STM JOURNALS

Research & Reviews: A Journal of
Drug Formulation, Development and Production

ISSN: 2394-1944
Volume 13, Issue 1, 2026
January–April
DOI (Journal): 10.37591/RRJoDFDP

https://journals.stmjournals.com/rrjodfdp

Review RRJoDFDP

Stability-Indicating RP-HPLC Development and Validation for the Estimation of Lercanidipine Hydrochloride Content in Tablet Dosage Form

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Abstract

A sensitive, stability-revealing, and easy reverse-phase high-performance liquid chromatographic (RP-HPLC) technique was developed and rationalized to be in a position to determine Lercanidipine hydrochloride in ingested dosing preparations. It was separated by chromatography on a C18 column using a mobile phase containing 10 mM potassium dihydrogen phosphate buffer and methanol (20:80, v/v; pH 4.0) at a flow rate of 1.0 mL/min and UV detected at 258 nm. The retention time of elution was 4.02 min using Lercanidipine hydrochloride. According to the requirements of ICH Q2(R1), specificity, linearity, accuracy, precision, robustness, sensitivity, and suitability of the system, the approach was proven to be consistent with ICH Q2(R1) requirements. The linearity of the technique was demonstrated to be large within the concentration range of 5–25 µg/mL with the correlation coefficient R2 0.9996. Precision and accuracy studies indicated a low value of the percentage recoveries as shown by accuracy study which reached out to 100 percent and a low percentage recovery as shown by a low preciseness study also attested to the reliability of the methodology employed. The limit of detection and limit of quantification were good enough and indicated that the method has been sensitive enough. Forced degradation study under acidic, alkaline, oxidative, thermal, and implausible conditions suggested that the process could isolate the drug and its degradation products were exhibiting the fastest degradation rates (17.3%). The confirmed process was used on assaying a commercialized tablet preparation, which is successful and 98.50% of labeled claim was attained. Generally, the devised RP-HPLC method is robust, exact, and sensitivity-indicating that it can be applicable in the daily quality control process and the stability test of Lercanidipine hydrochloride in pharmaceutical dosage forms.

Keywords: Forced degradation, ICH Q2(R1), Lercanidipine Hydrochloride, pharmaceutical analysis, RP-HPLC, stability-indicating method

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Received Date: January 05, 2026
Accepted Date: January 15, 2026
Published Date: January 17, 2026

Citation: Ratnakar Tripathi, Bhushan Korde, Sunil Kumar Shahs, B.K. Dubey, Deepak Kumar Basedia. Stability-Indicating RP-HPLC Development and Validation for the Estimation of Lercanidipine Hydrochloride Content in Tablet Dosage Form. Research & Reviews: A Journal of Drug Formulation, Development and Production. 2026; 13(1): 17–26p.

INTRODUCTION

One of the most popular methods of analysis in the pharmaceutical analysis is the high-performance liquid chromatography (HPLC) system because of its high sensitivity, selectivity, accuracy, and reproducibility. It is commonly used in quality control laboratories to identify, determine the purity, and establish the potency and the stability of pharmaceutical products as required by the regulations [1]. The ability to have stability as indicated by some analytical methods is significant especially in the field of quality assurance of pharmaceuticals. These techniques are characterized as procedures that have been validated to measure an active pharmaceutical

ingredient (API), which are free of their degradation products, impurities, and formulation excipients. The methods play a crucial role in comprehending degradation behavior, setting of shelf life, setting the right storage conditions as well as supporting the regulatory submissions in line with the International Council for Harmonisation (ICH) requirements [2].

