ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4

Journal of Coastal Life Medicine

Development and Validation of HPLC Method of Gabapentin

Received: 19 February 2023, **Revised:** 21 March 2023, **Accepted:** 25 April 2023

Manjusha Aher[1], Madhuri Balasaheb Kanawade[1], Sarika Bhabad[2], Ramanlal N. Kachave[3]*

1Amrutvahini College of Pharmacy, Sangamner, Amrutnagar, Sangamner, Ahmednagar, Maharashtra, 422608, India
2Samarth College of Pharmacy, Belhe, Nagar-Kalyan Highway, Pune, Maharashtra, 422606, India
3GES's Sir Dr. M. S. Gosavi College of Pharmaceutical Education and Research Nashik, Affiliated Savitribai Phule Pune University, Pune, Nashik, Maharashtra, 422005, India

***Corresponding author: Ramanlal N. Kachave**
Email: ramanlalkachave26@gmail.com

Keywords:
HPLC, UV Spectroscopy, Gabapentin, Development, Validation, GBP

Abstract

Gabapentin, an anticonvulsant, is commonly used to treat epilepsy. Gabapentin lacks a chromophore, making its absorption very low and complicating its analysis and reducing its sensitivity. Chemical derivatization adds a chromophore, allowing HPLC to identify and quantify the medication at much lower concentrations. An auxochrome group added a chromophore to gabapentin to derivatize it. Gabapentin was catecholized using coupling reagents. HPLC with UV/Vis detector developed the analytical method. Linearity, range, precision and accuracy were also validated. Gabapentin was derivatized using catechol reagent at 300 nm. HPLC employed 50:50 methanol-water mobile phase. The gabapentin eluted peak was isolated from other derivatization reagents. The analytical method was validated and met all validation requirements. The approach was linear (R2 = 0.9994), precise (RSD = 1.54), and accurate (99-103% recovery). It's straightforward and sensitive. It can analyse gabapentin in various dose forms and APIs. This research can be continued and utilised to evaluate gabapentin in biological systems.

1. Introduction:

Gabapentin is a gamma-aminobutyric acid-like antiepileptic [1]. Gabapentin treats and prevents migraines [1, 2]. It treats partial seizures and neuropathic pain as an anticonvulsant [4]. You should take 600–1800 mg of gabapentin per day [5]. Research explains how gabapentin treats seizures and relieves pain [6].

A white to off-white crystalline powder is gabapentin, USP. It dissolves in water, acidic, and alkaline solutions. At pH 7.4, the partition coefficient log for n-Octanol/0.05 M phosphate buffer is 1.25 [7]. Gabapentin was measured using dried plasma spots, capillary electrophoresis, fluorometry, gas chromatography mass spectrometry (GC-MS), and high-performance liquid chromatography (HPLC) [10-14]. The US Pharmacopoeia has a monograph on HPLC analysis of valproic acid [8].

Chemical derivitization of analytes is popular today. The method is developed to determine bulk or final pharmaceutical dose forms [9]. Using Tecan Safire II microplate reader to record fluorescence signal, gabapentin and fluorescamine were derivatized [10]. Another study utilised borate buffer to change pH for the same approach [11]. In another study, gabapentin was measured using a chromatographic column derivatized with 1-fluoro-2,4-dinitrobenzene [12]. In a similar work, HPLC with UV photometric measured gabapentin after precolumn derivatization with 2,4,6-trinitrobenzenesulfonic acid [13]. Using a simple automated o-phthaldialdehyde (OPA) derivatization in an acidic mobile phase and fluorimetric detection, gabapentin was determined using HPLC in various settings [14].

