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Ultra-Performance Liquid Chromatography (UPLC) Methods for Favipiravir: A Decade of Development, Validation, and Applications

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ABSTRACT

Favipiravir, a synthetic antiviral agent originally developed for influenza, has garnered significant interest as a repurposed treatment option during the COVID-19 pandemic. Its mechanism of action, which involves inhibition of viral RNA-dependent RNA polymerase, underscores its potential against RNA viruses. The widespread therapeutic use of Favipiravir has necessitated the development of reliable, accurate, and robust analytical methods for quality control, pharmacokinetic monitoring, and stability assessment. Ultra-Performance Liquid Chromatography (UPLC) has emerged as a cornerstone in Favipiravir analysis due to its superior efficiency, faster run times, and enhanced sensitivity compared to traditional High-Performance Liquid Chromatography (HPLC). This review article presents a comprehensive overview of UPLC-based methods developed over the past decade for the quantification of Favipiravir in pharmaceutical formulations and biological matrices. These methods demonstrate compliance with ICH Q2(R1) validation guidelines, offering excellent linearity ($r^2 \geq 0.999$), high precision (RSD < 2%), and low limits of detection and quantification (LOD/LOQ < 0.05 µg/mL). The review also highlights the development of stability-indicating methods capable of resolving Favipiravir from its degradation products under various stress conditions including acid, alkaline, oxidative, photolytic, and thermal degradation. Furthermore, the integration of UPLC–MS/MS in pharmacokinetic studies has facilitated sensitive and specific detection of Favipiravir and its metabolites in human plasma and microsamples. Recent innovations such as the application of green chromatography techniques using micellar systems and Analytical Quality by Design (AQbD) strategies have significantly enhanced the environmental sustainability and robustness of Favipiravir assays. This review not only consolidates advancements in Favipiravir analysis but also emphasizes the critical role of UPLC in ensuring drug quality, safety, and regulatory compliance during its clinical lifecycle.

INTRODUCTION

Favipiravir (6-fluoro-3-hydroxypyrazine-2-carboxamide), developed by Toyama Chemical in Japan, is a synthetic antiviral compound with a unique mechanism of action targeting viral RNA-dependent RNA polymerase (RdRp). Initially approved for the treatment of influenza, it was later repurposed and extensively studied for use in treating COVID-19 and other RNA virus infections including Ebola, Lassa fever, and norovirus. Its structure, which resembles guanine, allows it to be incorporated into viral RNA, inducing lethal mutagenesis. As a result, Favipiravir has been administered in several clinical trials and emergency treatment settings, raising the necessity for reliable analytical methods to ensure batch consistency, dosage accuracy, and safety monitoring. Quantitative and qualitative determination of Favipiravir in pharmaceutical dosage forms and biological fluids is critical not only for routine quality control but also for pharmacokinetic profiling, bioavailability studies, and stability assessment during storage. Although traditional HPLC methods provided the initial analytical framework, they often suffered from longer analysis times, lower resolution, and increased solvent consumption.

