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Method Development and Validation of Valsartan by Using Stability-Indicating RP-HPLC Method

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Abstract This study had the objective to establish and validate a reverse-phase high-performance liquid chromatography (RP-HPLC) technique for the quantification of valsartan in its formulations, serving as an indicator of stability. The selected HPLC system employed a UV-07368 column (Instrument ID: QCL-HPL-022), specifically the SHIMADZU LC2010C HT. A novel mobile phase was developed using a volumetric ratio of acetonitrile, water, and glacial acetic acid at 50:50:0.1 (V/V/V), with a flow rate set at 1 ml/min. Detection was carried out at 230 nm. Valsartan underwent stress testing, including UV deterioration, thermal degradation, and hydrolytic degradation in alkaline, acidic, along with neutral circumstances to evaluate the stability-indicating properties of the technique. The method exhibited a linear correlation over a concentration range of 80-240 ppm (r^2 = 0.999), described by the regression equation y = 21.80x - 188.2. Valsartan demonstrated noteworthy stability under conditions of heat, oxidative stress, acidity, base, and neutrality. The procedure underwent validation for robustness, linearity, specificity, accuracy, and precision. The findings suggested that the method is swift, accurate, precise, reproducible, and dependable, rendering it suitable for analyzing commercial dosage forms in accordance with ICH recommendations.

Keywords Forced Degradation Studies, ICH Guidelines, RP-HPLC, Stability Studies, Valsartan

1. Introduction

Valsartan is a prescribed medication utilized to manage various conditions, including hypertension, heart failure, and diabetic kidney disease. It is commonly employed as a preliminary line of medication to treat hypertension and is administered orally. The medicine performs by preventing angiotensin's activities II, a compound known for constricting blood vessels and activating aldosterone, both of which contribute to elevated blood pressure. Valsartan acts as an antagonist on angiotensin type I receptors (AT1).

In its specific formulation, Valsartan presents as white, oblong tablets with a convex shape and a broken line on one side, each containing 160mg. Chemically, Valsartan is represented as 3-methyl-2-[pentanoyl-[[4-[2-(2H-tetrazol5-yl) phenyl] phenyl] methyl] amino Butanoic acid. The chemical structure was shown in Figure 1 [1]. Classified as an angiotensin II receptor antagonist, Valsartan targets the AT1 subtype and is prescribed for the treatment of hypertension [2], congestive heart failure (CHF), and post-myocardial infarction (MI). The mechanism of action involves blocking angiotensin II, leading to blood vessel dilation and a subsequent reduction in blood pressure.

This study's main goal was to develop and validate the RP-HPLC method for accurately quantifying valsartan in tablet and bulk material formulations. The goal was to design a method that prioritizes speed, reliability, and cost-effectiveness. Following the guidelines outlined in ICH

Q1A (R2), stability testing was conducted to gather insights investigating how a drug's constitution or product quality has evolved over time in various environmental scenarios, including changes in temperature, humidity, and exposure to light. The overarching objective is to determine the lifespan for a medicinal product and then set up an additional testing time for the substance being treated, in addition to proposed storage instructions.

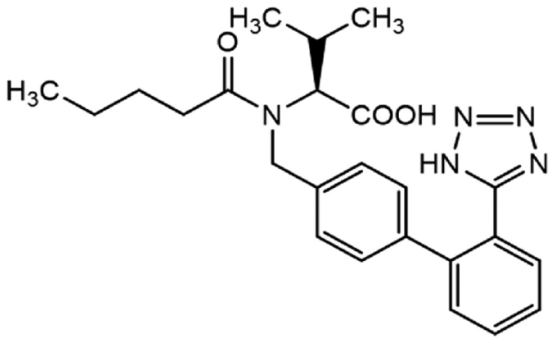


Figure 1. Chemical structure of Valsartan

Adherence to current Good Manufacturing Practices (GMP) regulations requires subjecting all pharmaceutical drugs to a stability-indicating assay methodology earlier than appearance. This essential process aims to identify potential degradation products, clarify the processes of destruction and assess the molecule's built-in protection. Additionally, it validates the effectiveness of the analytical procedures used to detect stability-indicating properties. The specific stress testing regimen employed depends on the unique characteristics of either the specific kind of substance being treated or its component [3].

Given the susceptibility of valsartan to various conditions, the development of a RP-HPLC analysis method becomes crucial. This method must effectively separate the drug from degradation products formed under recommended International Council for Harmonization (ICH) conditions, including hydrolysis, oxidation, photolysis, and thermal stress. These studies offer valuable insights into the inherent stability of the drug and significantly contribute to the validation of analytical methods for stability assessments [4].

An examination of the existing body of literature reveals a paucity of techniques for the quantification of valsartan in biological fluids and commercial formulations [5-8]. Previous research efforts have showcased the creation of stability-indicating liquid chromatography (LC) methods to ascertain levels of valsartan in a range of chemicals and product degradation as a consequence of research on compelled disintegration [9-13].

It is pertinent to note that in earlier investigations, the reported retention time for valsartan was documented as 27 minutes. In contrast, our present method achieves a significantly reduced retention time of 4.55 minutes. Consequently, our research endeavors aimed to establish a straightforward, selective, cost-effective, and highly specific stability-indicating reverse RP-HPLC method. This method is not only applicable for quantifying related substances but also for evaluating huge amounts of valsartan. In this paper, the evolution of this stability-indicating analytical technique utilizing samples from investigations involving forced degradation is covered in more detail.