A method of measuring gabapentin using liquid chromatography/mass spectrometry was created, validated, and followed for a year. Acetonitrile, internal isotopically labelled standards, reverse phase liquid chromatography ultraperformance separation, and a 3-minute run time were used to prepare a sample of protein precipitation. Researchers developed and validated a sensitive gas chromatographic-mass spectrometric (GC-MS)

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

approach for gabapentin detection by using GABA-d(2) as an internal standard during solid-phase extraction. The compound's 171 MW was confirmed by electrospray ionisation MS. With the use of this suggested method, gabapentin in physiological fluids was precisely quantified for pharmacokinetic and forensic study [15].

By conjugating the drug's molecular structure, this effort intends to build a trustworthy, straightforward, and workable analytical approach to measure gabapentin in small doses. The process will be approved by the international conference on harmonisation and pharmacopoeia [16].

DRUG PRFILE:

GABAPENTIN

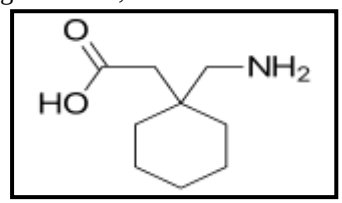

Figure 1: Structure of Gabapentin

IUPAC NAME	1-(Aminomethyl)-cyclohexane acetic acid.
BRAND NAME	Gralise, Neurontin, Gabawell.
MOLECULAR FORMULA	$C_9H_{17}NO_2$
MOLECULAR WEIGHT	171.24 /mol
COLOR	White to off-white
MELTING POINT	162-166°C
SOLUBILITY	Freely soluble in water, alkaline, and acidic
CATEGORY	Anti-convulsant
Log P	-1.10
PKa	3.7
HALF LIFE	5-7 hours

2. Experimental

Materials: Gabapentin API From Merck chemicals. Merck supplied HPLC-grade glacial acetic acid and acetonitrile. Loba Chemie supplied ammonium acetate, hydrogen peroxide (6%), and sodium hydroxide (AR grade). Milli-Q purified water [17].

Instrumentation: The chromatographic study's WATER 2695 HPLC has a quaternary pump, manual

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

injector, and diode array detector. Shimadzu-1700 UV-visible spectrophotometer. Open Lab Software controlled system, process, and data collecting [18].

Selection of Chromatographic Method: The accurate selection of chromatographic method is depending on the sample nature and the phases. The nature of sample includes ionic, non-ionic, neutral ions and its solubility. The drug selected in the research work is polar in nature; thus, any type of chromatographic method can be able to use for the study. Thus, because it its simplicity, method was chosen for the initial separation [19]

To achieve the optimized chromatographic condition for analyzing the gabapentin, each trial was changed by one or two parameters, and the chromatograms of the trials are recorded with mentioned chromatographic conditions [20].

Chromatographic Conditions:

Table 1: Optimized Chromatographic Condition for Assay Method.

PARAMETER	CONDITION
Stationary Phase	Zorbax SB C18 (250 x 4.6mm), 5µm.
Mobile Phase	Buffer: Methanol (65:35)
Flow Rate	1.0 ml/min
Detection	210 nm
Pump Mode	Isocratic
Injection Volume	10 µl
Run Time	12 min
Column Temperature	35°C
Retention Time	About 3.9 minute
Needle wash	Methanol: Mili-Q Water (50:50)

Method Validation Protocol

For the purpose of determining the percentage assay of gabapentin in gabapentin tablets, an HPLC method has been developed. The assay method for gabapentin in gabapentin tablets is being validated using this procedure, which is proposed for the validation of stability indicating HPLC methods [21].

Methodology Followed in Analytical Method Validation

Preparation of Buffer solution: Dissolve 5ml of Triethyl amine in 1000ml of water. Adjust pH to 6.9 +/- 0.05 with ortho phosphoric Acid. Filter buffer solution Nylon 0.45µ membrane filter.

Preparation of Mobile phase: Prepare a mixture of Buffer: Methanol in the ratio 65:35.

Preparation of Diluent: Mobile phase used as diluent.