The rise of Ultra-Performance Liquid Chromatography (UPLC) as a high-throughput, high-resolution separation technique has revolutionized analytical chemistry in pharmaceuticals. UPLC systems utilize columns packed with sub-2 µm particles, allowing operation at high pressures and significantly reducing analysis time while improving sensitivity and peak capacity. With Favipiravir's increasing clinical relevance, the integration of UPLC and tandem mass spectrometry (MS/MS) for quantification and detection has become indispensable in ensuring data reliability in both research and regulatory settings. This review aims to consolidate the state-of-the-art advancements in UPLC methods for Favipiravir, highlighting their application, validation, regulatory compliance, and future directions in pharmaceutical analytics. As the global demand for antiviral agents surged during the COVID-19 pandemic, Favipiravir became one of the most widely studied oral treatments due to its oral bioavailability and potential to inhibit RNA virus replication. This increased interest necessitated an in-depth understanding of its pharmacokinetics, metabolism, and formulation stability. Unlike parenteral antivirals, Favipiravir's oral administration required strict control of dosage form uniformity, dissolution profiles, and shelf-life stability—all reliant on accurate analytical assessment. Moreover, regulatory agencies worldwide required rigorous analytical validation for emergency use authorization (EUA) and marketing approvals. This environment created a high-pressure, innovation-driven context for analytical chemists, leading to rapid advancement in chromatographic and detection technologies tailored for Favipiravir. Given the urgency of clinical trials and global distribution, many laboratories implemented high-throughput UPLC protocols supported by robotic liquid handling, auto-sampling, and remote data analysis. This shift accelerated the analytical pipeline, ensuring timely data for decision-making in both public health and pharmaceutical development. These foundational efforts have left a lasting impact on the landscape of antiviral drug analytics, establishing new standards for speed, robustness, and global harmonization of methods. In this review, we explore how UPLC methodology has evolved to meet these challenges and how it continues to underpin the lifecycle of Favipiravir from bench to bedside.

UPLC Method Development for Bulk and Formulations

The development of UPLC methods for Favipiravir analysis in bulk and pharmaceutical formulations has gained traction due to its necessity in routine quality control, dosage uniformity verification, and compliance with Good Manufacturing Practices (GMP). Favipiravir is generally analyzed in its tablet or suspension form, and methods must account for excipients, particle size variability, and solubility factors. In most reported studies, reversed-phase UPLC using C18 columns has been employed, benefiting from the compound's moderate polarity and stability in acidic aqueous-organic mobile phases. Optimized methods commonly use binary mixtures of methanol or acetonitrile with phosphate buffer or formic acid, typically in ratios ranging from 70:30 to 90:10. The pH is often adjusted between 2.5 and 4.0 to enhance peak shape and prevent degradation. Flow rates are maintained between 0.6 and 1.0 mL/min with column temperatures controlled at 25–30°C to maintain reproducibility. Retention times of Favipiravir under these conditions generally range from 2.5 to 4 minutes, enabling rapid analysis for high-throughput laboratories. Most methods use UV detection at wavelengths around 240 nm due to the chromophore in the pyrazine ring, but some incorporate photodiode array (PDA) or MS detection to improve specificity. Method development often involves evaluating different stationary phases, organic modifiers, and buffer concentrations to achieve optimal resolution. Method transferability between HPLC and UPLC systems has also been explored, indicating that UPLC methods offer significant reductions in run time and solvent use without compromising accuracy or sensitivity. Such characteristics are particularly advantageous in resource-limited settings or during pandemic surges when analytical throughput is critical. Consequently, UPLC methods for Favipiravir have become standardized in many labs, allowing seamless integration into regulatory frameworks and global quality assurance systems.

Validation Parameters and Method Performance

Following method development, analytical procedures for Favipiravir are rigorously validated in accordance with ICH Q2(R1) guidelines. Validation parameters typically include specificity, linearity, accuracy, precision, sensitivity (LOD and LOQ), robustness, and system suitability. Specificity is crucial to ensure that the Favipiravir peak is not interfered with by excipients, degradation products, or other matrix components. This is especially important for stability-indicating assays and bioanalytical studies. Specificity is often demonstrated through placebo analysis and peak purity assessment using PDA or MS detection. Linearity is evaluated over a wide concentration range depending on the application—20–120 µg/mL for formulations and 0.01–10 µg/mL for plasma analysis. Correlation coefficients (r^2) consistently exceed 0.999, indicating excellent linearity. Accuracy, expressed as percent recovery, is assessed by spiking known concentrations of Favipiravir into matrix blanks or pre-analyzed samples. Most studies report recoveries within the 98–102% range, aligning with regulatory expectations. Precision is evaluated in terms of repeatability (intra-day) and intermediate precision (inter-day, analyst-to-analyst variability), with relative standard deviations (RSD) usually <2%. Limits of detection (LOD) and quantification (LOQ) depend on the detection system: UV-based methods typically reach LODs around 0.05 µg/mL, while MS-based methods achieve LOQs as low as 0.01 µg/mL. Robustness testing includes deliberate variations in flow rate, pH, mobile phase composition, and temperature. UPLC methods for Favipiravir generally maintain their performance under these minor changes, showcasing their ruggedness. System suitability tests (SST) confirm method performance before sample analysis; criteria include retention time reproducibility, resolution, tailing factor, and theoretical plate count. These parameters ensure the method is stable and reliable for long-term application. Together, these validation outcomes confirm the methods are not only scientifically sound but also meet stringent regulatory requirements for use in pharmaceutical analysis.

