine and its corresponding NIST library match is shown in **Figures 2 (A, B).** GC-MS Spectrum of Ketorolac Methyl Ester and its corresponding NIST library match is shown in **Figures 3 (A, B).**

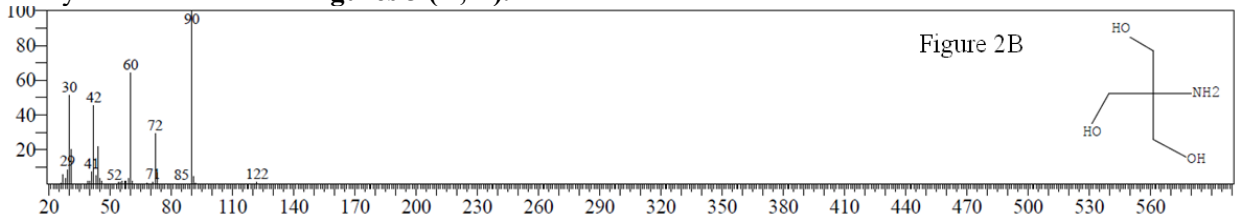


Figure 2B Corresponding GC-MS NIST library match of Tromethamine

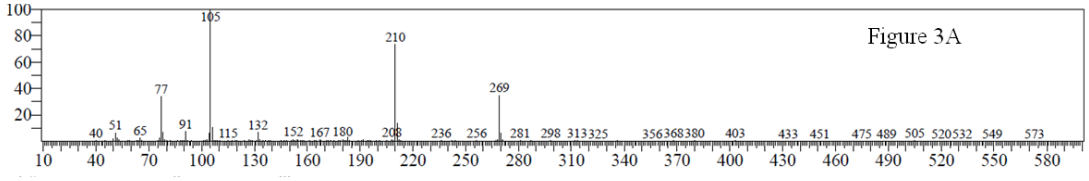


Figure 3A GC-MS Spectrum of Ketorolac Methyl Ester

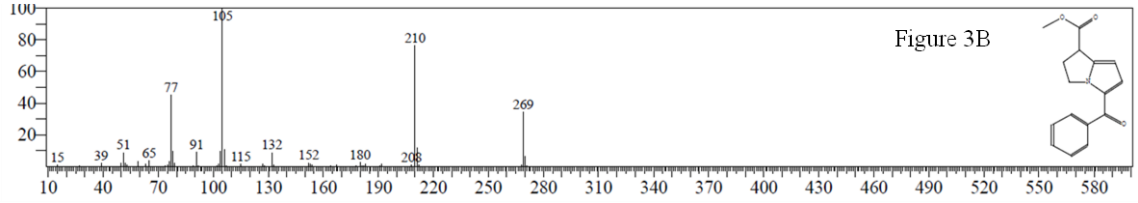


Figure 3B Corresponding GC-MS NIST library match of Ketorolac Methyl Ester

Identification of Sertraline in Sertagess® 50 mg Tablets

GC–MS examination of **Sertagess® 50 mg Tablets** identified **Sertraline**, a selective serotonin reuptake inhibitor (SSRI) commonly prescribed for major depressive disorder, generalized anxiety disorder, panic disorder, obsessive-compulsive disorder, and post-traumatic stress disorder. The chromatographic retention behavior and characteristic EI fragmentation pattern showed excellent agreement with the corresponding NIST reference spectrum.

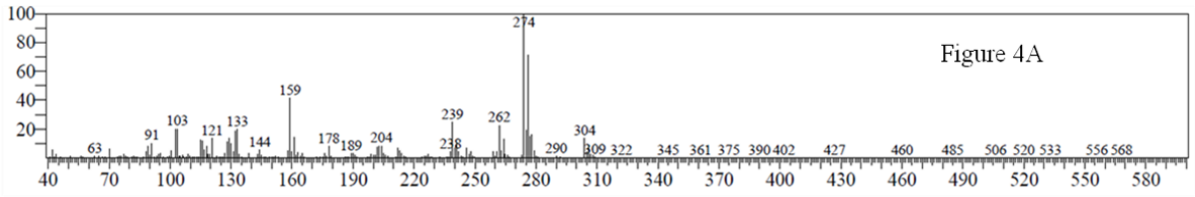


Figure 4A GC-MS Spectrum of Sertraline

Sertraline exhibits a well-established mass spectral profile that enables reliable identification using GC–MS following appropriate extraction. Detection of Sertraline in the seized tablets confirmed the labeled pharmaceutical composition and demonstrated the suitability of GC–MS for routine forensic identification of antidepressant medications. Such analytical confirmation is valuable in criminal investigations whenever pharmaceutical products constitute relevant physical evidence requiring scientific verification before judicial proceedings [18-19]. GC-MS Spectrum of Sertraline and its corresponding NIST library match is shown in **Figures 4 (A, B).**

