

# Analytical Method Development and Validation for Pharmaceutical dosage Forms: A Review

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## Abstract

Improvement of a technique is fundamental for disclosure, improvement, and assessment of drugs in the drug detailing. The principal point of this audit article was to check the turn of events and approval of the method utilized for the prescription from the beginning of the detailing to the total business clump of item. Right when a logical procedure is applied to deliver results for the nature of medication related examples, it is vital that the results are solid. In the pharma business, approval strategy is archived for how to perform approval, kinds of approval and approval strategy are consented to the necessities of good assembling practice (GMP) guidelines. Approval is vital for the compelling running of the drug firms. At each stage from natural substance to the got done, soundness, all over approval was performed. The strategy was grown appropriately, and approval boundaries are made sense of concerning exactness, explicitness, accuracy, cut off of discovery (LOD), breaking point of quantitation (LOQ), roughness, vigor, and framework reasonableness testing with the case of specific medications. All approval boundaries are utilized in the daily schedule and soundness examination.

**Keywords:** Analytical Method, LOD, Validation, Accuracy.

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## Introduction

Examination is imperative in any item or administration, and it is additionally significant in drug since it includes life. Insightful science is the examination of division, measurement and compound added substances ID of natural and manufactured materials comprised with at least one mixtures or variables [1]. Scientific science is isolated into two overwhelming classes, a subjective assessment that is to say the recognizable proof concerning the synthetic added substances exists in the test, while quantitative assessment gauges how much positive detail or compound inside the substance, for example the example [2]. The amount of prescription brought into the commercial center is developing every year. These drugs could likewise be either new substances or incomplete underlying adjustment of the current one. Meds should be open in such a sort that quality as well as bioavailability, sufficient plasma fixation, wanted period, the beginning of activity, right portion, wellbeing, adequacy and dependability on capacity of item, will be guaranteed all through the capacity of the items [3]. The progression of a medicine is a long method including drug development, an exploration lab preliminary, preclinical testing, clinical testing, and administrative enrollment. To moreover work on the ampleness and insurance of the drug after acknowledgment, various regulatory associations, for instance, the US food and drug organization (USFDA) in like manner expect that the medication item is assessed for its recognizable proof, strength, attributes, quality, steadiness, and immaculateness before it very well may be released for use. In this manner, drug approval and cycle controls are crucial in ignoring the issues that may be experienced [4]. Regularly, there is a delay from the date of presentation of a prescription into the market to the date of its thought in pharmacopeias. This happens due to the potential weaknesses inside the persistent furthermore, greater utilization of those medications, reports of progressing harmfulness (achieving their withdrawal from the market), improvement of impacted individual opposition and improvement of higher medication with the point of contest. Under these circumstances, prerequisites furthermore, insightful procedures for those drugs that may not be agreeable inside the pharmacopeias. It becomes fundamental, so as to create more up to

date insightful methodologies for such drugs [5]. Scientific methodology improvement and approval perform significant capabilities in the disclosure, improvement, and assembling of meds. The fundamental point of a logical measure is to get steady, reasonable, and right data. Approved scientific techniques play a critical job in accomplishing this objective. Results from approach approval might be utilized to pick the norm, unwavering quality, and consistency of logical outcomes, that is related as a fundamental part of any reasonable scientific practice. Approval of insightful techniques is additionally required by most guidelines and quality principles that influence labs[6].

### **Ventures for fostering a strategy**

Different advances are engaged with the improvement of a logical technique are as per the following:

#### **□ Portrayal of analyte and standard**

- Every one of the realized essential information concerning the analyte and its structure that is to specify the physical and substance properties like dissolvability, optical isomerism, and so on, are gathered.
- The standard analyte is equivalent to 100 percent virtue is gained[7].

Important game plan is to be made for the legitimate stockpiling (fridge, desiccators, and cooler).