Preparation of Standard Solution: A 50 ml volumetric flask was correctly weighed and filled with 200.0 mg of the working standard dosage of gabapentin. With intermittent shaking, add up to 30 ml of mobile phase, sonicate to dissolve, then cool and add mobile phase to dilute the solution to volume and mix. Filter and inject through a 0.45-inch nylon membrane filter [22].

Preparation of Sample Solution: 20 tablets average weight. Transfer 800 mg gabapentin powder to 250 ml

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

volumetric flask. Sonicate 150 ml mobile phase for 45 min with intermittent vigorous shaking. Dilute mobile phase to volume and mix at room temperature. Filter solution through 0.45 µ Nylon membrane filter. [23].

Evaluation of System suitability: Record chromatograms after five standard solution injections. Five duplicate injections should not exceed 2.0% relative standard deviation. The gabapentin peak should have a tailing of 2.0 and a predicted plate count of 7000 [24]. Inject blank and sample solution (in duplicate) into the chromatograph and record the chromatograms. Measure the area count and observe the retention time for Gabapentin peak.

SPECIFICITY:

Identification: Comparison between retention time of gabapentin in the chromatogram of the sample preparation corresponds to that of the gabapentin peak in the chromatogram of the standard preparation respectively [25].

Placebo interference: Prepared gabapentin pill placebo. Methodically prepared gabapentin tablet standard and sample solutions. Use a photodiode array detector in HPLC to inject the blank, placebo, sample, and standard solutions.

Known Impurity Interference: Spike three samples with 1.0% contaminants and compare the assay findings to unspiked samples. Check control and spiked sample peak purity.

LINEARITY AND RANGE: For determining the linearity for Gabapentin, a sequence of standard preparation of Gabapentin will be prepared to cover 50–150 percent of Gabapentin tablet working concentration. Minimum five points should be 50-150% of standard or sample concentration for Assay. Gabapentin's working concentration is 20µg/ml, hence the range is 10µg–30µg.

Preparation of Linearity Stock Solution: Weighed and properly transferred 400 mg gabapentin reference standard into 100 ml volumetric flask. Sonicate 60ml mobile phase. Mix mobile phase well. Pipette 50ml of this solution into a 100ml volumetric flask and add diluents and Mix. [26].

ACCURACY (RECOVERY):

Gabapentin tablet placebos were spiked at 80%, 100%, and 120% of label claim in triplicate. Each sample will be injected three times and the average area count calculated. Transfer API and placebo correctly into volumetric flasks as shown in the table below [27].

Preparation of Accuracy Stock Solution

Transfer 5 milligrammes Gabapentin to 50 ml volumetric flask. Add 30 ml of diluent, sonicate, and mix. Add 200 ml of diluent to each recovery flask and sonicate for 30 minutes with intermittent shaking. Fill to volume and mix. Filter the solution with 0.45 µm Nylon. Pipette 5ml of this clear solution into a 200ml volumetric flask and diluent to volume.

PRECISION:

System Precision: The HPLC was injected with five replicate standard preparation injections using the protocol.

Method precision: Six Gabapentin pill mg sample solutions are produced, injected into the system, and analysed according to the protocol.

Intermediate precision (Ruggedness)

The six Gabapentin standard and sample solutions are produced from the same batch, by a separate analyst, using the same column on a different day, injected in duplicate into various HPLC systems with standard preparation, and analysed [28].

STABILITY OF ANALYTICAL SOLUTION

The sample and standard preparations of Gabapentin tablets 800 mg are to be stored at room temperature and tested against freshly prepared standard for at least 24 hours.

FORCED DEGRADATION STUDIES:

Degradation studies will be performed under various conditions and the samples will be analyzed. The listed conditions are a starting point and adjustments may be made in order to achieve an appropriate amount of degradation without a protocol revision. The target level of degradation will be 5% to 25% though degradation outside this level may be accepted with a justification. At the end of the treatment, the acid and base treated samples will be neutralized with

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

an equivalent amount of Hydrochloric acid or Sodium hydroxide. After equilibration to room temperature, each degradation sample will be prepared as per the method. The treated sample preparations will be assayed using the methods described in Methodology of assay against a control preparation (bracketing injections) and the percent degradation will be determined by area normalization method. Simultaneously subjected the placebo to all the above finalized stress conditions and prepared the solutions in a similar manner followed for test sample and injected into HPLC. For peak purity determination, the spectral homogeneity of the Ropinirole peak will be evaluated [29].