Valsartan is chemically described as (2S)-3-Methyl-2-(pentanoyl {[2'-(1H-tetrazol-5-yl) biphenyl-4-yl] methyl} amino) butanoic acid, with a molecular formula of $C_{24}H_{29}N_5O_3$ and a molecular weight of 435.519 g/mol [14]. The objective of the current study was to validate the analytical procedure for quantifying Valsartan content in 160mg Valsartan tablets using HPLC in accordance with the prescribed method of analysis.

2. Materials and Methods

We utilized the SHIMADZU LC2010C HT, HPLC System equipped with UV-07368 detection (Instrument I.D: QCL-HPL-022) for our experiments. Analytical measurements were performed using a 4.6 mm × 25cm L1 column with 10 µm packing material. Precise measurements were obtained with the CITIZEN CX 220 analytical weighing balance (ID: QCL-ALB-003). To ensure purity, we employed Millipore membrane filters with a pore size of 0.2 µm in the filtration process. Various laboratory accessories were also used in our experiments. For our analyses, we utilized the following reagents, standards, and samples: Valsartan working standard, Valsartan tablets USP 160mg, glacial acetic acid (AR Grade), acetonitrile (HPLC Grade), and water (HPLC Grade). The quantitative analysis was carried out using an HPLC system equipped with a UV/VIS detector.

Chromatographic Conditions

Column: Utilize a 4.6-mm × 25-cm column packed with 10-µm L1 material.

Mobile Phase: Prepare a mixture of acetonitrile, water, and glacial acetic acid in a 50:50:0.1 ratios. Filter the solution through a 0.2 µm Nylon membrane filter paper and degas before application.

Wavelength: Set the detection wavelength at 230 nm.

Column Temperature: Maintain the temperature at 300 ℃.

Flow Rate: Maintain a flow rate of 1.0 ml/minute.

Injection Volume: Inject 20 µl of the sample.

Run Time: The total run time is 15 minutes.

Blank Solution: Use the diluent as the blank solution.

Diluent: Prepare the diluent by combining acetonitrile and water in a 50:50 ratio.

Prepare Standard Solution of Valsartan

Measure precisely 80 mg of the Valsartan working

standard into a 50 ml volumetric flask in order to prepare a standard Valsartan solution. Add twenty milligrams of an appropriate dilution to the flask and utilize the sonication to altogether dissolve the Valsartan. Increase the volumetric flask to the right level to ensure the dilution factor allows for all integration. Use 1 milliliter of the contents and place it into a 10-milliliter volumetric flask. To ensure accurate integration and to use the dilution for marking, dilute the 1 ml portion. To ensure purity and clarity, pass the resultant solution through a 0.2 µm nylon membrane filter.

Preparation of Test Solution

Place 20 tablets in a 1000 ml volumetric flask to serve as the test solution. After adding about 100 milliliters of water and giving it a good shake for five minutes, add 800 milliliters of acetonitrile. After 30 minutes of continuous shaking, sonicate for ten minutes, and then let it cool. Using acetonitrile, adjust the volume to the desired level. After centrifuging the mixture for ten minutes at 8000 rpm, pour 5.0 ml of the clear supernatant solution into a different 100 ml volumetric flask and top it off with an appropriate diluent. Put the solution through a 0.45 µm nylon membrane filter to ensure purity and clarity.

Procedure

To establish the system suitability solution, apply the Valsartan standard working solution. Equal volumes of a blank solution and five replicate injections of the system suitability solution should be injected. After that, perform two injections of the test solution, record chromatograms, and disregard any peaks originating from the blank. Calculate the percent relative standard deviation (% RSD) for every one of the five replicate injections of the system suitability solution. Investigate the theoretical plates for the peak and tailing factor in the chromatogram that resulted from the fifth injection of the system suitability solution.

Limits: Additionally, there can be no fewer than 2000 theoretical plates, a tailing factor of less than 2.0, and a percentage RSD of not more than 2.0%. Examine the HPLC method for validation parameters in accordance with ICH guidelines, especially Quality topics Q2A and Q2B of CPMP/ICH/281/95.

3. Results and Discussion

The validation study meticulously monitored system suitability parameters, and the findings have been meticulously documented within the validation report. Here is a summary of the validation data.

3.1. Specificity/Selectivity

Several solutions, including the diluent blank solution, additive combine the solution, system-appropriate solution, and testing solution, were introduced in order to evaluate selectivity. According to the established approval requirements, the Valsartan peak had to be clearly distinguished from any nearby peaks as well as from one another. Furthermore, it was expected that neither the excipient blend solution nor the diluent blank solution would show any peaks at the retention time that corresponded to Valsartan. Notably, it was discovered that the predefined acceptance criteria specified in the analytical method were exactly in line with the system suitability criteria.

Table 1. System suitability involves assessing selectivity

S. No.	Area of Valsartan
1	2216.08
2	2250.60
3	2240.11
4	2206.17
5	2222.81
Mean	**2227.15**
SD (±)	**18.02**
(%) RSD	**0.81**

The injections that were made were studied utilizing the technique described at the chosen wavelength. The process's selectivity has been demonstrated by its provenance that neither the diluting blank solution nor the placebo with the Valsartan peak wasn’t observed any interference. The data presented in Table 1 reveals that the relative standard percentage was less than one (0.81), validating the method's selectivity. The novel approach is characterized not only by its selectivity but also by its rapidity, boasting a concise run time of 4.6 minutes. Moreover, it necessitates only basic sample preparation techniques and specific mobile phase combinations. In summary, the developed method exhibits both selectivity and yields satisfactory results.

