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FORMULATION OPTIMIZATION AND EVALUATION OF PROCYCLIDINE HCL FLOATING TABLETS FOR ENHANCED GASTRIC RETENTION AND SUSTAINED RELEASE

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ABSTRACT

To determine how to prolong the stomach. retention and assure sustained medication release, the current study concentrated on developing and evaluating gastroretentive floating tablets of procyclidine HCl. Wet granulation was the technique employed to create five formulations (F1–F5), which included sodium bicarbonate as an effervescent agent, xanthan gum as a swelling agent, and HPMC K100M as the matrix-forming polymer. Following an extensive evaluation, it was determined that the tablets pre- and post-compression qualities - such as drug-excipient compatibility, flow characteristics, physical attributes, floating performance, and drug content uniformity—complied with accepted pharmacopeial standards. Effective floating competence has been established in vitro, with continuous buoyancy for up to 12 hours and lag periods ranging from 30 to 42 seconds. Higher polymer concentrations resulted in an increase in the swelling index, which helped with regulated medication release. The formulation which best fit the Korsmeyer-Peppas model, which identified a non-Fickian diffusion mechanism, occurred F4, which showed the most consistent release profile among the others. The formulation's resilience to stress was further validated by accelerated stability testing. In summary, the study successfully established a gastroretentive floating tablet method for Procyclidine HCl, which could be helpful manage Parkinsonism through decreasing the frequency of doses and improving patient compliance.

KEYWORDS: Procyclidine HCl**,** Gastroretentive Drug Delivery System (GRDDS)**,** Floating Tablets**,** Sustained Drug Release**,** HPMC K100M.

INTRODUCTION

Regarding its affordability, ease of use, and patient compliance, While oral administration is non-invasive and simple to perform, it is the most convenient and widely used method for systemic drug delivery.[1] However, due to rapid stomach emptying, medications having a limited window for absorption in the upper gastrointestinal (GI) tract frequently have low bioavailability and diminished therapeutic efficacy. In order to further enhance drug absorption in the stomach or upper small intestine, gastroretentive drug delivery systems (GRDDS) have been created as a successful approach to extend the gastric retention time.[2]

The main purposes of procyclidine hydrochloride (HCl), a centrally acting anticholinergic medication, being to treat Parkinson's disease and extrapyramidal symptoms introduced on by drugs.[8] Frequent dosage is necessary to maintain therapeutic medication levels because of its short half-life and limited absorption window in the upper GI tract. Because of these pharmacokinetic worries, procyclidine HCl is a perfect fit for GRDDS, which can improve stomach retention and provide for prolonged drug release, thus increasing therapeutic effectiveness while lowering the frequency of doses.

As a subtype of GRDDS, floating drug delivery systems have been designed to float on gastric fluid, proactively maintaining the dosage form in the stomach for an extended period of time without which impacts the stomach's release rate.[9] By putting swelling agents like xanthan gum and hydrophilic polymers like Hydroxypropyl Methylcellulose (HPMC K100M), a gel barrier that controls drug diffusion and offers a controlled release pattern can be created. By producing carbon dioxide when they get into contact with the contents of their stomachs, effervescent substances such as sodium bicarbonate aid the achievement of buoyancy.[3][4]

The development and comprehensive assessment of gastroretentive floating tablets of procyclidine HCl utilizing acceptable polymers and excipients are the main objectives of the present research. In order to improve the effectiveness of therapy and patient compliance, a stable, efficient, and patient-friendly dosage form that can deliver sustained drug release over 12 hours is being investigated desired.

MATERIALS AND METHODS

Materials

Procyclidine HCl (API), HPMC K100M (Matrix polymer), Xanthan Gum (Swelling agent), Sodium Bicarbonate (Effervescent agent), Citric Acid (Acid source), PVP K30 (Binder), Magnesium Stearate (Lubricant), Colloidal anhydrous silica (Glidant), and Microcrystalline Cellulose (MCC) (Diluent) are used.

Formulation of Gastroretentive Floating Tablets

The technique of wet granulation was used to formulate floating tablets of procyclidine HCl. With the notable exception of Colloidal anhydrous silica and magnesium stearate, all necessary materials were precisely weighed and sieved through a #40 mesh screen. The medication, HPMC K100M, xanthan gum, sodium bicarbonate, citric acid, and microcrystalline cellulose have all been thoroughly mixed in a polyethylene bag for ten minutes to create an identical blend. After that, the blend was gradually mixed with a binding solution of PVP K30 in isopropyl alcohol until a cohesive wet mass was created. Granules were obtained by passing the wet mixture through a #16 sieve, and the particles were then dried for 30 to 45 minutes at 40 to 45°C in a hot air oven. After being passed through a #20 filter out the dried granules were incorporated with magnesium stearate and Colloidal anhydrous silica. The final stage of the mixture was blend 5 minutes. Lastly, a single-punch tablet press was used to compress the entire mixture into tablets. The total tablet weight for each formulation had been established at 300 mg.

Table No. 1: Formulation design of Procyclidine Hcl.