Lercanidipine hydrochloride is a dihydropyridine calcium channel blocker of the third generation that is commonly used to treat hypertension. Due to its lipophilic nature and great affinity to the vascular smooth muscle cells, its antihypertensive effect is long-term. Lercanidipine hydrochloride is however prone to degradation in different conditions of stress such as acidic, alkaline, oxidative, thermal, and photolytic environments which can influence the quality and therapy efficacy of the product [3]. A number of analytical methods have been reported in the literature for the quantitative determination of Lercanidipine hydrochloride using spectrophotometric and chromatographic techniques, including UV spectrophotometry, HPTLC, and reverse-phase HPLC methods [4–6]. However, many of these reported methods lack comprehensive forced degradation studies or do not adequately demonstrate the effective separation of the drug from its potential degradation products, thereby limiting their suitability as stability-indicating methods [7]. Furthermore, several chromatographic procedures employ complex mobile phase compositions involving multiple buffers or gradient elution systems, as well as prolonged run times exceeding 10–15 minutes, which reduce analytical efficiency and make them less practical for routine quality control applications [8–9]. In view of these limitations, the present study aims to develop and validate a simple, robust, accurate, and stability-indicating reverse-phase HPLC method for the estimation of Lercanidipine hydrochloride in marketed tablet dosage forms. The proposed method is validated in accordance with the requirements of ICH Q2(R1) guidelines, and comprehensive forced degradation studies are performed to evaluate the method's capability to effectively separate the drug from its degradation products. This ensures that the method is suitable for routine quality control analysis as well as stability testing of pharmaceutical formulations (Figure 1).

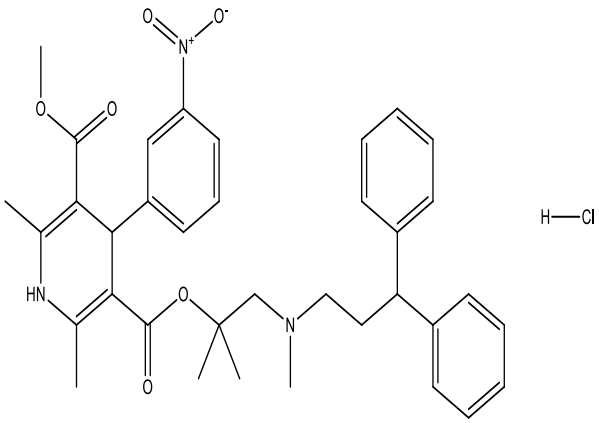


Figure 1. Chemical structure of lercanidipine hydrochloride.

MATERIALS AND METHODS

Chemicals and Reagents

Lercanidipine hydrochloride reference standard was received as a gift sample of Aurobindo Pharma Limited, India. Acetonitrile and water (HPLC grade), and methanol were purchased by Merck Ltd., India. The buffer preparation and pH regulation were done using potassium dihydrogen phosphate and orthophosphoric acid of reagent grade. Reagents and chemicals used were of analytical or HPLC grade.

Instrumentation

A High-Performance Liquid Chromatography (HPLC) system was used to carry out chromatographic analysis including a quaternary pump, UV detector and a data acquisition system. Separating was done of a Thermo C18 column (250 × 4.6 mm, 5 µm particle size). A UV-visible spectrophotometer was used together with 1 cm quartz cells in the studies of UV spectrophotometry [5].

Marketed Formulation

A marketed tablet formulation of Lercanidipine hydrochloride (Maximune 500 mg tablets, Cipla Laboratories Ltd.) was procured from a local pharmacy and used for assay and validation studies.

Method Development and Chromatographic Conditions

The separation of the various products in the chromatography was done using the mobile phase comprising the required quantity of 10 mM potassium dihydrogen phosphate buffer and methanol (20:80, v/v) [6]. The orthophosphoric acid helped in changing the pH of the mobile phase to 4.0, which was filtered using the 0.45 mm membrane filter and the sonication procedure after which it was utilized. The flow rate that was used was 1.0 mL/min, the wavelength of the detection at 258 nm and injection volume of 20 µL were used [7]. Ambient temperature (25 ± 2°C) had been used to run the column and the run time had been a total of 10 minutes (Table 1).

Table 1. Chromatographic conditions.