3.2. Forced Degradation

To validate the assay method's capability to detect and quantify potential degradation products, forced degradation studies were conducted. Both Valsartan WS and the sample were exposed to various stress conditions, including 5N HCl, 5N NaOH, thermal degradation, and UV degradation, as delineated in Table 2. Chromatographic analysis of the resultant solutions was executed, and the chromatograms were recorded to assess the impact of these stress conditions on the compounds. Figures 2–5 illustrate the recorded chromatograms of Valsartan forced degradation, with time in minutes divided by the area percentage for clarity.

3.3. Conditions for Forced Degradation

Acid Degradation: Subjecting the material to a stress condition involves exposing it to 5N hydrochloric acid (HCl) while heated at approximately 60 ℃ for a duration of 10 minutes using a water bath.

Alkali Degradation: The stress condition for alkali degradation entails treating the material with 5N sodium hydroxide (NaOH) under the conditions of heating at about 60 ℃ for 10 minutes using a water bath.

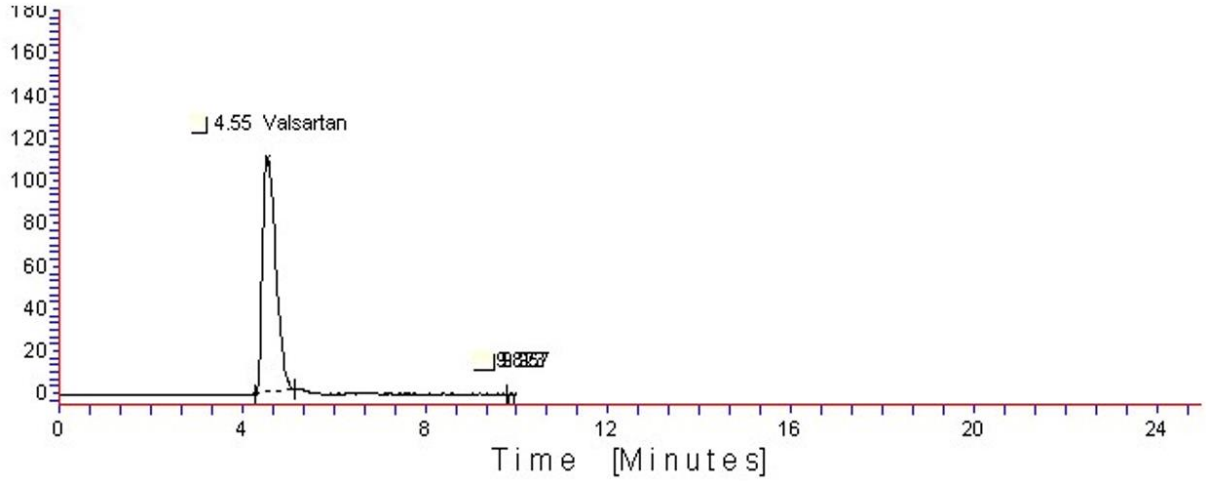
Thermal Degradation: To induce thermal degradation, the material is subjected to a temperature of 105 ℃ for a period of 12 hours.

UV Degradation: The stress condition for UV degradation entails exposing the material to UV radiation continuously for a duration of 7 days.

Table 2 indicates the findings of the method applied to determine the ability of the system in compelled deterioration. In accordance with the analysis, the mean area is 2258.18, with a percentage RSD of 1.37.

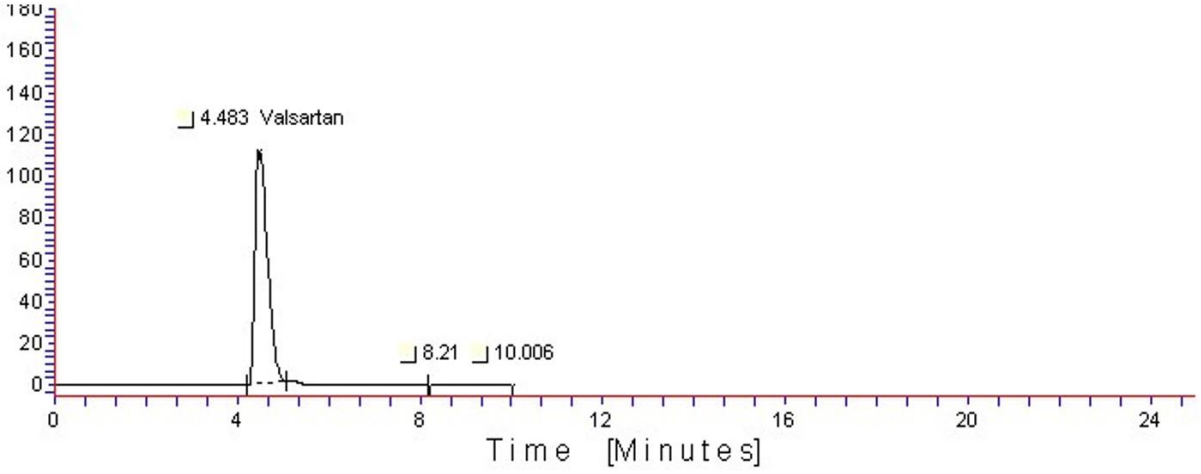
Table 2. Assessing forced degradation serves the purpose of assessing system suitability