3. Results and Discussion:

Specificity

Identification: Gabapentin (GBP) peaks in the Sample and Standard preparations have the same retention time.

Table 2: Table for retention time (Identification)

Sample information.	Retention time (mins.)
Gabapentin standard	3.900
Gabapentin sample	3.987

Placebo Interference: Representative Placebo, Standard, and Sample Gabapentin tablet solutions were produced and injected into the HPLC using a photodiode array detector.

Table 3: Table for Specificity

Sr. No.	Name	Purity Angle	Purity Threshold
1	Standard solution Gabapentin	0.538	1.587
2	Sample solution Gabapentin	0.582	1.689

Gabapentin peak retention was unaffected by Blank and Placebo. Standard and Sample solutions have pure Gabapentin peaks. Thus, Gabapentin in tablet HPLC is particular.

Known Impurity Interference: Two samples of Gabapentin tablet were analyzed by spiking with the one known related substance at 1% level and compared the Assay results with un-spiked sample. No interference was found and the result obtained was within the limit.

Table 4: Table for Specificity

Sr. No.	Name	Purity Angle	Purity Threshold
1	Standard solution	1.819	3.194
2	Sample solution 3mg	1.713	2.730

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

Table 5: Table for Peak Purity

Sr. No.	Name	Purity Angle	Purity Threshold
1	Standard solution	1.182	2.710
2	Sample solution 3mg	0.789	2.324

Table 6: Table for Known impurity interference

	Control sample (% label claim)	Spiked sample (% label claim)
1	99.9	99.6
2	98.2	100.3
Mean	99.05	99.95
SD	1.23	1.24
%RSD	1.02	1.09

Linearity and Range

Experiment: The sequence of Standard preparations of Gabapentin (GBP) Standard was prepared over a range of 50% to 150% of the working concentration of Gabapentin

Table 7: Linearity for Gabapentin

% Conc.	Conc. (µg per ml)	Area	Statistical analysis	
50%	10	230585	**Slope**	**229.73**
60%	12	273929		
75%	15	342334	**Intercept**	**-2335.2**
100%	20	451193		
110%	22	502025	**Correlation Coefficient**	**0.9994**
140%	28	636789		
150%	30	694046		

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

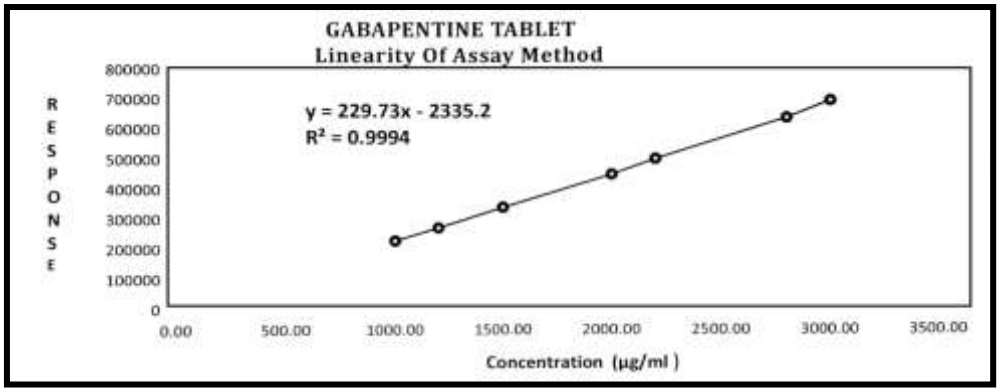

Figure 2: Linearity Assay Graph of Gabapentin (GBP)

Minimum correlation coefficient is 0.999. Gabapentin correlated 0.9994. The HPLC technique for gabapentin in Tablet is linear.