Parameter	Condition
Column	C18 (250 × 4.6 mm, 5 µm)
Mobile phase	10 mM KH_2PO_4: Methanol (20: 80, v/v)
pH of mobile phase	4.0 (adjusted with orthophosphoric acid)
Flow rate	1.0 mL/min
Detection wavelength	258 nm
Injection volume	20 µL
Column temperature	Ambient (25 ± 2°C)
Run time	10 min

Preparation of Standard Solutions

A stock solution of Lercanidipine hydrochloride was prepared by accurately weighing 10 mg of the reference standard and transferring it into a 50 mL volumetric flask. The drug was initially dissolved in 10 mL of methanol and sonicated for 10 minutes to ensure complete dissolution. The volume was then adjusted to 50 mL with methanol, vortex-mixed thoroughly, and filtered through Whatman filter paper No. 41 to obtain a stock solution with a concentration of 200 µg/mL (Stock A). A sub-stock solution (Stock B) was prepared by transferring 5 mL of Stock A into a 10 mL volumetric flask and diluting to volume with the diluent to obtain a concentration of 100 µg/mL. Working standard solutions were subsequently prepared by transferring 0.5, 1.0, 1.5, 2.0, and 2.5 mL of Stock B into separate 10 mL volumetric flasks and diluting to volume with methanol, yielding final concentrations of 5, 10, 15, 20, and 25 µg/mL, respectively [10].

METHOD VALIDATION

Precision

Precision was evaluated in terms of repeatability (intra-day precision) and intermediate precision (inter-day precision). The low variability observed under both conditions confirmed the consistency and reproducibility of the method during routine analytical operations.

Accuracy

The accuracy of the method was confirmed through recovery studies using the standard addition technique at varying concentration levels. The recovery results demonstrated that the experimentally obtained values were close to the true values, indicating good trueness of the method.

Linearity

Linearity was assessed by analyzing a series of standard solutions at different concentration levels. Calibration curves were constructed to establish the relationship between analyte concentration and detector response, confirming proportionality over the studied concentration range [11].

LOD and LOQ

The sensitivity of the method was determined by calculating the limit of detection (LOD) and limit of quantification (LOQ). These parameters were derived based on the standard deviation of the response and the slope of the calibration curve, demonstrating the method's capability to detect and quantify low concentrations of the analyte.

Robustness

Robustness was assessed by introducing small, deliberate variations in chromatographic parameters such as flow rate and mobile phase composition. The results indicated that these minor changes did not significantly affect the analytical performance, confirming the robustness of the method.

System Suitability

System suitability testing was performed prior to analysis to ensure satisfactory system performance. Chromatographic parameters including retention time, number of theoretical plates, and tailing factor were evaluated to confirm that the system was functioning properly for routine quality control analysis [12].

FORCED DEGRADATION STUDIES

Acidic Degradation

Approximately 50 mg of Lercanidipine hydrochloride was transferred into a 50 mL round-bottom flask, and 50 mL of 0.1 N hydrochloric acid was added. The solution was mixed thoroughly and maintained under continuous stirring at 80°C for 8 hours. After the stress period, an appropriate aliquot was withdrawn, neutralized if necessary, diluted with the mobile phase to obtain a final concentration of 10 µg/mL, and subjected to HPLC analysis.

Alkaline Degradation

For alkaline hydrolysis, 50 mg of the drug was placed in a 50 mL round-bottom flask, and 50 mL of 0.1 M sodium hydroxide solution was added. The mixture was stirred continuously at 80°C for 8 hours. After degradation, the solution was suitably neutralized, diluted to obtain a concentration of 10 µg/mL, and analyzed by HPLC.

Oxidative Degradation

Oxidative stress was performed by treating 50 mg of Lercanidipine hydrochloride with 50 mL of 3% hydrogen peroxide solution in a 50 mL round-bottom flask. The mixture was kept at room temperature for 24 hours with intermittent shaking. After completion of the stress period, the solution was diluted appropriately to a concentration of 10 µg/mL and analyzed using the developed method [13].

Thermal Degradation

For thermal degradation, 50 mg of the drug was spread uniformly in a petri dish and placed in a hot air oven maintained at 50°C for four weeks. After the exposure period, the stressed sample was dissolved in methanol, diluted to obtain a final concentration of 10 µg/mL, and analyzed by HPLC.

Photolytic Degradation

Photolytic degradation was carried out by exposing the drug sample to light under controlled laboratory conditions for a specified duration. After exposure, the sample was dissolved in methanol, diluted to a concentration of 10 µg/mL, and analyzed using the developed RP-HPLC method [14].