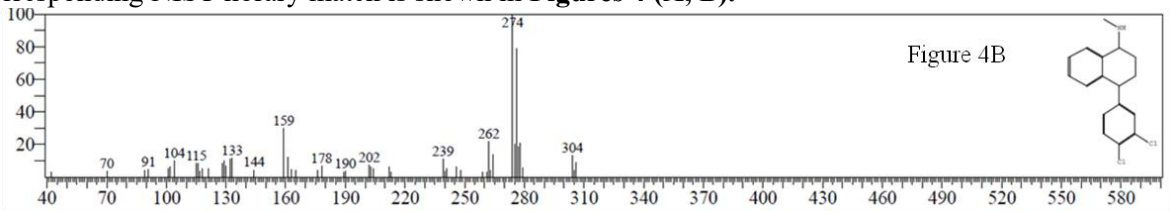


Figure 4B Corresponding GC-MS NIST library match of Sertraline

Forensic Significance of the Analytical Findings

The principal objective of forensic pharmaceutical analysis is not merely to identify chemical constituents but also to provide scientifically reliable evidence that supports the overall criminal investigation. In the present case, GC–MS conclusively established the chemical identities of the APIs present in the seized therapeutic drug formulations, the analytical results strengthened the evidentiary value of the recovered pharmaceutical exhibits.

It is important to emphasize that qualitative identification of seized pharmaceutical exhibits strictly establishes chemical composition; it does not demonstrate administration to a victim, drug-induced impairment, temporal association with an assault, or criminal intent. The analytical findings serve exclusively to provide objective laboratory verification of exhibit identity for investigative records. Such scientifically objective interpretation is fundamental to modern forensic practice and ensures that laboratory conclusions remain evidence-based and unbiased [20].

It is important to note that this investigation was designed solely for qualitative identification. Quantitative measurements, such as absolute drug concentration, relative abundance, peak area quantification, and assay comparison against labeled therapeutic dosages, were not performed as they fall outside the qualitative scope required for initial exhibit verification.