Accuracy (Recovery)

Placebo of Gabapentin Tablets was spiked with Gabapentin Drug Substance at 50%, 100%, and 150% of the label claim in triplicate (nine determinations) and then continued with Sample solution as indicated under.

Table 8: Accuracy for Gabapentin (GBP)

Sample No.	**Amt. added (mg)**	**Amt. recovered (mg)**	**% Recovery**
Accuracy 50% -1	20.00	20.65	**103.2**
Accuracy 50% -2	20.00	20.62	**103.1**
Accuracy 50% -3	20.00	20.51	**102.6**
Accuracy 100% -1	40.00	40.33	**100.8**
Accuracy 100% -2	40.00	41.24	**103.1**
Accuracy 100% -3	40.00	40.98	**102.5**
Accuracy 150% -1	60.00	60.29	**100.5**
Accuracy 150% -2	60.00	59.65	**99.4**
Accuracy 150% -3	60.00	59.73	**99.6**
Mean **SD** **% RSD**			**101.6** **1.563** **1.54**

Recovery should be 98.0%–102.0%. Maximum RSD is 2.0%. GBP recovery was 101.6% and RSD 1.54. The HPLC technique for Gabapentin (GBP) in Tablets was accurate.

Precision

a. System Precision: Methodology was used to inject six replicates of the Standard preparation into the HPLC apparatus.

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

Table 9: Data sheet for System Precision

Injection	**Gabapentin Area**
1	906226
2	901177
3	897222
4	896743
5	901073
6	898621
Mean	**900177**
SD	**3502.534**
%RSD	**0.39**

Maximum RSD is 2.0%. Gabapentin had 0.39% system precision RSD. Calculated medication average area, standard deviation, and %RSD. This procedure passed system precision because Precision was less than 2. Gabapentin was accurately measured by HPLC.

.

b. Method Precision: Using the procedure outlined in the Methodology section, six replicate injections of the Sample preparation were made into the HPLC apparatus

Table 10: Data sheet for Method Precision

Sample	**% Label claim Gabapentin**
1	97.2
2	96.6
3	96.2
4	96.6
5	97.4
6	97.2
Mean	**96.9**
SD	**0.49**
%RSD	**0.51**

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

The RSD should not exceed 2.0%. For gabapentin, the RSD of the technique precision was 0.51%. Consequently, the tablets of gabapentin were determined using the HPLC technique.

Intermediate Precision (Ruggedness)

A different analyst prepared six sample preparations of the same lot of gabapentin using a different column on a different day, and they were then injected in duplicate into a different HPLC according to the procedure outlined under Methodology and Standard preparation.

Table 11: Table for Ruggedness of Gabapentin (GBP)

Sample	**Analyst -1 % Label claim**	**Analyst -2 % Label claim**
1	97.2	96.3
2	96.6	97.1
3	96.2	95.9
4	96.6	96.5
5	97.4	97.3
6	97.2	96.7
Mean	**96.9**	**96.6**
SD	**1.24**	**1.25**
%RSD	**1.07**	**1.09**
Overall Mean	**96.7**	
Overall SD	**1.05**	
Overall %RSD	**1.01**	

Twelve findings should have an overall RSD of no more than 2.0%. For gabapentin (GBP), the RSD of intermediate precision was 0.89%. As a result, the HPLC approach is reliable for figuring out how much gabapentin (GBP) is in a gabapentin tablets.