RESULTS AND DISCUSSION

Method Optimization

The optimal chromatographic conditions led to sharp and symmetric Lercanidipine hydrochloride peak and equal retention behavior, which suggests mediocre performance regarding chromatography. Methanol and water mixtures using the mobile phase system exhibited low resolution and unsatisfactory peak symmetry but the buffer-methanol system gave much better separation and peak symmetry. The

optimized chromatogram displayed effective interaction of the analyte with the stationary phase which gave good results in retention time and peak shape. The chromatographic performance at such situations as shown in Figure 2 indicates that the method is suitable to be used in further validation as well as stability-indicating investigations.

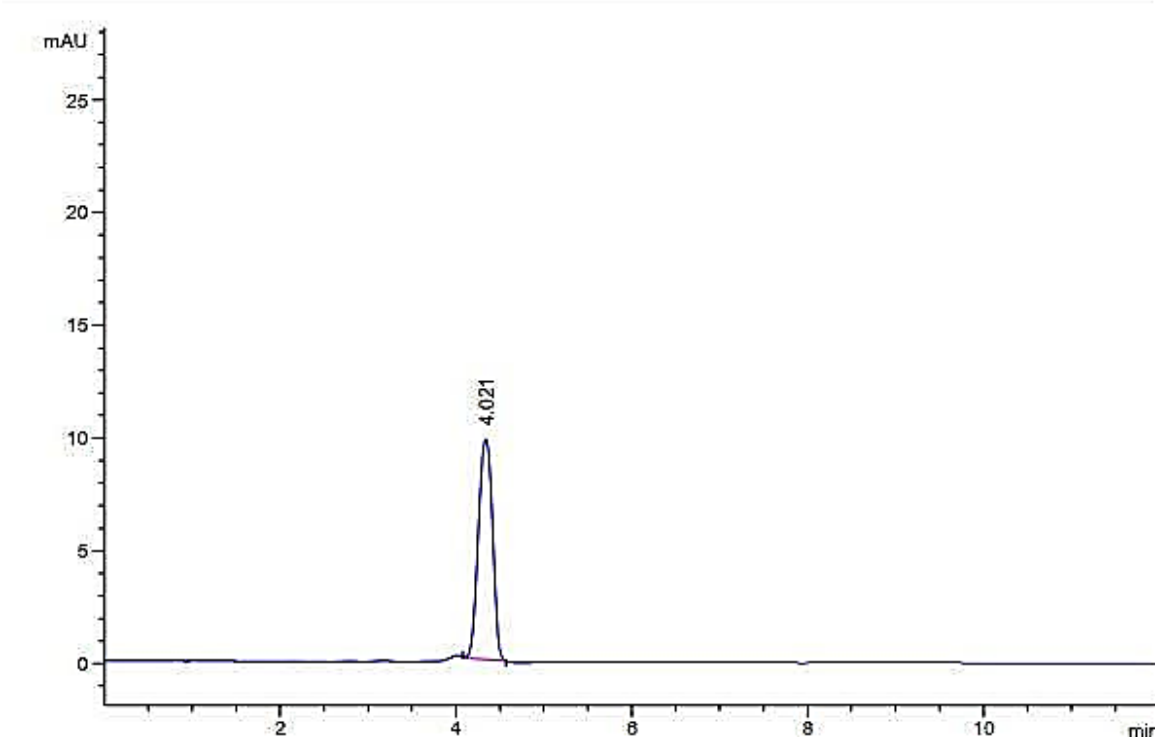


Figure 2. Chromatogram of lercanidipine HCl in 10Mm KH2PO4: methanol (20:80v/v).

System Suitability

The suitability of the evaluation of the system supported consistent chromatographic performance of the developed RP-HPLC method. The retention time was highly reproducible with minimal variation (mean 4.03 min, 0.16 mean percentage standard deviation). The efficient functioning of the column in terms of high theoretical plate count (3650.33) and the tailing factor was almost equal to unity (1.14). The parameters of all system suitability were within acceptable parameters, which proves that the method can be applied to a quantitative and stability-indicating analysis (Table 2).