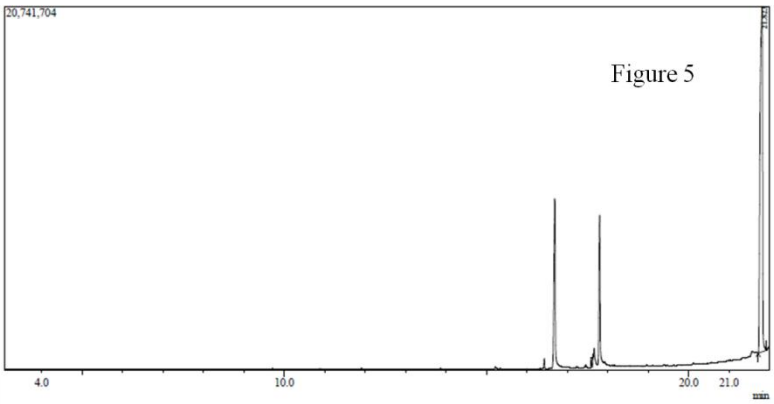


Figure 5 GC-MS Chromatogram of Flunarizine

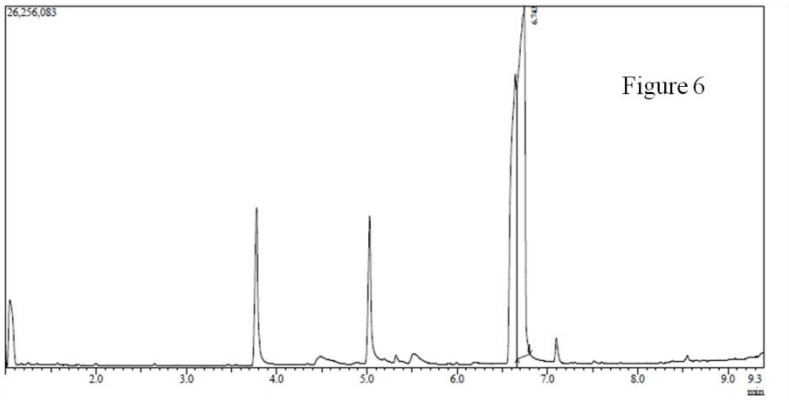


Figure 6 GC-MS Chromatogram of Sertraline

GC-MS total ion chromatogram (TIC) analysis was conducted to identify the target compound(s). Flunarizine exhibited a single integrated retention peak at t_R = 21.823 min (100% relative peak area) as shown in **Figure 5**. Sertraline eluted at t_R = 6.743 min with high chromatographic intensity (100% relative area) as shown in **Figure 6**. For the multi component sample, Tromethamine and Ketorolac methyl ester were resolved at retention times of 1.382 min (98.80% area) and 6.295 min (1.20% area), respectively as shown in **Figure 7**.

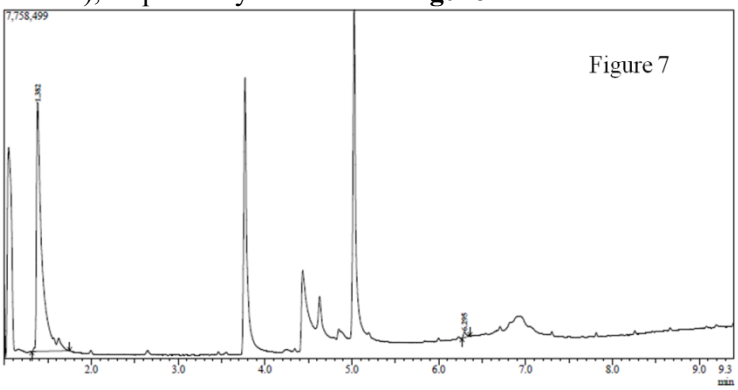


Figure 7 GC-MS Chromatogram of Tromethamine and Ketorolac Methyl Ester

Role of GC–MS in Forensic Pharmaceutical Identification

Gas Chromatography–Mass Spectrometry remains one of the most powerful analytical tools available for forensic pharmaceutical investigations because of its high chromatographic resolution, excellent mass spectral specificity, reproducibility, and extensive validated spectral databases. Identification based on spectral matching with authenticated reference libraries substantially reduces analytical uncertainty and enhances confidence in forensic conclusions.

The present study further demonstrates that GC–MS can rapidly and accurately identify active pharmaceutical ingredients present in commercially manufactured therapeutic formulations recovered during criminal investigations.

Integration of analytical chemistry with forensic toxicology and forensic medicine enables comprehensive interpretation of physical evidence and strengthens medico-legal opinions presented before courts of law. Adoption of standardized analytical protocols, validated instrumentation, and internationally recognized quality-assurance practices further enhances the credibility, reproducibility, and legal admissibility of forensic laboratory findings [3, 14].

Conclusion

The present study demonstrates the effectiveness of Gas Chromatography–Mass Spectrometry (GC–MS) as a robust and reliable analytical technique for the qualitative identification of active pharmaceutical ingredients (APIs) in seized therapeutic drug formulations recovered during a medico-legal investigation. GC–MS analysis, supported by comparison with the National Institute of Standards and Technology (NIST) Mass Spectral Library, conclusively identified Flunarizine in Sibelium® 5 mg Tablets, Tromethamine and Ketorolac methyl ester in Ketrol-DT® 10 mg Tablets, and Sertraline in Sertagess® 50 mg Tablets, thereby confirming the chemical identity of the seized pharmaceutical exhibits.

The analytical findings provide objective scientific confirmation regarding the chemical identity of the seized pharmaceutical formulations. These qualitative laboratory results are strictly confined to exhibit identification and do not infer drug administration, dosing timeline, or biological effect in relation to the alleged physical assault.

The study further highlights the importance of integrating forensic analytical chemistry, forensic toxicology, forensic medicine, and criminal investigation to achieve comprehensive, evidence-based interpretation of complex medico-legal cases. Such multidisciplinary collaboration enhances the reliability, transparency, and legal admissibility of forensic evidence presented before judicial authorities.

In conclusion, standardized GC–MS methodologies, coupled with validated spectral library matching and rigorous quality assurance practices, provide a scientifically sound approach for the examination of pharmaceutical evidence in forensic casework. The adoption of validated analytical protocols and multidisciplinary interpretation will continue to improve the quality of forensic investigations, strengthen medico-legal opinions, and contribute to the fair administration of justice.

Acknowledgement

The author, Bhvimane Sanna Jilani, gratefully acknowledges the support and facilities provided by the Regional Forensic Science Laboratory, Kalaburagi.