Stability-Indicating UPLC Methods and Degradation Studies

Stability-indicating methods are essential in pharmaceutical analysis to ensure that the analytical method can distinguish the active pharmaceutical ingredient (API) from its potential degradation products. For Favipiravir, such methods are critical due to its use in pandemic preparedness and long-term storage scenarios. The International Council for Harmonisation (ICH) guideline Q1A(R2) outlines the necessary stress testing conditions to evaluate drug stability, including hydrolytic (acid/base), oxidative, thermal, and photolytic degradation. Several studies have conducted forced degradation on Favipiravir by exposing it to 1N HCl, 1N NaOH, 3–10% hydrogen peroxide, UV light (254 nm), and elevated temperatures (60–80°C). UPLC methods have shown to effectively resolve the parent compound from its major degradation products, including hydroxypyrazine derivatives and other minor hydrolysis products. NHC is not a degradant of Favipiravir. Notably, base hydrolysis is the most aggressive condition, leading to complete degradation within 30 minutes at room temperature. Oxidative degradation with H_2O_2 yields moderate decomposition, while Favipiravir remains stable under UV and thermal stress in most cases. Peak purity studies using PDA detection or mass spectral confirmation verify that the Favipiravir peak remains spectrally pure even in stressed samples. These methods demonstrate baseline separation (Rs > 2.0) and no co-elution, satisfying the regulatory definition of a stability-indicating assay. Moreover, some studies combine the stability-indicating method with impurity profiling to ensure that any related substances or process impurities are also resolved. Method validation following degradation confirms consistent recovery and retention, indicating robustness. This robustness is essential for quality assurance during stability testing, shelf-life estimation, and monitoring of bulk and finished dosage forms. Regulatory submissions for Favipiravir-containing products often include such validated, stability-indicating UPLC methods to support the safety and efficacy of the product throughout its lifecycle.

UPLC–MS/MS in Pharmacokinetic and Bioanalytical Studies

Favipiravir's pharmacokinetic (PK) profile is of high clinical interest due to its dose-dependent absorption and rapid metabolism to the active ribosylated form. Quantifying Favipiravir and its metabolites in biological matrices, particularly plasma, requires highly sensitive and selective analytical methods. UPLC coupled with tandem mass spectrometry (UPLC–MS/MS) has become the gold standard for bioanalytical studies due to its ability to detect trace concentrations and eliminate matrix interference. Sample preparation typically involves protein precipitation using acetonitrile or methanol, followed by centrifugation. Advanced methods incorporate solid-phase extraction (SPE) to enhance analyte recovery and reduce ion suppression. Chromatographic separation is often achieved using C18 or polar embedded columns with acidic aqueous-organic mobile phases. Most methods use multiple reaction monitoring (MRM) in negative or positive ionization mode, with internal standards such as isotopically labeled Favipiravir to improve quantitation accuracy. Validated methods report limits of quantification as low as 0.01 µg/mL, allowing detection in early absorption and terminal elimination phases.