S. No.	Area of Valsartan
1	2229.99
2	2272.05
3	2248.51
4	2305.26
5	2235.06
Mean	**2258.18**
SD (±)	**30.95**
(%) RSD	**1.37**



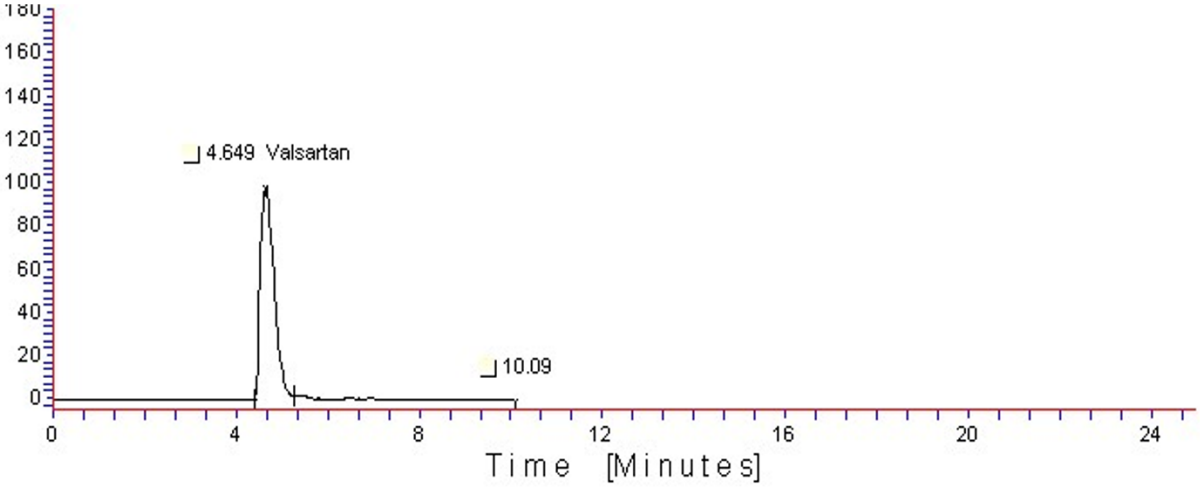
Peak No	Retn.Time	Area	Height	Area %	Height %	Width@50%
1	4.55	2231.963	111.171	99.519	96.284	0.333
2	9.823	7.585	2.152	0.338	1.864	0.066
3	9.957	3.209	2.139	0.143	1.853	0.033
Total		**2242.757**	**115.462**	**100**	**100**	

Figure 2. Chromatogram of Valsartan sample in Acid degradation



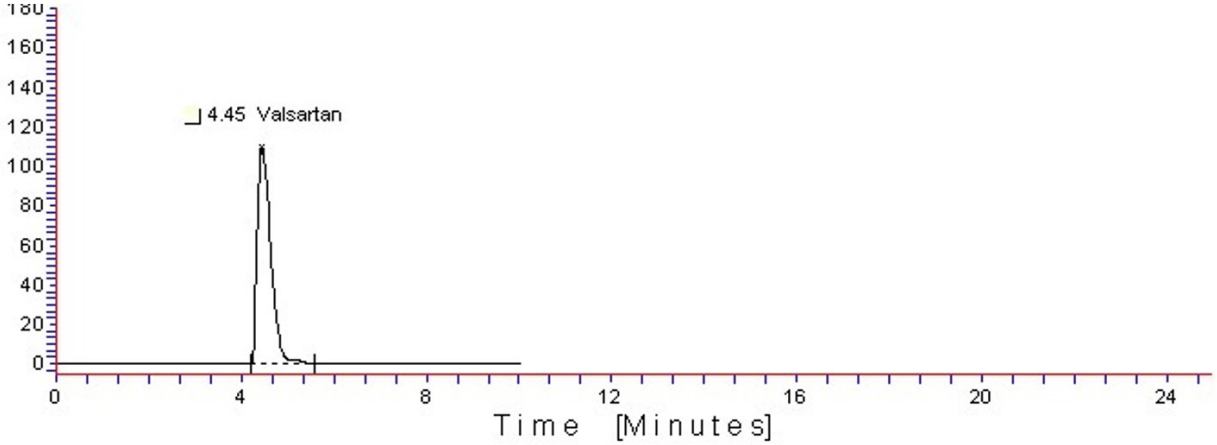
Peak No	Retn.Time	Area	Height	Area %	Height %	Width@50%
1	4.483	2146.103	112.202	99.652	96.775	0.316
2	8.21	4.691	1.869	0.218	1.612	0.05
3	10.006	2.804	1.869	0.13	1.612	0.033
Total		**2153.598**	**115.94**	**100**	**100**	

Figure 3. Chromatogram of Valsartan sample in Alkali degradation



Peak No	Retn.Time	Area	Height	Area %	Height %	Width@50%
1	4.65	1280.417	97.979	99.99	99.915	0.216
2	10.09	0.125	0.083	0.01	0.085	0.033
Total		**1280.542**	**98.062**	**100**	**100**	

Figure 4. Chromatogram of Valsartan sample in Thermal degradation



Peak No	Retn.Time	Area	Height	Area %	Height %	Width@50%
1	4.45	2229.817	110.627	100	100	0.333
Total		**2229.817**	**110.627**	**100**	**100**	

Figure 5. Chromatogram of Valsartan sample in UV degradation

Observations Regarding Acid Degradation:

a) Two distinctive degradation peaks were evident in the acid degradation of the Standard preparation.
b) Figure 2 depicts that the acid degradation of the Sample preparation also showcased two degradation peaks.