- In the example framework, when different parts are to be estimated how much components is noticed properly introducing the data also, the availability of standard are determined.
- Strategies like spectroscopy (UV-Noticeable, FTIR, nuclear assimilation spectroscopy, and so forth), superior execution fluid chromatography and gas chromatography so on and, are anyway about once composed with the dependability of tests [8].

#### **□ Necessity of the method:**

Prerequisite of insightful system is fundamental for develop the insightful fig. of benefit like linearity, selectivity, particularity, range, exactness, accuracy, LOD, LOQ and so on will be illustrated [9].

#### **□ Writing study and earlier techniques:**

Every one of the information of writing connected with the medication are inspected for its physical and compound properties, assembling, dissolvability and pertinent insightful ways regarding pertinent books, diaries, US pharmacopeia/public formulary(USP/NF), relationship of official farming scientific experts (AOAC) and american culture for testing and materials (ASTM) distributions and it is very helpful to look Substance Digests Administration programmed electronic writing [10].

#### **□ Choosing the strategy**

- Using the information got from the writing, the procedure is advancing since the technique is being adjusted any place required. In some cases, it is vital to obtain extra instrumentation to make, adjust or recreate and approve existing methodology for analytes and tests.
- In the event that there are no past suitable ways accessible to explore the analyte to be inspected [11].

#### **□ Legitimate instrumentation and starting examinations:**

Establishment capability (intelligence level), activity capability (OQ), and execution capability (PQ) of instrument relevant to explore standard philosophy is inspected by a fitting set up of instruments [12].

#### **□ Enhancement:**

While performing improvement, once a boundary is changed at a time, and a gathering of conditions are separated, prior to using experimentation approach. This work is required for achieved basing on a logical coordinated technique plan properly all vital focuses and recorded with connection to dead closes [13].

### **Significant stages in approval of Validation**

The activity relating to approval studies can be arranged basically into three phases:

#### **Stage 1**

This incorporates pre-approval capability stage which covers all practices relating to item studies and improvement, detailing pilot bunch testing, increase research, trade of advancement to business scale gatherings, setting up security conditions, also, overseeing of in-process, completed drug details, capability of gear, ace records, and interaction limit [14].

#### **Stage 2**

This includes interaction approval stage. Making sure that is expected each introduced restriction of the indispensable cycle boundary is significant and that good items can be made even underneath horrible circumstances [15].

#### **Stage 3**

It is likewise called as the approval upkeep stage, it requires consistent audit of all system related documents, including approval of the audit answers, to ensure that there have been no adjustments, takeoff, disappointments, and modification to the creation methodology and that all standard working strategies (SOPs), including change control methodology, had been noticed. At this stage, the endorsement group affecting individuals addressing all fundamental offices likewise ensures that there have been no alterations/deviations that should have achieved requalification and revalidation[16].

### **Equipment validation**

□ The vital idea of approval is to give a serious level of revealed affirmation that the gear and the methodology adjust to the composed rules. The degree (or power) is directed by the intricacy of the gadget or framework. The approval ought to give the fundamental information and test strategies expected to give that the gadget and strategy meet decided essentials[17]. Hardware Approval incorporates the accompanying:

#### **□ Establishment capability (intelligence level):**

level of intelligence ensures all essential handling, bundling framework, and subordinate things are in consistence with the establishment. It makes sure that the hardware has been laid out or introduced according to the producer's idea in a efficient way and situated in encompassing proper for its implied reason [18].

### **Establishment capability focuses incorporate**

- Gear design character that is the material of development cleanability and numerous others.
- Establishment circumstances like wiring, usefulness, utility, etc.
- Adjustment, precaution security, purifying plans.
- Wellbeing attributes.
- Provider documentation, prints, outlines, and hand worked.
- Programming documentation.
- Enroll the extra parts.

- Climate related conditions like clean room necessities, stickiness, and temperature [19].

□ **Functional capability (OQ):**

OQ performed to give a significant level of level of confirmation that the hardware functions as proposed [20].