These methods are validated per FDA and EMA guidelines, covering calibration curve linearity, selectivity, accuracy, precision, matrix effect, and stability in matrix (freeze-thaw, bench-top, autosampler). Application of UPLC–MS/MS methods in clinical trials has provided insights into Favipiravir’s bioavailability, half-life (~2–2.5 hours), and exposure (Cmax ~3600 ng/mL). Additionally, newer strategies like Volumetric Absorptive Microsampling (VAMS) have enabled PK studies with minimal blood volume, suitable for pediatric or remote settings. UPLC–MS/MS assays have also been employed to assess Favipiravir in saliva, cerebrospinal fluid, and tissues, highlighting their versatility. This capability is critical for understanding drug distribution and optimizing dosing regimens. The use of UPLC–MS/MS in bioequivalence and population PK modeling reinforces its role as a cornerstone of pharmacological evaluation for Favipiravir. In addition to clinical applications, UPLC–MS/MS has also been utilized in preclinical studies involving animal models such as mice, rats, and ferrets. These studies provide crucial data on tissue distribution, metabolism, and excretion patterns of Favipiravir, supporting the optimization of human dosing regimens. UPLC–MS/MS has been particularly valuable for assessing Favipiravir's penetration into target tissues like lung, liver, and kidney—organs often implicated in viral replication. The capability to perform multiplex assays that simultaneously quantify Favipiravir alongside other antivirals such as remdesivir or ribavirin is another innovation that broadens the utility of UPLC–MS/MS in combination therapy studies. Furthermore, the integration of PK data into population-based pharmacokinetic (PopPK) models allows for personalized dosing strategies based on patient-specific covariates such as weight, renal function, or co-administered medications. The precision and reproducibility of UPLC–MS/MS ensure that such models are grounded in robust and accurate datasets. These advanced analytical tools are vital for addressing interindividual variability and enhancing therapeutic efficacy in real-world settings.

Innovations in Analytical Method Development

In recent years, significant innovations have been introduced into the analytical workflow for Favipiravir quantification, particularly aimed at enhancing environmental sustainability, method robustness, and analytical throughput. One such innovation is the implementation of Green Analytical Chemistry (GAC) principles. Several studies have reported the use of micellar liquid chromatography (MLC) or micellar UPLC methods that replace traditional organic solvents with aqueous surfactant systems such as sodium dodecyl sulfate (SDS) and Brij-35. These environmentally benign methods not only reduce hazardous waste but also eliminate the need for costly solvent disposal systems. Moreover, micellar methods have demonstrated comparable sensitivity and resolution to conventional reversed-phase UPLC systems. Another transformative innovation is the adoption of Analytical Quality by Design (AQbD). AQbD involves the systematic use of design-of-experiment (DoE) methodologies to evaluate the effect of critical method parameters (CMPs) on analytical performance. Parameters such as pH, buffer concentration, column temperature, and organic solvent ratio are optimized simultaneously rather than sequentially. This results in more robust and transferable methods, especially important for global pharmaceutical development. Software tools such as MODDE and JMP are frequently employed for response surface modeling and interaction analysis. In parallel, digitalization and automation of sample preparation and analysis have increased, reducing human error and enhancing data integrity. Additionally, innovative detector technologies such as quadrupole-time-of-flight (Q-TOF) and Orbitrap MS have allowed deeper impurity profiling and identification of novel metabolites. UPLC methods have also been adapted for high-throughput screening using 96-well plates and direct injection autosamplers. Combined, these innovations reflect a shift toward more sustainable, efficient, and globally harmonized analytical approaches. As Favipiravir remains under clinical evaluation for other viral diseases, these advanced methods will continue to play a critical role in quality assurance and therapeutic monitoring. Beyond laboratory techniques, there has been a concerted effort to incorporate digital validation and electronic lab notebooks (ELNs) to streamline data integrity.