Observations Regarding Alkali Degradation:

a) The alkali degradation of the Standard preparation revealed the presence of two degradation peaks.
b) Figure 3 illustrates that the alkali degradation of the Sample preparation exhibited two degradation peaks as well.

Observations Regarding Thermal Degradation (105℃ for 12 hours):

a) The thermal degradation of the Standard preparation showed two degradation peaks.
b) In contrast, Figure 4 shows that only a single degradation peak was noted during the thermal degradation of the Sample preparation.

Observations Regarding UV Degradation (Exposure to UV radiation for 7 days):

a) It is essential to note that no degradation peaks were observed after subjecting the Standard preparation to UV radiation for 7 days.
b) Similarly, figure 5 demonstrates that no degradation peaks were detected following the exposure of the Sample preparation to UV radiation for 7 days.

Acceptance Criteria

Ensure a clear separation of degradation peaks, with the Valsartan peak meeting the required standards for peak purity.

Conclusion

The results presented in Table 4 provide an amount of Valsartan deterioration according to various circumstances. Importantly, there is no discernible interference among chromatogram peaks in the degradation preparations. The forced degradation results in distinct peaks and the Valsartan peak exhibit satisfactory purity. Consequently, the HPLC method showcases outstanding precision, selectivity, and specificity in the quantification of Valsartan in 160 mg tablets. The method is stability-indicating, as evidenced by the unequivocal separation of degraded products from both Valsartan and adjacent peaks.

Table 3. Percentage of degradation observed under varying conditions

Acid Stress	**% Degradation**
Standard	0.032
Sample	0.481
Alkali Stress	**% Degradation**
Standard	0.128
Sample	0.348
Thermal Stress	**% Degradation**
Standard	0.324
Sample	0.010
UV Stress	**% Degradation**
Standard	NA
Sample	NA

Linearity

We prepared five standard Valsartan solutions ranging in concentration from 50% to 150% of the theoretical assay preparation levels for the linearity assessment. Both the linearity solution and the system appropriateness solution were introduced to the system according to the procedure that had been developed. The correlation coefficient was determined and a graph showing levels versus peak

response was made. A correlation coefficient of no lower than 0.999 had to be achieved for this evaluation to receive approval from the FDA.

Results

Table 4 details the injection sequence for linearity. Valsartan computed linearity is shown, together with the five test solutions' percentage RSD and standard deviation (0.53). Table 4 gives the mean area of Valsartan as 2258.47. The analytical method's predetermined requirements for approval were successfully met by the system suitability criteria (refer to Table 4 for system suitability results).

Plotting the average region of peaks for various Valsartan concentrations in opposition to the concentrations of the samples conveyed as percentages resulted in the establishment of a linearity graph. Table 5 provides the conclusions of the linearity investigation that revealed a significant relationship between peak area and the concentration of analyte.

Table 4. System suitability involves assessing the linearity of the sample

S. No.	Area of Valsartan
1	2242.45
2	2234.21
3	2226.41
4	2241.82
5	2258.47
Mean	**2240.67**
SD (±)	**11.90**
(%) RSD	**0.53**

Table 5. Results pertaining to the linearity of the sample

Linearity Level	Sample Concentration (in %)	Sample Concentration(in ppm)	Peak Area	Correlation Coefficient
Level – 1	50	80	921.28	**0.999**
Level – 2	75	120	1403.86	
Level – 3	100	160	2008.90	
Level – 4	125	200	2556.88	
Level – 5	150	240	3070.47	