**OQ concerns comprise of:**

- Process control limits like temperature, time, stress, line speed, set up conditions, etc.

**Process approval**

The interaction approval is a part of the intelligent requirements of a quality administration framework [21]. Process Approval is the most fundamental and seen boundaries of current great assembling rehearses. The target of a quality framework is to create things that are coordinated with their proposed use consistently. Process endorsement is a vital part in ensuring that these guidelines and goal are met[22].

□ Process approval is accounted for proof which gives a significant level of insistence that a specific system will create an item meeting its resolved essentials. It fundamentally includes the following

□ **Planned approval:**

It is portrayed as the notable detailed program that a gadget does what it demonstrated to do based on pre-arranged conventions. This approval is regularly performed beforehand for circulation both of a more current thing or thing made under a reconsidered creation process [23].

In this approval, the convention is achieved before the system is put into modern use [24].

Planned approval should consolidate, in any case, not be restricted to the resulting:

- Short portrayal of the methodology.
- Rundown of the significant handling moves toward be assessed.
- Gear/offices list is to be used (including estimation, noticing/recording gear) by and large with its alignment status.
- Completed measurement structures for release[25].
- Rundown of logical strategies, as reasonable.
- Proposed in-process controls with detail standards.
- Extra testing to be finished, with particular cutoff points and insightful endorsement, as appropriate.
- Inspecting plan.
- Procedures for recording and evaluating results.
- Capabilities and commitments.
- Proposed plan [26].

□ **Simultaneous approval:**

It is same as imminent approval except for the functioning firm, will offer the item at the season of capability runs, to the general public at its market cost, and moreover like review approval. This sort of approval remembers for process seeing of crucial handling steps and item looking at. This assists with creating and detailed confirmation to show that the assembling method is in a state of control [27].

This endorsement remembers for process seeing of fundamental handling steps and item testing. This makes and recorded confirmation to exhibit that the creation methodology is in a state of the control.

- In astounding circumstances, it very well may be OK not to complete the approval program before routine assembling starts[28].
- The decision to finish synchronous endorsement should be upheld, documented and acknowledged by approved faculty.
- Documentation essentials for synchronous approval are comparable as assigned for imminent approval [29].

#### □ **Review approval:**

It is portrayed by the laid out detailed affirmation that a framework does what it suggests to do on the review and examination of verifiable information. This is achieved by the review of the antiquated assembling testing data to show that the technique has consistently stayed in charge. This sort of endorsement of a methodology for a thing currently in dispersion. Review approval is satisfactory for well established methodology and will be off-base where there have been current adjustments inside the piece of the item, working techniques or gadget [30].

#### **Hardly any fundamental parts of review approval are:**

- Bunches are delivered for an unmistakable length (last 10 progressive clumps). The quantity of parts released consistently.
- Bunch size/strength/maker/year/time frame.
- Ace assembling/bundling documents.
- Current specifics for dynamic fixings/completed materials[31].

#### **Revalidation:**

Revalidation gives the evidence that adjustments in the method, as well as the system condition that are introduced try not to ominously impact process ascribes and item quality. Associations, offices, gear and techniques which incorporate cleaning, should be occasionally evaluated to avow that they stay legitimate. Where no momentous alterations have been made to the endorsed status, a survey with verification that offices, associations, gear and methods address the suggested necessities fulfills the requirement for revalidation [32].

Revalidation becomes crucial in unambiguous conditions. Not many of the alterations that require approval are referenced underneath:

- Alterations in unrefined materials.
- Alterations in the gear.
- Alterations in the wellspring of dynamic unrefined material maker.
- Change of pressing material.
- Alteration of the methodology.
- Alterations inside the plant/office.
- A choice is no longer to do revalidation studies need to be totally legitimate and revealed [33].

#### **Scientific technique approval**

Approval of a scientific methodology is laid out through lab research, that the execution credits of the strategy meet the prerequisites for the proposed logical application. Approval is expected for any new or adjusted strategy to check

that it is good for giving unsurprising and reliable results, once utilized by different overseers by use of equivalent instrumentation inside the comparative or totally particular labs [34].