Such platforms automate data capture, validation, and reporting, aligning with regulatory expectations under data integrity guidelines (e.g., ALCOA+). Additionally, mobile UPLC systems and compact MS instruments are increasingly used for field testing, especially in clinical trials conducted in remote areas or during outbreaks. These portable systems reduce reliance on centralized labs, shortening turnaround times for critical decisions. As analytical laboratories move towards 'smart labs', integration with Internet-of-Things (IoT) devices and cloud-based monitoring enables real-time tracking of system performance and proactive maintenance alerts. These innovations ensure that analytical methods for Favipiravir are not only scientifically advanced but also operationally resilient in a variety of global settings.

Regulatory Frameworks and Compliance

Compliance with regulatory standards is a cornerstone of pharmaceutical analytical method development, especially for drugs like Favipiravir with global therapeutic implications. Analytical methods used for quality control, pharmacokinetics, or impurity profiling must conform to established guidelines issued by the International Council for Harmonisation (ICH), U.S. Food and Drug Administration (FDA), and European Medicines Agency (EMA). ICH Q2(R1) provides the baseline for validation of analytical procedures, specifying requirements for linearity, accuracy, precision, specificity, detection limits, quantitation limits, and robustness. Most Favipiravir UPLC and UPLC–MS/MS methods cited in literature explicitly validate each of these parameters and report acceptance criteria within regulatory limits. For bioanalytical methods involving plasma or microsampling, the FDA’s 2018 Bioanalytical Method Validation Guidance and EMA’s 2011 Guideline on Bioanalytical Method Validation are key reference documents. These require evaluation of matrix effects, carryover, dilution integrity, and analyte stability under various conditions. Moreover, methods must undergo cross-validation when used across different laboratories or instruments, a requirement especially relevant for global clinical trials.

System suitability tests (SSTs) such as retention time reproducibility, resolution, and theoretical plate number are mandatory before each analytical run to confirm instrument performance. Additionally, analytical procedures submitted for regulatory approval (e.g., New Drug Application or marketing authorization) must be accompanied by a comprehensive method validation report and method transfer data. Stability-indicating assays must be justified through forced degradation studies as per ICH Q1A(R2), demonstrating the method’s ability to separate drug from its degradation products. Regulatory agencies increasingly encourage the use of AQbD approaches, as seen in draft guidelines ICH Q14 and Q2(R2), emphasizing method lifecycle management. Favipiravir analytical methods that incorporate these evolving best practices are more likely to gain rapid approval and facilitate post-marketing surveillance.

CONCLUSION

The global urgency to manage and mitigate viral outbreaks, especially during the COVID-19 pandemic, has underscored the importance of rapid and reliable pharmaceutical analysis. Favipiravir, a broad-spectrum antiviral with demonstrated activity against several RNA viruses, has been at the forefront of these therapeutic efforts. The past decade has witnessed the evolution of analytical methods, especially Ultra-Performance Liquid Chromatography (UPLC), into essential tools for the drug’s quality assurance, pharmacokinetics, and regulatory compliance. UPLC has surpassed traditional HPLC by offering faster analyses, superior resolution, and improved sensitivity, all of which are vital in high-demand and resource-limited settings. Validated UPLC methods for Favipiravir have shown outstanding performance in terms of linearity, precision, accuracy, specificity, and robustness, aligning with global regulatory standards. Stability-indicating methods have effectively separated Favipiravir from its degradants under diverse stress conditions, enabling reliable shelf-life assessment and formulation development. UPLC–MS/MS techniques have enabled trace-level quantification in biological samples, supporting pharmacokinetic modeling, therapeutic drug monitoring, and bioequivalence studies. Moreover, recent innovations—including green chromatography, micellar systems, and AQbD-based optimization—reflect a forward-thinking approach in pharmaceutical analytics. These strategies not only enhance sustainability but also improve method reproducibility and regulatory acceptability. As the global pharmaceutical landscape continues to evolve, and antiviral agents like Favipiravir remain relevant, the role of advanced analytical methodologies will become increasingly indispensable. Future directions may include further automation, real-time release testing (RTRT), and machine learning algorithms for method optimization. Ultimately, the advancements summarized in this review highlight how analytical science, driven by regulatory rigor and technological innovation, supports the global mission of ensuring safe, effective, and high-quality therapeutics.