Table 2. System suitability parameters result.

Replicate	Retention time (min)	Area under curve (AUC)	Theoretical plates (N)	Tailing factor
Mean	4.03	263.31	3650.33	1.14
SD	0.01	7.09	12.21	0.01
%RSD	0.16	2.69	0.33	1.21

Linearity

The RP-HPLC method developed displayed a high degree of linearity throughout the entire 5–25 µg/mL concentration of recombinant protein as the results indicated a proportional change in the peak area of 133.88 to 668.35 as the concentration rose. A regression analysis provided a linear equation, which has a slope of 26.79, and the correlation coefficient R2 = 0.9996) which supports uniform detector responses and high-quality linear behavior. Figures 3 and 4 give a calibration curve and a Standard Chromatogram, and the respective linearity data is summed up in Tables 3 and 4, confirming the appropriateness of the procedure to quantitative estimation of the Lercanidipine hydrochloride accurate.

Table 3. Linearity data for lercanidipine hydrochloride.

Concentration (µg/mL)	AUC						Mean
	1	2	3	4	5	6	
5	132.854	128.452	135.968	138.524	129.875	137.624	133.8828
10	265.784	259.324	252.874	268.452	272.658	260.745	263.3062
15	395.874	382.965	388.452	399.214	392.654	389.875	391.5057
20	534.875	542.324	537.658	540.214	545.875	538.965	539.9852
25	655.214	662.874	668.452	671.214	679.854	672.475	668.3472

Table 4. Linearity response ratio data.

Replicate	Concentration (µg/mL)	AUC Mean	Response ratio
1.	5	137.624	27.52
2.	10	260.745	26.07
3.	15	389.875	25.99
4.	20	538.965	26.95
5.	25	672.475	26.90

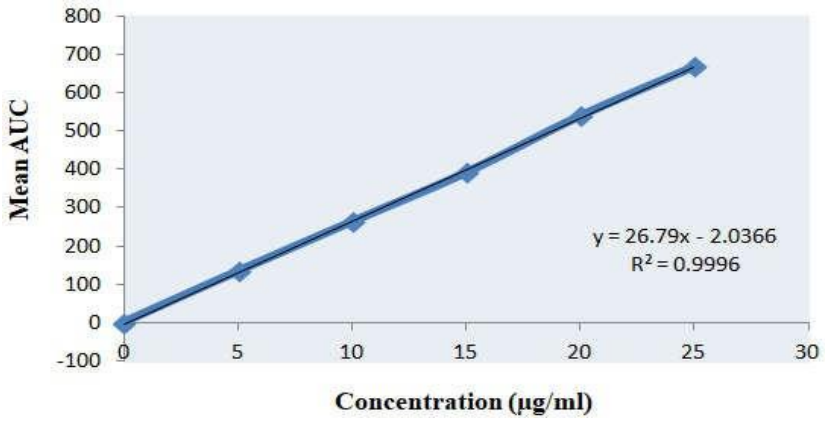


Figure 3. Calibration curve of lercanidipine HCl.