Strategy approval is a revealed program that proposals with that the handling framework will give an elevated degree of certification to meet its predicated acknowledgment premise [35].

It comprises of mostly five distinct advances which are as per the following:

□ **Capability of the framework:**

Framework capabilities grant to make sure that the instrument is fitting for the arranged examination, the materials are proper to be utilized in scientific decisions, the experts have the right guidance, abilities, also, prior documentation, for example, insightful comprehensive of logical methodologies, appropriate approved convention with pre-set up norms have been evaluated. If the general capabilities of a gadget are neglected, and inconvenience emerges, the wellspring of the issue will be difficult to perceive [36].

□ **Testing:**

Examining aids the decision of a delegate part of the texture which is thusly exposed to assessment. The choice of a reasonable examining strategy is of critical significance since it gives affirmations that the example picked is truly illustrative of the material overall with the end goal of significant measurable derivations. Inside the measurable writing, there is a significant assortment of work on testing methods, at any rate the relative costs and time drew in with each method should be evaluated early [37].

□ **Planning of test:**

Readiness of the example is a key part to powerful technique approval. It has been referenced that example arranging addresses 60 to 80% of the work activity and working costs in an insightful lab. The writing on the readiness of the example is sufficient and appropriately reported. In any case, the examiner should review that the decision of a specific arrangement method depends upon centralizations of analytes, test grid, size of the example and the instrumental strategy [38]

**Cleaning approval**

Cleaning approval is a detailed evidence with an elevated degree of affirmation that can consistently clean a framework or gear to not set in stone and detail rules. It is a to Clean endorsement revealed technique that exhibits the adequacy and consistency in cleaning drug creation hardware. The objective of cleaning endorsement is to actually take a look at the feasibility of the cleaning framework for the ejection of item stores, degradants, added substances, excipients, or on the other hand cleaning specialists and in a the control of potential microbial pollution[39].

**Approving cleaning strategies for the accompanying motives is indispensable:**

- Drug items and dynamic drug fixing (Programming interface) can be polluted by different items and microorganisms.
- It is a regulatory essential in drug item fabricate the concern is the very ensure that the hardware is appropriately perfect and wellbeing and quality is kept up.
- It is similarly ensured from an inside control and consistency point of view the nature of production.
- To safeguard item honesty.
- To reuse the gear [40].

**Need for cleaning approval**

To really take a look at the suitability of cleaning strategies and to ensure that no gambles are connected with cross-pollution of Programming interface or cleansers [41].

### **Cleaning approval convention**

- The objective of the approval methodology.
- Commitments in regards to performing and supporting the approval study.
- Hardware subtleties.
- The span between the finish of creation and the beginning of the cleaning procedures.
- Cleaning strategies to be used for each item, each producing gadget or each piece of hardware.
- The amount of the cleaning cycle to be performed persistently.
- Routine actually looking at hardware.
- Inspecting procedures, including the reason for why a particular it is used to test procedure.
- Obviously characterized testing regions.
- Data on recuperation studies, where appropriate.
- Logical methods including LOD and LOQ.
- The acknowledgment standards, alongside including the strategy for thinking for setting determined limits [42].

### **Approval boundaries**

The principal point of strategy approval is to create proof that the technique will what it should do, precisely, solid what's more, predictable [9]. The approval boundaries according to ICH rules are portrayed beneath:

#### **□ Precision:**

Exactness is communicated as the proximity of understanding between the qualities found and values that are as of now accessible. It can likewise be characterized as the closeness between the genuine worth and the noticed esteem. It is in some cases called as certainty, and it very well may be not entirely settled by utilizing no less than 9 conclusions over at least 3 focus over the predetermined reach [43].