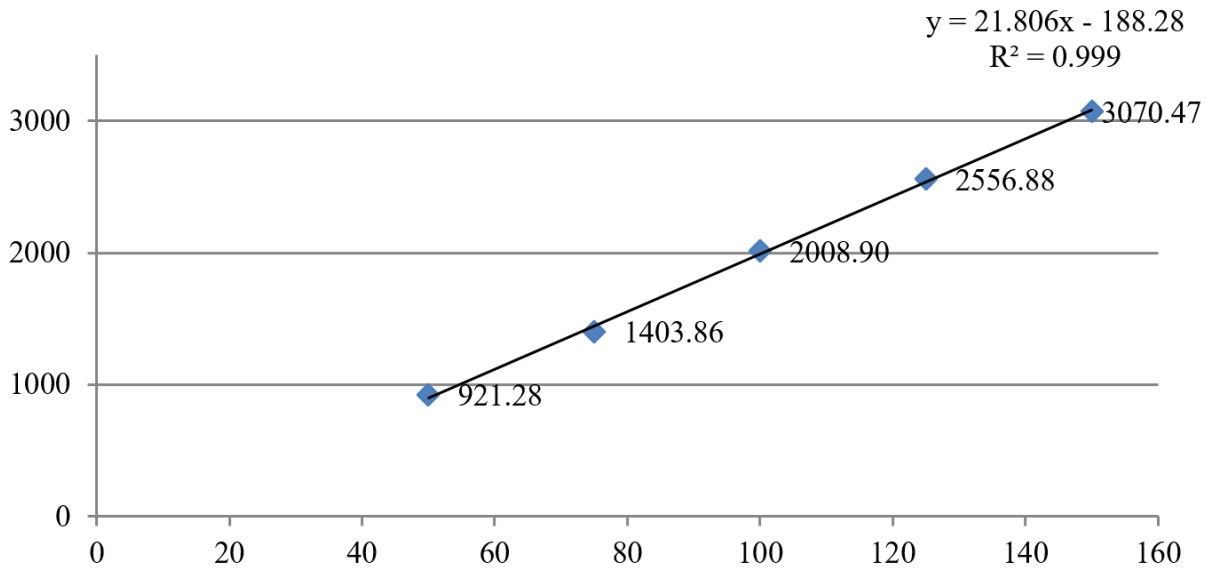
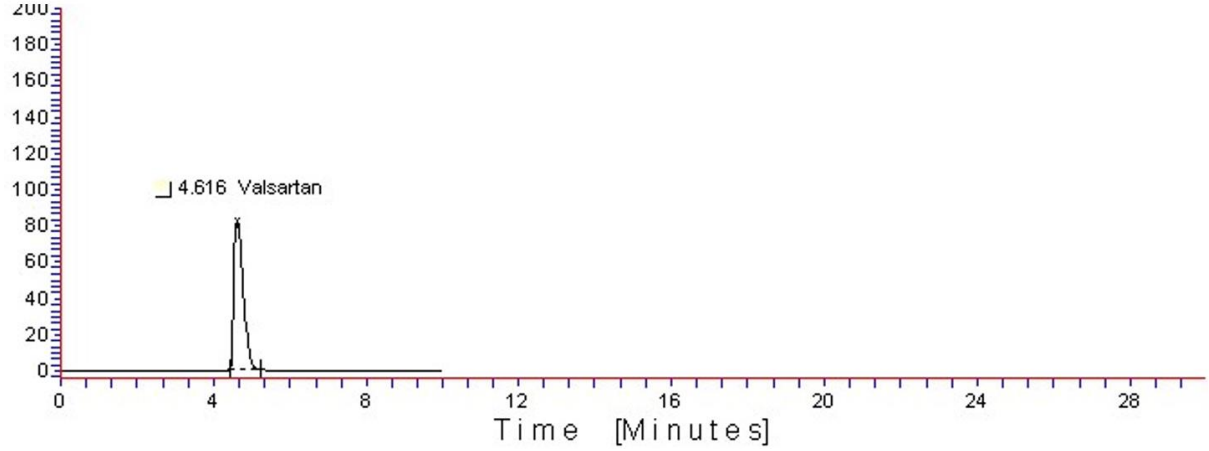


Figure 6. Linearity graph of Valsartan sample



Peak No	Retn.Time	Area	Height	Area %	Height %	Width@50%
1	4.616	1396.936	83.011	100	100	0.283
Total		1396.936	83.011	100	100	

Figure 7. Chromatogram of Valsartan sample

A graphical representation of linearity, displaying the average area at each concentration level, revealed a linear relationship, as depicted in Figure 6. The calibration curve's regression equation was determined as Y=21.80x-188.2, accompanied by a robust correlation coefficient (R^2) value of 0.999, signifying excellent linearity that surpassed 0.999. A linear correlation was identified between 50% and 150% of the performing quantity, corresponding to the evaluation that assessed the linearity of the Valsartan sample in the measured concentration that ranged from 50 ppm to 150 ppm. The chromatogram of the Valsartan sample revealed a peak at 4.616 retention time, well within acceptable limits, as illustrated in Figure 7.

3.4. Method Precision

Six Valsartan specimens from Valsartan For the aim of assessing precision and technique precision, the 160 mg pills were meticulously manufactured in accordance with the specified analytical procedure. The outcomes of tests conducted by analyst-1 are presented in Table 6, showcasing a mean area of 2255.55 and a % RSD of 0.83. The percentage of relative standard deviation (% RSD) for the assay of these six samples is displayed in detail in Table 7. The approval requirements, stipulating that the % RSD should not exceed 2.0% for the results of the six test solutions, were successfully met. It was confirmed that the system's suitability adhered to the predetermined approval requirements was outlined in the analytical method. The summary of assay results from the preparation of the six test solutions is presented in Table 7.

Table 7 reports a mean area of 100.44 square feet, accompanied by a %RSD of 0.37 percent. Notably, the %RSD for the six determinations of the Valsartan assay using different test solutions is remarkably small.