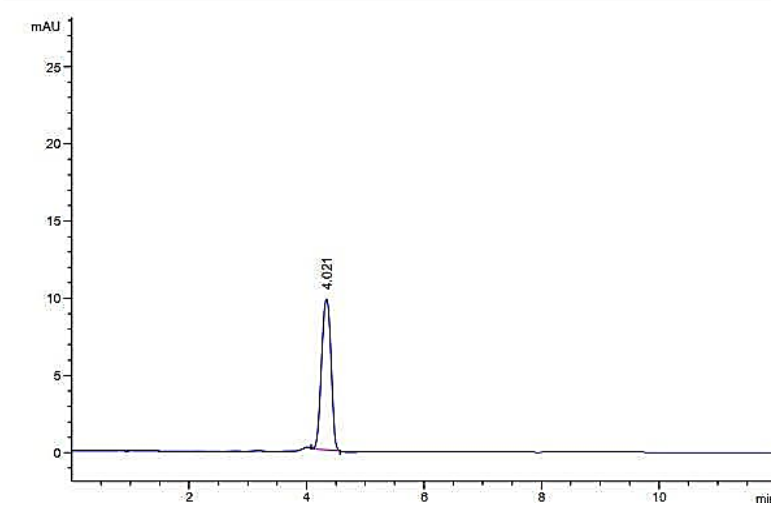
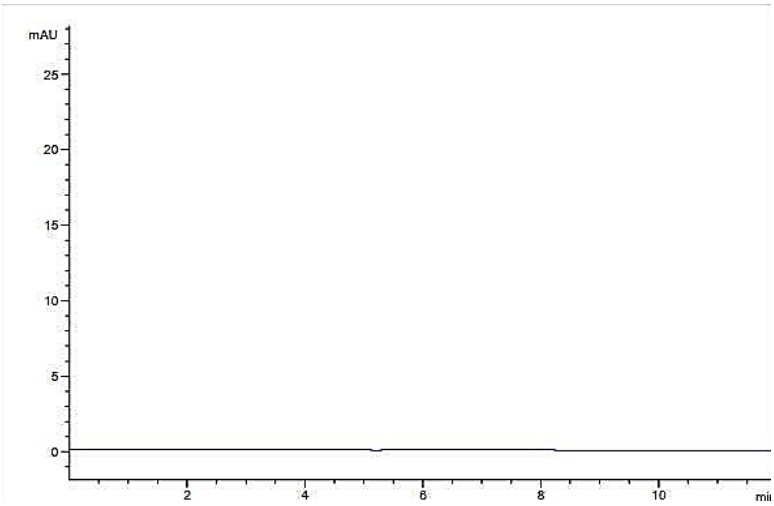


Figure 4. Standard chromatogram of lercanidipine HCl.

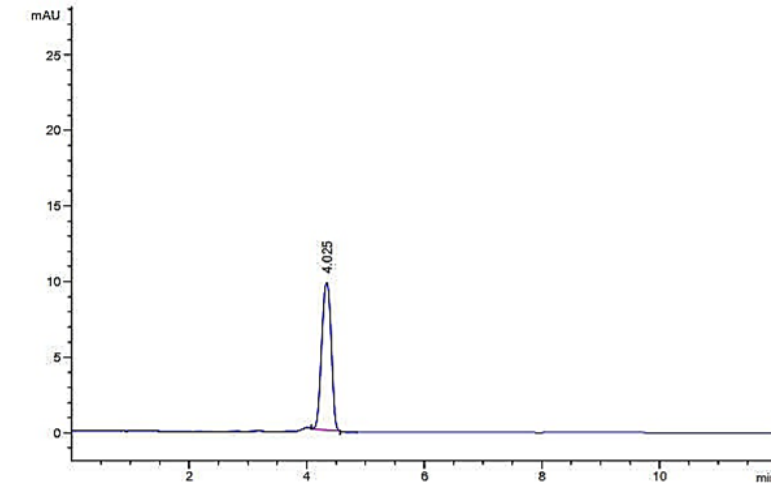
Specificity

Specificity assays revealed that Lercanidipine hydrochloride was resolved well with excipients of the formulations and degradation products. One clear drug peak was found in the retention time of around

4.025 min and no other interfering peaks existed in the blank sample and in the placebo sample. Figure 5 shows that the chromatogram of the pure drug reflected a good limit in the separation of the peaks, which would support identification and accurate quantification of Lercanidipine hydrochloride, and this would be indicative of the stability quality of the method.



(a)



(b)

Figure 5. Chromatogram of pure drug.

Accuracy

The developed RP-HPLC method was tested with the standard addition method in terms of accuracy in the recovery studies at the levels of 80, 100, and 120 percent. It was observed that the mean percent recoveries were 99.42%, 99.87% as well as 99.38% at 80, 100, and 120 percent levels respectively with low values of the % RSD (not more than 0.983) indicating high accuracy and reproducibility of the method. The results of the recovery Table 5 show that the Lercanidipine hydrochloride is knowingly quantified without interference with the formulation excipients, and this shows the suitability of the method to be used in a regular quality control analysis.