Precision of prochlorperazine maleate (Star) and betahistine hydrochloride (BET) was concentrated on by the standard expansion strategy at three unique levels (half, 100 percent, and 120%). A known sum of medication was added to the pre-broke down example and rate recuperation determined. At the point when this strategy was utilized for precision, the recuperation was viewed as 99.38% for betahistine hydrochloride and 99.11% for prochlorperazine maleate [44].

For the simultaneous assurance of nitazoxanide and ofloxacin exactness was concentrated on by the standard expansion technique at five various levels (half, 75%, 100 percent, 125%, and 150%). The outcomes demonstrate that the recuperations were seen to be in the scope of 80% to 120%, hence, the strategy is precise [45].

Exactness of paracetamol was concentrated by getting ready standard arrangement of various fixations (10, 35, 55 µg/ml) and infused to check the % recuperation. The percent recuperation of the medication was viewed as in the scope of 98.8 to 102.0% separately for all fixations [46].

#### **□ Accuracy:**

The precision of a logical technique communicates the proximity of understanding (level of disperse) between a gathering of estimations got from various examining of a uniform example under the recommended conditions [47].

**Accuracy might be thought about at 3 levels:****• Repeatability:**

It communicates the precision under a comparable working condition over a short time period and furthermore alluded as intra-test accuracy. At least six duplicates test planning of a comparable or predictable example prepared at the 100 percent check [48].

**• Moderate accuracy:**

It communicates the precision under inside research labs, in unmistakable days, through particular examiner, on unmistakable instruments/hardware. Two unique investigators each getting ready six example arrangements, according to determined technique [49].

**• Reproducibility:**

It alludes to the accuracy between various insightful labs. Each exploration office set up a total of six test arrangements, as indicated by the insightful procedure [50].

The accuracy of prochlorperazine maleate (Genius) and betahistine hydrochloride (BET) not set in stone by interday and intraday variety (% RSD). Intra-day accuracy was performed by examining standard medication arrangements inside the adjustment range, multiple times around the same time. Between day accuracy was performed by examining drug arrangements inside the alignment range on three unique days over a time of seven days. The low % RSD upsides of interday (1.02 to 1.48% for BET at 252.9 nm and 0.67 to 0.82% for Genius at 260.15 nm) and intraday (0.77 to 1.09% for BET at 252.9 nm and 0.27 to 0.61% for Star at 260.15 nm variety for BET and Ace, uncovered that the technique is exact [51].

For synchronous assessment of nitazoxanide and ofloxacin accuracy performed by infusing six imitates of an example arranged from business tablets and measure was determined to decide the repeatability of maintenance time and a pinnacle area of standard and tests. The rate relative standard deviation (% RSD) values for the area of nitazoxanide and ofloxacin were 0.44 and 0.2% and RSD values for a maintenance season of nitazoxanide and ofloxacin were 0.44% for both the medications [52].

The accuracy of paracetamol was checked by infusing an answer of 80 µg/ml for multiple times in same days, various days, and in an alternate time stretch around the same time. The % RSD was viewed as not exactly 3%, which showed great accuracy [53].

**□ Particularity:**

For each progressive phase, the logical method ought to exhibit particularity. The method was ought to have the ability to unequivocally evaluate the analyte of interest though inside the presence of every single expected part, which can incorporate degradants, excipients/test network, and test clear tops.

Particularity was performed to decide the maintenance season of each drug in a combination and in the example. The maintenance season of standard medicates not entirely set in stone, and being 3.750 min was found furthermore, 1.533 min for nitazoxanide and ofloxacin and maintenance season of the two medications in the standard blend was viewed as 3.760.

**Linearity:**

Linearity might be described as the limit of an scientific strategy to create results which are straightforwardly related to the grouping of an analyte in the Standard arrangement of betahistine hydrochloride (BET) and prochlorperazine maleate (Master) was taken in a 10 ml volumetric cup and weakened with 0.1 N HCL to get the last focus in the scope of 4 to 24µg/ml for BET and 3 to 18µg/ml for Expert. Ready multiple times in this adjustment reach still up in the air at the particular frequency for each medication alone. The outcomes show great linearity among absorbance and fixation in the recommended fixation range for both the medications [54].