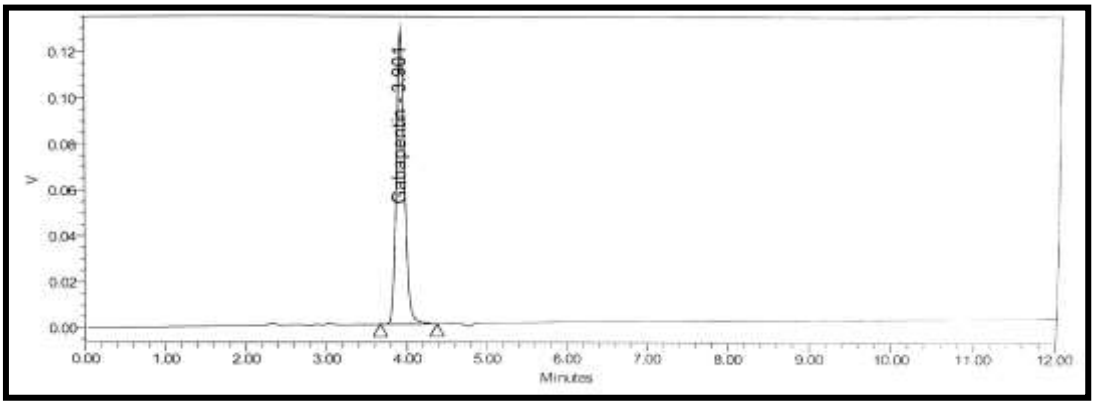

Figure 3: Optimized HPLC chromatogram OF Gabapentin

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

Stability of Analytical Solution

The standard preparations and sample were both kept at room temperature while being put to the test for a full day against newly made standard preparations.

Table 12: Stability of Analytical solution at RT for Gabapentin

Sr. No.	Name	% Content 0 hours	%Content 24 hours	% Correlation
1	Standard Solution	99.7	99.3	**100**
2	Sample Solution	100.5	101.3	**100.8**

Standard and sample solutions are stable for 24 hours at room temperature.

Forced Degradation Study

The formulation was used to conduct the degradation studies, and injections of degradation samples were made. All of the injected samples passed the limits of degradation during the calculated assay.

Table 13: Table for Forced Degradation Studies for Gabapentin

Sr. No	Experiment	Degradation Condition	% Assay	% Degradation	Purity Angle	Purity Threshold
1	Control	--	100.3	--	1.819	3.194
2	Acid Degradation	5N HCl/ 70°C-3 hr	96.4	3.9	5.014	8.272
3	Base Degradation	2N NaOH/ 70°C -15mins	77.1	23.1	0.323	3.669
4	Peroxide Degradation	50% H_2O_2/ 70°C –3 hours	95.1	5.2	0.166	1.146
5	Thermal Degradation	Heat at Oven 105°C for 4 hr	87.3	13.0	0.794	2.004
6	Humidity Degradation	25°C/92%RH-72 hours	101.2	-	0.514	1.617
7	Photolytic Degradation	1.2 million lux hours of Light	100.5	-	0.852	2.029

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

4. Conclusion

A state-of-the-art HPLC technique was developed and then validated to analyse gabapentin. The technique was shown to be efficient, exact, accurate, sensitive, and resilient by the validation criteria. Stress testing of the method's specificity worked well, demonstrating the effectiveness of the testing. It's probable that this suggested approach will help and be applicable to the standard analysis of gabapentin. The approach is determined to be particular, hardy, robust, accurate, and linear under the circumstances stated. The technique works well for measuring gabapentin in tablet dose form.

Funding support:

Nil

Conflict of interest:

Nil

References:

[1] Ciavarella, A.B., Gupta, A., Sayeed, V.A., Khan, M.A. and Faustino, P.J., 2007. Development and application of a validated HPLC method for the determination of gabapentin and its major degradation impurity in drug products. *Journal of pharmaceutical and biomedical analysis*, *43*(5), pp.1647-1653.

[2] Gupta, A., Ciavarella, A.B., Sayeed, V.A., Khan, M.A. and Faustino, P.J., 2008. Development and application of a validated HPLC method for the analysis of dissolution samples of gabapentin drug products. *Journal of pharmaceutical and biomedical analysis*, *46*(1), pp.181-186.