Table 5. Accuracy (recovery) study of lercanidipine hydrochloride.

Recovery level (%)	Mean % Recovery	SD	%RSD
80	99.42	0.723	0.727
100	99.87	0.098	0.098
120	99.38	0.977	0.983

Precision

Precision of the developed RP-HPLC method was evaluated in terms of repeatability and intermediate (day-to-day) precision over the concentration range of 5–25 µg/mL. Low %RSD values were obtained at all concentration levels, with repeatability %RSD values ranging from 0.067 to 0.137 and intermediate precision %RSD values ranging from 0.060 to 0.138, indicating excellent reproducibility and reliability of the method for routine quality control analysis (Table 6).

Table 6. Precision data for lercanidipine hydrochloride.

Nominal concentration (µg/mL)	% Mean (Repeatability)	%RSD (Repeatability)	% Mean (Intermediate precision)	%RSD (Intermediate precision)
5	96.560	0.127	97.440	0.138
10	98.360	0.129	98.580	0.131
15	99.560	0.069	99.733	0.117
20	99.220	0.137	99.620	0.060
25	98.880	0.067	98.920	0.092
Mean	*98.516*	*0.106*	*98.859*	*0.108*

Robustness

The studies on robustness revealed that minor intentional changes in chromatographic conditions did not manifest greatly by changes in analytical performance. The stability in the results of the assays carried out in different conditions shows that the method is not sensitive to small changes in operations. The data in Table 7 about the robustness support the stability and the reliability of the method when it is used in normal laboratory work.

Table 7. Robustness study for lercanidipine hydrochloride.

Nominal concentration (µg/mL)	Mean concentration (µg/mL)	% Mean	SD	%RSD
5	4.878	97.560	0.076	0.078
10	9.816	98.160	0.111	0.113
15	14.960	99.733	0.117	0.117
20	19.768	98.840	0.145	0.147
25	24.686	98.744	0.069	0.070
Overall mean	—	*98.607*	*0.104*	*0.105*

Sensitivity (LOD and LOQ)

The RP-HPLC method was developed and its sensitivity measured using the limits of detection (LOD) and the limits of quantification (LOQ). The method exhibited an LOD of 0.45 µg/mL and an LOQ of 1.50 µg/mL (Table 8), indicating a high level of sensitivity.

Table 8. Limit of detection (LOD) and limit of quantification (LOQ).

Parameter	Value (µg/mL)
LOD	0.45
LOQ	1.50

Assay of Marketed Tablet Formulation

The validated RP-HPLC method was successfully applied to the analysis of a marketed tablet formulation of Lercanidipine hydrochloride. The assay results showed 98.50% of the labeled claim with low variability, indicating uniform drug content and the absence of interference from formulation excipients. The assay results summarized in Table 9 confirm the suitability and reliability of the method for routine quality control analysis.

Table 9. Assay of lercanidipine hydrochloride in tablet formulation.

Parameter	Result
Label claim (mg)	10
Amount found (mg)	9.85
% Assay	98.50
%RSD	0.118

Forced Degradation Studies

To determine the stability-indicating ability of the developed RP-HPLC technique, forced degradation experiment was conducted under acidic, alkaline, oxidative, thermal, and photolytic degradation stresses. The standard unstressed drug sample had a recovery of 99.45% which confirms the stability of the analytical procedure and the stability of the drug as a matter of fact. The drug had a degradation of 12.8% under acidic hydrolysis, which means that it was not very particularly vulnerable to acidic environment. The maximum degradation (17.3% was achieved in alkaline hydrolysis), and this shows that Lercanidipine hydrochloride is much more susceptible to the fundamental environment. The degradation due to oxidative degradation was 6.13% which indicates moderate resistance to oxidative stress. The degree of degradation caused by photolytic exposure was 9.19% which meant slight degradation behavior due to photo. Notably, in all stress conditions, degradation products had been sufficiently separated with the main drug peak, which indicates the method specificity and stability. Table 10 sums up the results of the degradation. These results indicate that the designed RP-HPLC technique can differentiate between the drug and the products of its degradation and is applicable to those of stability investigation.