For concurrent assessment of nitazoxanide and ofloxacin linearity proceed as five distinct convergences of standard combinations ready, half, 75%, 100 percent, 125%, 150% were infused, and chromatogram was recorded. The connection coefficient was determined and was seen to be more prominent than 0.99 for both the drugs which are inside the cutoff .

The linearity of paracetamol was performed by getting ready unique fixations (6.25, 12.5, 25, 50, and 100 $\mu$ g/ml) from a stock arrangement of 10 mg/ml. The arrangement of 20  $\mu$ l was infused into segment multiple times. Linearity of paracetamol was tracked down in the fixation scope of 6.25-100 $\mu$ g/ml with a relationship coefficient of 0.999 .

□ **Range:**

It tends to be described as the span among upper also, lower amounts of analyte in the example. Least of the determined reach to be 80% to 120% of the test for the examine test.

□ **Toughness:**

Roughness is the degree or proportion of reproducibility under various circumstances, for example, in various labs, different investigator, various machines, natural conditions, administrators and so on .

In the concurrent assessment of nitazoxanide and ofloxacin, roughness was performed by various expert and in various labs in various days to checks for any variety in the chromatography. The % RSD for region and maintenance time was determined for assurance.

□ **Power:**

It is described by the degree of capacity of an logical method, to remain comparable by minute deliberately change in the procedure boundary. The different procedure boundaries which can be adjusted in superior execution fluid chromatography are pH, float rate, the temperature of the segment and portable stage organization .

In the synchronous assessment of nitazoxanide and ofloxacin, the vigor of the proposed strategy confirmed by to perform investigation under factor stream rates. The stream rate according to the created technique is 1.5 ml/min. Slight change in stream rate is 1.3 ml/min and 1.7 ml/min and chromatogram recorded. Because of a slight change in the stream pace of strategy shows great outcomes and stay unaffected by that moment change. Thus, we can say that the technique is powerful.

For vigor of paracetamol, little alteration in the stream rate, % of acetonitrile and pH of the versatile stage, the strategy remains unaffected and % RSD esteem acquired are roughly close [55].

□ **Framework appropriateness boundaries:**

Framework reasonableness test is utilized to really look at the responsiveness, goal, and reproducibility of the chromatographic framework are well for the investigation to be finished. The factors for the most part utilized in framework reasonableness are following variable, a number of the hypothetical plate, maintenance time, goal, and so forth.

## Conclusion

This article gives a thought that what is approval, its sorts, why it is important, how to foster a technique and how to complete the approval system to show that the procedure is capable for its proposed reason. All approval boundaries like linearity, LOQ, LOD, Reach, explicitness, vigor, roughness and framework reasonableness are characterized well with instances of specific medications. Approval is a vital procedure in the pharma office, and it is utilized to guarantee that the quality is worked into the strategies supporting the improvement of medication and creation.

## References

1. Hema, Swati Reddy G. A review on new analytical method development and validation by RP-HPLC. Int Res J Pharm Biosci 2017;4:41-50.