[3] Zhu, Z. and Neirinck, L., 2002. High-performance liquid chromatographic method for the determination of gabapentin in human plasma. *Journal of Chromatography B*, *779*(2), pp.307-312.

[4] Jalalizadeh, H., Souri, E., Tehrani, M.B. and Jahangiri, A., 2007. Validated HPLC method for the determination of gabapentin in human plasma using pre-column derivatization with 1-fluoro-2, 4-dinitrobenzene and its application to a pharmacokinetic study. *Journal of Chromatography B*, *854*(1-2), pp.43-47.

[5] Udaykumar Rao, B., Maqdoom, F. and PRATIMA NIKALJE, A.N.N.A., 2009. Determination of gabapentin in bulk drug and in pharmaceutical dosage form by HPLC method. *Journal of the Chilean Chemical Society*, *54*(4), pp.424-427.

[6] Pathan, A.S., Jain, P.G., Mahajan, A.B., Kumawat, V.S., Ahire, E.D., Surana, K.R., Rajora, A.K. and Rajora, M.A.K., 2023. Beneficial Effects of Water-Soluble Vitamins in Nutrition and Health Promotion. *Vitamins as Nutraceuticals: Recent Advances and Applications*, pp.235-251.

[7] Yagi, T., Naito, T., Mino, Y., Takashina, Y., Umemura, K. and Kawakami, J., 2012. Rapid and validated fluorometric HPLC method for determination of gabapentin in human plasma and urine for clinical application. *Journal of clinical pharmacy and therapeutics*, *37*(1), pp.89-94.

[8] Martinc, B., Roškar, R., Grabnar, I. and Vovk, T., 2014. Simultaneous determination of gabapentin, pregabalin, vigabatrin, and topiramate in plasma by HPLC with fluorescence detection. *Journal of Chromatography B*, *962*, pp.82-88.

[9] Souri, E., Jalalizadeh, H. and Shafiee, A., 2007. Optimization of an HPLC method for determination of gabapentin in dosage forms through derivatization with 1-fluoro-2, 4-dinitrobenzene. *Chemical and Pharmaceutical Bulletin*, *55*(10), pp.1427-1430.

[10] Jiang, Q. and Li, S., 1999. Rapid high-performance liquid chromatographic determination of serum gabapentin. *Journal of Chromatography B: Biomedical Sciences and Applications*, *727*(1-2), pp.119-123.

[11] Ahire, E.D., Sonawane, V.N. and Surana, K.R., 2020. Role of drug repurposing in current treatment strategies against COVID-19; systemic review. *Pharm Reson*, pp.24-9.

[12] Pawar, S.D., Deore, S.D., Bairagi, N.P., Deshmukh, V.B., Lokhande, T.N. and Surana, K.R., 2023. Vitamins as Nutraceuticals for Anemia. *Vitamins as Nutraceuticals: Recent Advances and Applications*, pp.253-279.

[13] Ulu, S.T. and Kel, E., 2011. Highly sensitive determination and validation of gabapentin in pharmaceutical preparations by HPLC with 4-fluoro-7-nitrobenzofurazan derivatization and fluorescence detection. *Journal of chromatographic science*, *49*(6), pp.417-421.

ISSN: 2309-5288 (Print)
ISSN: 2309-6152 (Online)
CODEN: JCLMC4
Journal of Coastal Life Medicine

[14] Ragham, P.K. and Chandrasekhar, K.B., 2016. Development and validation of a stability-indicating RP-HPL C-CAD method for gabapentin and its related impurities in presence of degradation products. *Journal of Pharmaceutical and Biomedical Analysis*, *125*, pp.122-129.

[15] Lakshmi, B., 2012. RP-HPLC method development for the quantification of gabapentin in formulations. *Experiment*, *1*(2), p.84.