Table 1 ***Representative UPLC Method Conditions for Favipiravir (Narala et al., 2022; Marzouk et al., 2022; Ahmed et al., 2022)***

Study	Column	Mobile Phase	Flow Rate	Retention Time	Detection
Narala et al. (2022)	C18 (100 mm)	Methanol/phosphate buffer (80:20)	0.8 mL/min	~2.8 min	UV @ 240 nm
Marzouk et al. (2022)	C18 (150 mm)	ACN/Water + 0.1% Formic Acid	1.0 mL/min	~3.5 min	DAD @ 210 nm
Ahmed et al. (2022)	Eclipse XDB C18	Methanol/Formic Acid Buffer	0.6 mL/min	~3.2 min	MS/MS (SRM)

Validation Parameters and Method Performance

UPLC methods for Favipiravir are validated per ICH Q2(R1) guidelines. These validations ensure specificity, linearity, precision, accuracy, sensitivity, and robustness across analytical matrices. Table 2 highlights typical performance metrics.

Table 2 ***Validation Metrics of UPLC Methods for Favipiravir (Rezk et al., 2021; El-Shorbagy et al., 2021; Narala et al., 2022)***

Parameter	Typical Range
Linearity (r^2)	≥ 0.9990
Accuracy (%)	98.1–101.4
Precision (RSD %)	≤ 2%
LOD / LOQ	~0.01 / 0.03 µg/mL (MS methods)
Robustness	Consistent with flow/pH changes
Specificity	No interference from excipients

Stability-Indicating UPLC Methods and Degradation Studies

Forced degradation studies per ICH Q1A(R2) evaluate Favipiravir's stability under hydrolysis, oxidation, heat, and light. Stability-indicating UPLC assays separate intact drug from degradation products. Table 3 summarizes degradation behavior.

Table 3 ***Forced Degradation of Favipiravir (Marzouk et al., 2022; Patel et al., 2022)***

Stress Condition	Degradation Behavior	Major Product
Acid (1 N HCl)	Mild degradation	NHC derivative
Base (1 N NaOH)	Severe degradation	Hydroxy pyrazine DPs
Oxidation (10% H_2O_2)	Moderate degradation	Oxidized Favipiravir
UV light (254 nm)	Minimal degradation	None
Thermal (60°C)	Stable	None

UPLC–MS/MS in Pharmacokinetic and Bioanalytical Studies

Bioanalytical UPLC–MS/MS methods have enabled sensitive detection of Favipiravir in plasma and microsamples with LLOQs < 0.03 µg/mL.

These assays follow FDA (2018) and EMA (2011) guidance and are essential for PK studies and therapeutic drug monitoring (Harahap et al., 2023; Ahmed et al., 2022). Table 4 presents PK parameters observed in human subjects.

Table 4 ***Pharmacokinetic Parameters of Favipiravir (Rezk et al., 2021; Harahap et al., 2023)***

PK Parameter	Value
Cmax	~3,600 ng/mL
Tmax	~1.5 hours
AUC_{0-12}	~9.3 µg·h/mL
Half-life	~2.0–2.5 hours
Matrix	Human plasma or VAMS