Declaration

No conflicts to declare

References

[1] United Nations Office on Drugs and Crime (UNODC). *Guidance for the Forensic Analysis of Drugs Facilitating Sexual Assault and Other Criminal Acts.* Manual for Use by National Forensic Laboratories. Vienna: United Nations; 2023.

[2] The International Association of Forensic Toxicologists (TIAFT). *TIAFT Committee for Quality Assurance and Accreditation: Laboratory Guidelines.* 2022.

[3] Scientific Working Group for the Analysis of Seized Drugs (SWGDRUG). *Recommendations for the Analysis and Identification of Seized Drugs*. Version 8.0. 2024.

[4] Maurer H. H. Hyphenated mass spectrometric techniques in clinical and forensic toxicology. *Journal of Mass Spectrometry*, 2020; 55(4): e4495. DOI: 10.1002/jms.4495

[5] Causon R. & Standard J. Chromatographic and mass spectrometric identification of active pharmaceutical ingredients in forensic casework. *Forensic Science International*, 2021; 320: 110688. DOI: 10.1016/j.forsciint.2021.110688.

[6] Musshoff F. & Madea B. Analytical strategy in forensic toxicology for pharmaceutical drug screening. *Forensic Sciences Research*, 2021; 6(2): 112–125. DOI: 10.1080/20961790.2021.1891234.

[7] Peters F. T. & Steuer A. E. Analytical developments in postmortem toxicology and pharmaceutical exhibit analysis. *Current Opinion in Toxicology*, 2022; 29: 34–42. DOI: 10.1016/j.cotox.2022.01.003.

[8] de Zeeuw R. A., Franke J. P. & Steen, B. Mass spectral database matching in systematic toxicological analysis. *Journal of Analytical Toxicology*, 2021; 45(5): 421–430. DOI: 10.1093/jat/bkaa089.

[9] Sweetman S. C. (Ed.). *Martindale: The Complete Drug Reference.* 40th ed. London: Pharmaceutical Press; 2020.

[10] Brunton L.L, Hilal-Dandan R and Knollmann B.C. *Goodman & Gilman's The Pharmacological Basis of Therapeutics*. 14th ed. McGraw-Hill; 2023.
[11] Katzung B.G. *Basic and Clinical Pharmacology*. 16th ed. New York McGraw-Hill; 2023.
[12] Houck M. M. & Siegel J. A. Multidisciplinary evidence interpretation and quality control in forensic science. *Forensic Science International*, 2022; 331: 111150. DOI: 10.1016/j.forsciint.2022.111150.
[13] International Organization for Standardization (ISO). *ISO/IEC 17025:2017. General Requirements for the Competence of Testing and Calibration Laboratories*. Geneva, Switzerland: ISO; 2017.
[14] National Institute of Standards and Technology (NIST). *NIST/EPA/NIH Mass Spectral Library (NIST 23)*. Gaithersburg, MD, USA: National Institute of Standards and Technology; 2023.
[15] United Nations Office on Drugs and Crime (UNODC). *Guidance for the Validation of Analytical Methodology and Calibration of Equipment Used for Testing of Illicit Drugs in Seized Materials and Biological Specimens*. Vienna: United Nations; 2020.
[16] Causon R. Recent developments in GC–MS applications for forensic pharmaceutical analysis. *Forensic Science International*. 2022; 335: 111290. DOI: 10.1016/j.forsciint.2022.111290.
[17] de Zeeuw R. A. & Franke J. P. Gas chromatographic screening of non-steroidal anti-inflammatory drugs in solid dose exhibits. *Journal of Analytical Toxicology*, 2022; 46(3): 215–224. DOI: 10.1093/jat/bkab045.
[18] Moffat AC, Osselton MD & Widdop B. *Clarke's Analysis of Drugs and Poisons*. 5th ed. London: Pharmaceutical Press; 2021.
[19] United Nations Office on Drugs and Crime (UNODC). *Recommended Methods for the Identification and Analysis of Pharmaceutical Preparations*. Vienna: United Nations; 2022.
[20] Houck MM &Siegel JA. *Fundamentals of Forensic Science*. 4th ed. Academic Press; 2023.

2026, by the Authors. The articles published from this journal are distributed to the public under "Creative Commons Attribution License" (http://creativecommons.org/licenses/by/3.0/). Therefore, upon proper citation of the original work, all the articles can be used without any restriction or can be distributed in any medium in any form.

Publication History
Received 28.07.2026
Revised 30.10.2026
Accepted 30.10.2026
Online 31.10.2026