Table 6. System suitability involves evaluating the precision of the method

Analyst – 1 HPLC No.: EH/R&D/HPLC-024

S. No.	Area of Valsartan
1	2277.98
2	2233.53
3	2245.69
4	2272.05
5	2248.51
Mean	**2255.55**
SD (±)	**18.76**
(%) RSD	**0.83**

Table 7. Method precision results

Test Solution	% Assay of Valsartan
1	99.87
2	100.67
3	100.09
4	100.64
5	100.83
6	100.53
Mean	100.44
SD (±)	0.37
(%) RSD	0.37

3.5. Intermediate Presicion

In six different instances, the technique of analysis was carefully executed to prepare the test solutions of 160 mg Valsartan tablets for the intermediate precision method. Various researchers conducted the analysis with various HPLC systems and columns—all from the same brand, but

utilizing various serial numbers. The predetermined standards of acceptance for system suitability were determined to be met through the use of statistical methods. The calculated percentages RSD for the assay findings from twelve test solutions (six from intermediate precision and six from method precision) met the criteria for approval requirements, which specifies the percentage of RSD is not greater than 2.0%. The pre-established acceptance standards specified in the analytical method have been proven to be met by the system suitability criteria (refer to Table 8 for method suitability outcome). Table 9 displays the assay results from six test solutions, including both method exactitude and intermediate precision (a total of nine results), along with their related percentage RSD values.

Table 8. Intermediate precision results

Analyst – 2 HPLC No.: EH/R&D/HPLC-023

Test Solution	% Assay of Valsartan
1	99.17
2	100.81
3	100.28
4	102.16
5	98.89
6	100.85
Mean	100.36
SD (±)	1.21
(%) RSD	1.20

Demonstrating the precision of the methodology, the percent relative standard deviation (RSD) values consistently remained below 2%, affirming the approach's accuracy.

Methodology for Assessing Accuracy

The accuracy assessment involved the analysis of Valsartan test solutions, which were created by blending Valsartan Active Pharmaceutical Ingredient (API) with an excipient mixture. These solutions covered concentrations of 50%, 75%, 100%, 125%, and 150% of the target concentration, achieved by incorporating Valsartan API into the excipient blend.

Acceptance Criteria

The predetermined acceptance criteria stipulated that the mean recovery at each concentration level should fall within the range of 98.0% to 102.0%. The assessment of system suitability criteria verified their conformity with the specified approval requirements outlined in the analytical technique. Results of the Accuracy Study: comprehensive findings from the accuracy study can be found in Table 10.

The data in Table 10 reveal consistent Valsartan recovery levels ranging from 98.0% to 102.0%, with a % Relative Standard Deviation (% RSD) consistently below 1.0% at each recovery level. This demonstrates that the analytical method aligns with the predetermined approval requirements for the recovery study outlined in the protocol. The mean % drug recovery, calculated at 99.95%, reinforces the effectiveness of the suggested approach for Valsartan, in line with previous reports [15]. In summary, the method's accuracy is conclusively established.

Table 9. The outcomes from twelve Valsartan test solutions, six pertaining to method precision and six pertaining to intermediate precision

Analysis conducted as part of the method precision study by Analyst 1 using system 1 and column 1 on day 1	
Same column	**% Assay of Valsartan**
1	99.87
2	100.67
3	100.09
4	100.64
5	100.83
6	100.53
Analysis conducted as part of the intermediate precision study by Analyst 2 using system 2 and column 2 on day 2	
Column sr. no.	**015452030142 01**
Test Solution	**% Assay of Valsartan**
7	99.17
8	100.81
9	100.28
10	102.16
11	98.89
12	100.85
Mean of twelve samples	100.40
SD (±)	0.85
(%)RSD	0.85

Table 10. Results for accuracy (% recovery).

Level of addition	**Amount of Valsartan added in mg**	**Amount of Valsartan found in mg**	**Recovery (%)**
First Level	74.7	74.58	99.84
Second Level	116.5	116.71	100.18
Third Level	160.4	160.25	99.91
Fourth Level	206.9	206.75	99.93
Fifth Level	254.8	254.48	99.87
Mean			99.95
SD(±)			0.14
(%) RSD			0.14

To further validate the method's robustness, a study was conducted using the same Valsartan lot as in sections 7.0.a and 7.0.b of the Valsartan Tablets 160 mg analytical method. Two test solutions were prepared following the

specified analytical method and injected under various chromatographic conditions, including changes in column lot, flow rate (± 0.2 ml/minute), wavelength (± 2 nm), and mobile phase composition (± 0.2). This aimed to assess if the system suitability criteria met the predetermined approval requirements.

In the case of a change in column lot, a column with dimensions of 4.6mm × 25cm and 10 µm packing of L1 was used under normal experimental conditions. The results of the robustness study offer comprehensive insights into the system suitability criteria under varied experimental conditions. Importantly, the % RSD between results under altered conditions and the method's average precision did not exceed 2.0%, satisfying the approval requirements. In conclusion, based on the robustness study outcomes, we can affirm that the proposed method is not only accurate but also exhibits resilience under diverse chromatographic conditions. The results from various flow rate conditions are presented in Table 11.

Table 11. Results for robustness with a change in the column

Flow rate →	**Same column**	**Different column**
Sample	**% Assay**	
Test solution	99.87	99.37
Average assay result from method precision	100.44	100.44
Mean	100.61	99.91
SD (±)	0.40	0.76
(%) RSD	0.40	0.76

The assessment of system suitability has verified compliance with the prescribed approval requirements detailed in the analytical method, demonstrating a deviation in flow rate within the specified range of ± 0.2 mL/minute. For a detailed analysis of the system suitability results under standard experimental conditions (1.0 mL/minute), the results from various flow rate conditions are presented in Table 12.