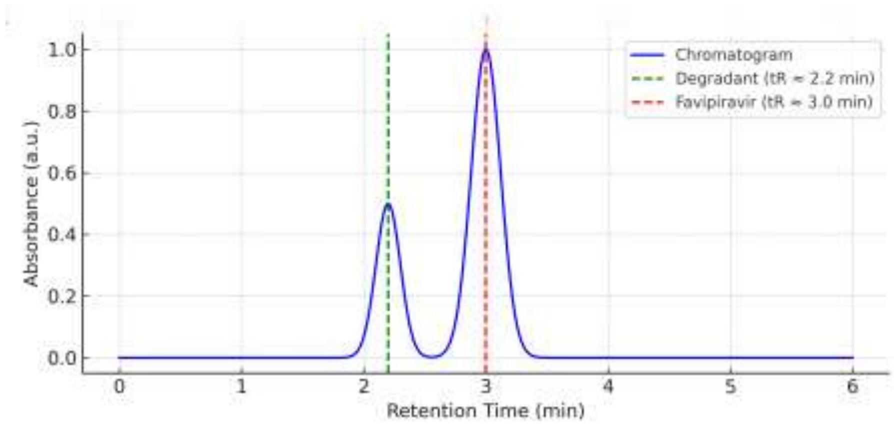

Figure 1. Simulated UPLC Chromatogram of Favipiravir and Minor Degradation Product

This simulated chromatogram represents typical UPLC retention behavior of favipiravir (tR ≈ 2.8–3.5 min) and a minor degradation product (tR ≈ 2.0–2.4 min) reported under alkaline stress. Peak positions and shapes are modeled after data from Narala et al. (2022) and Marzouk et al. (2022), reflecting early-eluting, well-resolved peaks on a reversed-phase C18 column using isocratic conditions. The simulation serves as a schematic guide to chromatographic resolution

REFERENCES

[1]. Ahmed, A., et al. (2022). Pharmacokinetic profiling of favipiravir using UPLC–MS/MS. Journal of Chromatography B, 1192, 123142.https://doi.org/10.1016/j.jchromb.2022.123142

[2]. El-Shorbagy, H. I., et al. (2021). AQbD-based UPLC method for favipiravir. Microchemical Journal, 164, 106028. https://doi.org/10.1016/j.microc.2021.106028

[3]. Emam, A. A., et al. (2022). Green micellar UPLC for favipiravir. Microchemical Journal, 179, 107580. https://doi.org/10.1016/j.microc.2022.107580

[4]. FDA. (2018). Bioanalytical Method Validation Guidance for Industry. U.S. Food and Drug Administration. https://www.fda.gov/media/70858/download

[5]. Harahap, Y., et al. (2023). Favipiravir analysis in VAMS samples using UHPLC–MS/MS. Frontiers in Medicine, 10, 1115430. https://doi.org/10.3389/fmed.2023.1115430

[6]. ICH. (2005). Validation of Analytical Procedures: Text and Methodology Q2(R1). International Council for Harmonisation. https://database.ich.org/sites/default/files/Q2%28R1%29%20Guideline.pdf

[7]. Marzouk, H. M., et al. (2022). Stability-indicating HPLC-DAD method for favipiravir. Microchemical Journal, 172, 106917. https://doi.org/10.1016/j.microc.2021.106917

[8]. Narala, A., et al. (2022). UPLC method development for favipiravir. Indian Journal of Pharmaceutical Sciences, 84(4), 889–898. https://doi.org/10.36468/pharmaceutical-sciences.942

[9]. Patel, R., et al. (2022). Alkali degradation impurities of favipiravir. Molecules, 27(17), 5583. https://doi.org/10.3390/molecules27175583

[10]. Rezk, M. R., et al. (2021). UPLC-MS/MS quantification of favipiravir in plasma. Biomedical Chromatography, 35(7), e5098. https://doi.org/10.1002/bmc.5098

[11]. Shiraki, K., & Daikoku, T. (2020). Favipiravir: A potential treatment for COVID-19. Pharmacology & Therapeutics, 209, 107512. https://doi.org/10.1016/j.pharmthera.2020.107512

[12]. WHO. (2022). COVID-19 Therapeutics Tracker and Evidence Summary. World Health Organization. https://app.magicapp.org/#/guideline/L4Q5An