2. Ravisankar P, Navya CN, Pravallika D, Sri DN. A review on step-by-step analytical method validation. *IOSR J Pharm* 2015;5:7-19.
3. Patel A, Dwivedi N, Kaurav N, Bashani S, Patel S, Sharma HS, et al. Chemical analysis of pharmaceuticals: a review. *J Med Pharm Innov* 2016;3:4-7.
4. Jatto E, Okhamafe AO. An overview of pharmaceutical validation and process controls in drug development. *Trop J Pharm Res* 2002;1:115-22.
5. Pathuri R, Muthukumar M, Krishnamoorthy B, Nishat A. A review on analytical method development and validation of the pharmaceutical technology. *Curr Pharm Res* 2013;3:855-70.
6. Patil R, Deshmukh T, Patil V, Khandelwal K. Review on analytical method development and validation. *Res Rev J Pharm Anal* 2014;3:1-10.
7. Chauhan A, Mittu B, Chauhan P. Analytical method development and validation: a concise review. *J Anal Bioanal Tech* 2015;6:1.
8. Mahar P, Verma A. Pharmaceutical process validation: an overview. *Int J Pharm Res Biosci* 2014;3:243-62.
9. Lavanya G, Sunil M, Eswarudu MM, Eswaraiah MC, Harisudha K, Spandana BN, et al. Analytical method validation: an updated review. *Int J Pharm Sci Res* 2013;4:1280.
10. Verma P, Madhav NS, KR Gupta V. A review article on pharmaceutical validation and process controls. *Pharma Innovation* 2012;1:51-60.
11. Md Alamshoib. Pharmaceutical process validation: an overview. *J Adv Pharm Edu Res* 2012;2:185-200.
12. Ahir KB, Singh KD, Yadav SP, Patel HS, Poyahari CB. Overview of validation and basic concepts of process validation. *Sch Acad J Pharm* 2014;3:178-90.
13. Nandhakumar L, Dharmamoorthy G, Rameshkumar S, Chandrasekaran S. An overview of pharmaceutical validation: quality assurance viewpoint. *Int J Res Pharm Chem* 2011;1:1003-14.
14. Bhardwaj SK, Dwivedi K, Agarwal DD. A review: HPLC method development and validation. *Int J Anal Bioanal Chem* 2015;5:76-1.
15. Araujo P. Key aspects of analytical method validation and linearity evaluation. *J Chromatogr B* 2009;877:2224-34.
16. Goyal D, Maurya S, Verma C. Cleaning validation in the pharmaceutical industry-an overview. *Pharma Tutor* 2016;4:14-20.
17. Lodhi B, Padamwar P, Patel A. Cleaning validation for the pharmaceuticals, biopharmaceuticals, cosmetic and nutraceuticals industries. *J Innov Pharm Biol Sci* 2014;1:27-38.
18. Murthy DN, Chitra K. A review article on cleaning validation. *Int J Pharm Sci Res* 2013;4:3317.
19. Srivastava RK, Kumar SS. An updated review: analytical method validation. *Eur J Pharm Med Res* 2017;4:774-84.
20. Patel Paresh U. Development and validation of simultaneous equations method for estimation of betahistine dihydrochloride and prochlorperazine maleate in tablet dosage form. *Inventi Rapid: Pharm Analysis and Quality Assurance*; 2013.
21. Nirupa G, Tripathi UM. RP-HPLC analytical method development and validation for simultaneous estimation of two drugs nitazoxanide, ofloxacin and its pharmaceutical dosage forms. *Int J ChemTech Res* 2012;5:775-83.
22. Devi TP, Setti A, Srikanth S, Nallapeta S, Pawar SC, Rao JV, et al. Method development and validation of paracetamol drug by RP-HPLC. *J Med Allied*
23. Nayudu ST, Suresh PV. Bio-analytical method validation—a review. *Int J Pharm Chem Res* 2017;3:283-93. *Sci* 2013;3:8.
24. Daksh S, Goyal A, Pandiya CK. Validation of analytical methods— strategy and significance. *Int J Res Dev Pharm Life Sci* 2015;4:1489-97.
25. Tijare LK, Rangari NT, Mahajan UN. A review on bioanalytical method development and validation. *Asian J Pharm Clin Res* 2016;9:6-10.
26. Tiwari G, Tiwari R. Bioanalytical method validation: an updated review. *Pharm Methods* 2010;1:25-8.
27. Pasbola K, Chaudhary M. Updated review on analytical method development and validation by HPLC. *World J Pharm Pharm Sci* 2017;6:1612-30.
28. Geetha G, Raju KN, Kumar BV, Raja MG. Analytical method validation: an updated review. *Int J Pharm Biol Sci* 2012;1:64-1.
29. Shrivastava A, Gupta VB. Methods for the determination of limit of detection and limit of quantitation of the analytical methods. *Chron Young Sci* 2011;2:21.