Table 10. Results of forced degradation studies.

Stress condition	Drug recovered (%)	Drug degraded (%)
Standard (unstressed)	99.45	0.00
Acidic hydrolysis	86.65	12.8
Alkaline hydrolysis	82.15	17.3
Oxidative degradation	93.32	6.13
Photolytic degradation	90.26	9.19

CONCLUSION

An easy, specific, and stability notifying RP-HPLC protocol was effectively created and confirmed to estimate Lercanidipine hydrochloride in tablet dosage types. The procedure became very linear within the concentration range of 5 to 25 µg/mL having a perfect correlation coefficient (R2 = 0.9996). Mean percentage recoveries of 99.42–99.87% with values of less than 1% were found to be accurate; precision studies indicated good reproducibility with values of less than 0.14% percent. The procedure was sufficiently sensitive with LOD of 0.45 µg/mL and LOQ of 1.50 µg/mL. Submission to a formulated tablet preparate deemed in the market yielded an assay value of 98.50 percent of labeled assertion which affirmed its applicability in daily quality monitoring. The forced degradation experiment determined the stability-reflecting property of the method, where the highest degradation rate occurred at alkaline condition (17.3%), but the degradation products were clearly separated in all the stress conditions. In general, the validated RP-HPLC technique is dependable, sensitive, and applicable in regular assay testing and stability testing of Lercanidipine hydrochloride.

Acknowledgment

The corresponding author sincerely acknowledges TIT-College of Pharmacy, Bhopal for providing the necessary fundamental research facilities to carry out this work.

Conflict of Interest

No conflict of interest.

Funding
Nil.

REFERENCES

1. Patil P. HPLC method development – a review. SGVU J Pharm Res Educ. 2017;1(2):243–60.
2. Kaushal C, Srivastava B. A process of method development: A chromatographic approach. J Chem Pharm Res. 2010;2(2):519–45.
3. Singh R. HPLC method development and validation. J Pharm Educ Res. 2013;4(1):26–33.
4. Sabir AM, Molony M, Singh BP. HPLC method development and validation: A review. Int Res J Pharm. 2013;4(4):39–46.
5. Snyder LR, Kirkland JJ, Glajch JL. Practical HPLC method development. In: Snyder LR, editor. Practical HPLC Method Development. 2nd ed. New York (NY): John Wiley & Sons; 1997. p. 233–91.
6. Blessy M, Patel RD, Prajapati PN, Agrawal YK. Development of forced degradation and stability-indicating studies of drugs—A review. J Pharm Anal. 2014;4(3):159–65.
7. Bakshi M, Singh S. Development of validated stability-indicating assay methods—Critical review. J Pharm Biomed Anal. 2002;28(6):1011–40.
8. Ngwa G. Forced degradation studies: Forced degradation as an integral part of HPLC stability-indicating method development. Drug Deliv Technol. 2010;10(5).
9. Bajaj S, Singla D, Sakhuja N. Stability testing of pharmaceutical products. J Appl Pharm Sci. 2012;2(3):129–38.
10. ICH Q2(R1). Validation of analytical procedures: Text and methodology. International Conference on Harmonisation; 2005.
11. United States Pharmacopeial Convention. United States Pharmacopoeia 29–NF 24. 29th ed. Rockville (MD): United States Pharmacopeial Convention; 2006. p. 587.
12. Kalal DJ, Redasani VK. Stability-indicating RP-HPLC method development and validation for estimation of mupirocin calcium in bulk and pharmaceutical formulation. Future J Pharm Sci. 2022;8(1).
13. Tiwari B, Shirsat MK, Kulkarni A. Development and validation of stability-indicating RP-HPLC method for estimation of cilnidipine. J Drug Deliv Ther. 2020;10(1):97–100.
14. Chhalotiya UK, Bhatt KK, Shah DA, Baldania SL. Development and validation of a stability-indicating RP-HPLC method for duloxetine hydrochloride in bulk and tablet dosage form. Sci Pharm. 2010;78(4):857–68.