[16] Ahire, E.D., Surana, K.R., Patil, C.D., Shah, H.S., Sonwane, G.B. and Talele, S.G., 2020. Role of omega-3 fatty acids in different neurodegenerative disorders. In *Applied Pharmaceutical Science and Microbiology* (pp. 173-194). Apple Academic Press.

[17] Ahire, E.D., Sharma, N., Gupta, P.C., Khairnar, S., Surana, K., Ahire, B., Sonawane, V., Laddha, U., Sonkamble, S., Sabale, R. and Kshirsagar, S., 2022. Developing Formulations of Prebiotics and Probiotics. *Prebiotics and Probiotics in Disease Regulation and Management*, pp.271-290.

[18] Singh, A., Diwaker, M., Thakur, A., Surana, K., Chopra, M., Kumar, H. and Sharma, S., 2023. Regioselective Pd-catalyzed decarboxylative C-6 acylation of 7-O-carbamate coumarins and their anti-inflammatory evaluation. *Tetrahedron*, *134*, p.133295.

[19] Volpe, D.A., Gupta, A., Ciavarella, A.B., Faustino, P.J., Sayeed, V.A. and Khan, M.A., 2008. Comparison of the stability of split and intact gabapentin tablets. *International journal of pharmaceutics*, *350*(1-2), pp.65-69.

[20] Surana K, Ahire ED, Pawar R, Khairnar R, Mahajan S, Kshirsagar S, Talele SG, Thombre N, Ahire B, Keservani RK. Oral Health and Prebiotics. Prebiotics and Probiotics in Disease Regulation and Management. 2022 Sep 1:291-309.

[21] Forrest, G., Sills, G.J., Leach, J.P. and Brodie, M.J., 1996. Determination of gabapentin in plasma by high-performance liquid chromatography. *Journal of Chromatography B: Biomedical Sciences and Applications*, *681*(2), pp.421-425.

[22] Chollet, D.F., Goumaz, L., Juliano, C. and Anderegg, G., 2000. Fast isocratic high-performance liquid chromatographic assay method for the simultaneous determination of gabapentin and vigabatrin in human serum. *Journal of Chromatography B: Biomedical Sciences and Applications*, *746*(2), pp.311-314.

[23] Surana, K.R. and Mahajan, S.K., 2022. In silico Study of Chromane Ring Compound Rubranonoside from Plumeria rubra as Anticancer Potential. *Trends in Sciences*, *19*(24), pp.3305-3305.

[24] Surana, K.R., Ahire, E.D., Sonawane, V.N. and Talele, S.G., 2021. Biomolecular and Molecular Docking: A Modern Tool in Drug Discovery and Virtual Screening of Natural Products. In *Applied Pharmaceutical Practice and Nutraceuticals* (pp. 209-223). Apple Academic Press.

[25] Surana, K.R., Ahire, E.D., Sonawane, V.N., Talele, S.G. and Talele, G.S., 2021. Informatics and methods in nutrition design and development. In *Natural Food Products and Waste Recovery* (pp. 33-49). Apple Academic Press.

[26] Aher, P., Surana, K., Ahire, E., Patil, D., Sonawane, D. and Mahajan, S., 2023. Development and Validation of RP-HPLC Method for Quantitative Determination of 4-Amino Benzene Sulphonamide in Sulphonamide Hydrochloride. *Trends in Sciences*, *20*(6), pp.5209-5209.

[27] Kesharwani, R.K., Vishwakarma, V.K., Keservani, R.K., Singh, P., Katiyar, N. and Tripathi, S., 2020. Role of ADMET tools in current scenario: application and limitations. *Computer-Aided Drug Design*, pp.71-87.

[28] Keservani, R.K., Sharma, A.K. and Jarouliya, U., 2015. Protein and peptide in drug targeting and its therapeutic approach.

[29] Keservani, R.K., Bandopadhyay, S., Bandyopadhyay, N. and Sharma, A.K., 2020. Design and fabrication of transdermal/skin drug-delivery system. In *Drug Delivery Systems* (pp. 131-178). Academic Press.