30. Ravichandran V, Shalini S, Sundram KM, Harish R. Validation of analytical methods–strategies and importance. *Int J Pharm Pharm Sci* 2010;2:18-2.
31. Shweta K, Anita S. A review on analytical method validation. *Int J Pharm Res Rev* 2016;5:30-6.
32. Boque R, Maroto A, Riu J, Rius FX. Validation of analytical methods. *Grasas Aceites* 2002;53:128-43.
33. PushpaLatha E, Sailaja B. Bioanalytical method development and validation by HPLC: a review. *J Med Pharm Innov* 2014;1:1-9.
34. Gupta V, Jain AD, Gill NS, Gupta K. Development and validation of HPLC method-a review. *Int Res J Pharm Appl Sci* 2012;2:17-5.
35. Bose A. HPLC calibration process parameters in terms of system suitability test. *Austin Chromatogr* 2014;1:4.
36. <http://www.chromacademy.com>. [Last accessed on 19 Jun 2018]
37. Tiwari P, Singh BK. HPLC: a modern approach of development and validation. *World J Pharm Res* 2016;5:1616-31.
38. Kenkel J. *Analytical Chemistry for Technicians*. Lewis Publishers. 2003.
39. Kissinger PT. Instant Notes: Analytical Chemistry. *Clin Chem*. 2002; 48(12): 2303.
40. Harvey D. *Modern analytical chemistry*. McGraw-Hill. 2000.
41. Ravisankar P, Navya CN, Pravalika D, Sri DN. A review on step-by-step analytical method validation. *IOSR J Pharm*. 2015; 5(10): 7-19.
42. Jeffery GH. *Textbook of quantitative chemical analysis*. Longman. 1989.
43. Chatwal GR, Anand SK. *Instrumental Methods of Chemical Analysis*. Himalaya Publishing House. 2002.
44. Kumar S. Spectroscopy of organic compounds. *Cosmic rays*. 2006; 10: 4.
45. Luxminarayan L, Sharma N, Viswas A, Khinchi MP. A review on chromatography techniques. *Asian Journal of Pharmaceutical Research and Development*. 2017; 1-8.
46. Chawla G, Chaudhary KK. A review of HPLC technique covering its pharmaceutical, environmental, forensic, clinical and other applications. *Int J Pharm Chem Anal*. 2019; 6(2): 27-39.
47. Vidushi Y, Meenakshi B. A review on HPLC method development and validation. *Res J Life Sci*. 2017; 2(6): 178.
48. McPolin O. *An introduction to HPLC for pharmaceutical analysis*. Lulu. 2009.
49. Malviya R, Bansal V, Pal OP, Sharma PK. High performance liquid chromatography: a short review. *J Glob Pharma Technol*. 2010; 2(5): 22-26.
50. Jena AK. HPLC: highly accessible instrument in pharmaceutical industry for effective method development. *Pharm Anal Acta*. 2011; 3.
51. Agilent Technologies. *The LC Handbook Guide to LC Columns and Method Development*. Agilent Technologies. 2016; 16.
52. Hamilton RJ, Sewell PA. *Introduction to high performance liquid chromatography*. Springer. 1982; 1-12.
53. Chauhan A, Mittu B, Chauhan P. Analytical method development and validation: a concise review. *J Anal Bioanal Tech*. 2015; 6(1): 1-5.
54. Ravisankar P, Gowthami S, Rao GD. A review on analytical method development. *Indian J Res Pharm Biotech*. 2014; 2(3): 1183.
55. Lavanya G, Sunil M, Eswarudu MM, Eswaraiah MC, Harisudha K, Spandana BN. Analytical method validation: An updated review. *Int J Pharm Sci Res*. 2013; 4(4): 1280