Table 12. Results for robustness with a change in flow rate

Flow rate →	**0.8 mL/minute**	**1.2mL/minute**
Sample	**% Assay**	
Test solution	100.27	99.49
The mean assay outcome derived from method exactness	100.44	100.44
Mean	100.36	99.97
SD (±)	0.12	0.67
(%) RSD	0.12	0.67

The examination of wavelength variation within a range spanning ±2 nm, conducted under standard experimental conditions at 230 nm, demonstrated conformity with the specified acceptance criteria outlined in the analytical method. For a detailed breakdown of the system suitability results, the presented table, denoted as Table 13, exhibits assay results acquired using different wavelength conditions.

Table 13. Results for change in wavelength

Wavelength →	**228 nm**	**232 nm**
Sample	**% Assay**	
Test solution	100.74	99.51
The mean assay outcome derived from method exactness	100.44	100.44
Mean	100.59	99.98
SD (±)	0.21	0.66
(%) RSD	0.21	0.66

Change in Change in Composition of Mobile Phase

The mobile phase according to the circumstances of the experiment consists of a 50:50:0.1 combination of acetonitrile, water, and glacial acetic acid. To ensure accordance with the specified approval requirements specified in the analytical method, an evaluation of the system suitability parameters was carried out. The provided data in Table 14 illustrate assay results obtained through the modification of the mobile phase composition.

Table 14. Results for change in change in composition of mobile phase

Mobile phase composition	**A:W:GAA: 48:52:0.1**	**A:W:GAA: 52:48:0.1**
Sample	**% Assay**	
Test solution	100.78	98.69
The mean assay outcome derived from method exactness	100.44	100.44
Mean	100.61	99.57
SD (±)	0.24	1.24
(%) RSD	0.24	1.24

A thorough evaluation of a uniform batch of Valsartan tablets, each containing 160 mg, was conducted under diverse conditions, encompassing variations in column lots, flow rates, wavelengths, and mobile phase compositions. All of the system suitability tests met the predefined guidelines, and the percentage RSD (relative standard deviation) between the modified conditions results and the method precision average result was less than 2.0%. The protocol's predetermined approval requirements for a robustness study are satisfied by the analytical technique, verifying its robustness.

Stability of Analytical Solution

Experimental Procedure

In this stability assessment, Valsartan Tablets 160 mg were examined at specific time points, namely 0 hours, 12 hours, 24 hours, 36 hours, and 48 hours, throughout the duration of the experiment. These tablets were processed to

create both system suitability and test solutions, which were then stored at room temperature for their respective time intervals. The final analysis occurred at the 48-hour mark, utilizing a freshly prepared test solution. Simultaneously, the system suitability solution was freshly prepared at the time of analysis. The primary focus of the analysis was to determine the assay of Valsartan Tablets 160 mg in the samples.

Acceptance Criteria

The stability of the analyte was evaluated by monitoring any significant changes in % assay. The results of the assay obtained during the solution stability experiment are detailed in Table 15. The acceptability of the analyte's stability is contingent upon the absence of a notable deviation in % assay.

Table 15. Results for solution stability

% Assay results calculated against the freshly prepared system suitability standard	
Sample	**% Assay of Valsartan**
0^{th} hour	99.60
12^{th} hour	98.02
24 hour	101.22
36 hour	100.04
48 hour	101.56
Mean	100.09
SD (±)	1.41
(%) RSD	1.41

In Table 15, the average area demonstrates stability at 100.09, with a %RSD of 1.41%, both effectively across allowable limits. The system suitability assessment validates its compliance with established standards. Furthermore, the % RSD variance between assay results for newly generated test solutions and stored ones is below 2.0%. Notably, the test solution exhibits remarkable stability, as evidenced by minimal fluctuations in assay levels when kept at room temperature for 48 hours. Consequently, it can be concluded that the solution maintains stability for up to 48 hours under these specified conditions.

4. Conclusions

Following ICH criteria, we have successfully created and validated a RP-HPLC technique to quantitatively determine valsartan in diverse formulations. The HPLC chromatogram displayed an average retention time of 4.616 minutes for valsartan. In validation experiments, the method showcased exceptional traits, encompassing speed, simplicity, accuracy, precision, specificity, selectivity, and cost-effectiveness.

Moreover, force degradation studies revealed the appearance of two degradation peaks in acidic and basic environments, with no degradation peaks observed under thermal or UV exposure. The method's limits of detection (LOD) and quantification (LOQ) were established at 0.284 and 0.852 µg/ml, respectively. The analytical method's range spans from 50 ppm to 150 ppm, with linearity evident in the 80% to 240% range of the working concentration.

The procedure's precision as well as accuracy met satisfactory criteria. The developed HPLC approach was deemed appropriate, and the analytical solution maintained stability for 48 hours at room temperature. Valsartan recovery consistently fell within the range of 98.0% to 102.0%, with a RSD below 1.0% for each recovery level. The mean average % recovery stood at 99.95.

This validated analytical method proves valuable for evaluating samples in accelerated stability testing, effectively isolating the medication from degradation products, chemicals, and excipients in tablet formulations. The results of the research clarify that the technique used has been scientifically confirmed and is suitable for everyday evaluation and stability testing. Consequently, the proposed method can be advantageous for both quantitative quality control and future research in the pharmaceutical industry. Furthermore, the suggested procedure is feasible and helpful for analyzing the contents of pharmaceuticals in huge quantities.

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