S.No	Name of Ingredients	F1	F2	F3	F4	F5
1	Procyclidine HCl (API)	5	5	5	5	5
2	Microcrystalline Cellulose PH 102	113	53	23	23	83
3	PVP K30	20	25	30	30	25
4	Iso Propyl Alcohol	60	60	60	60	60
5	HPMC K100M	80	100	120	100	90
6	Xanthan Gum	20	30	30	40	20
7	Sodium Bicarbonate	40	60	60	70	50
8	Citric Acid	10	15	20	20	15
9	Colloidal Anhydrous Silica	6	6	6	6	6
10	Magnesium Stearate	6	6	6	6	6
Tablet Weight (mg/T)		300	300	300	300	300

Determination of Absorption Maxima for Procyclidine HCl

Using a blank reagent as the reference, the working standard solutions of Procyclidine HCl were scanned across the UV spectrum (200–400 nm) in order to figure out the absorption maxima. All subsequent analytical measures were carried out at the most suitable wavelength, which was determined to be the wavelength corresponding to maximum absorption (λ-max).[5]

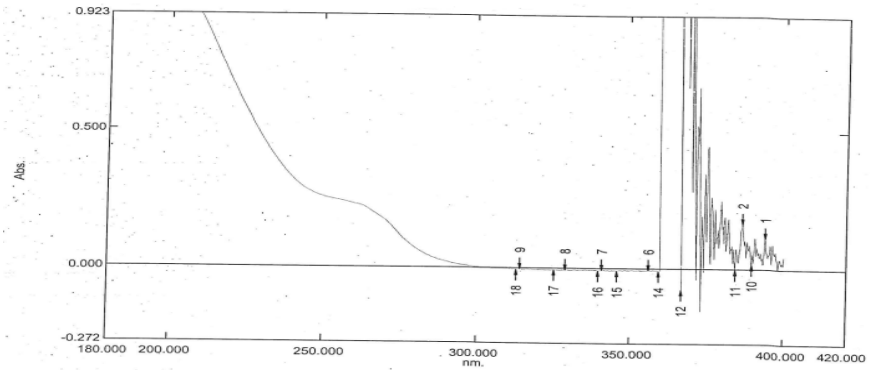

Fig. No. 1: λmax Scan of Procyclidine HCl.

After detecting the working standards across a wavelength range of 200 to 400 nm against a reagent blank, the absorption maxima (λ-max) have been identified at 261 nm. This perfect wavelength has therefore been employed for accurate and trustworthy analytical measurements in dissolution research and to determine the standard calibration curve.

Assay Procedure

Using UV-Visible[7] Spectrophotometer

Standard Preparation

10 mg of the reference standard should be carefully and precisely weighed before being transferred into a 100 mL volumetric flask to make the working standard solution of procyclidine HCl. In order to make sure complete dissolving, add roughly 70 mL of 0.1N HCl and sonicate the solution for 30 seconds. Make use of the same solvent to dilute the solution to the appropriate level in order to get a stock solution with a concentration of 100 µg/mL. In order to establish a working standard solution of 10 µg/mL, pipette 5 mL of this stock solution into a 50 mL volumetric flask and dilute to volume with 0.1N HCl. ensure use of a UV spectrophotometer to determine this solution's absorbance at 261 nm.

Sample Preparation

Ten milligrams of Procyclidine HCl were put in to a 100 milliliter volumetric flask after twenty tablets had been properly measured and pulverized into powder. To ensure effective drug extraction, the powder was combined with 70 mL of 0.1N HCl and sonicated for 30 minutes. Whatman No. 41 filter paper (or an equivalent) was implemented to filter the solution after it had cooled and the volume had been adjusted to 100 mL using 0.1N HCl. To get to a final concentration of 10 µg/mL, a 5 mL aliquot of the filtrate was then further diluted to 50 mL with 0.1N HCl. A UV-visible spectrophotometer was used to measure this solution's absorbance at 261 nm.

$$\text{Amount of drug (mg/tablet)} = \left(\frac{\text{Absorbance of sample}}{\text{Absorbance of standard}}\right) \times \text{Weight of standard (mg)}$$

Procedure for dissolution testing

Method of analysis

Using a USP Type-II (paddle) equipment and 900 mL of 0.1N HCl (pH 1.2) as the dissolution medium, an in-vitro dissolution research was carried out. The temperature had been maintained at 37 ± 0.5°C, and the device was set to 50 RPM. In order to maintain sink conditions, samples were taken at 0, 1, 2, 4, 6, 8, 10, and 12 hours. At each time, 5 mL of the sample had been taken out and promptly replaced with an equivalent volume of freshly heated medium. The samples were processed through a 0.45 µm membrane filter before analysis.

UV-Visible Spectrophotometry Method

Standard Preparation

In a volumetric flask with a volume of 100 m 10 mg of Procyclidine HCl is dissolved in 0.1N HCl in order to prepare a standard solution. Sonication is then employed to ensure full dissolution. A stock solution containing 100 µg/mL can then be obtained by adjusting the volume to 100 mL using 0.1N HCl. In order to generate a 10 µg/mL working standard solution, a 5 mL aliquot of this stock is further diluted to 50 mL with 0.1N HCl. The absorbance of this solution is measured at 261 nm (λmax).

Sample Preparation

Five milliliters of the dissolving medium have been collected at each predetermined interval and subsequently passed via Whatman filter paper. To make sure the concentrations of the

filtered samples remained within the conventional calibration range, samples were then diluted as applicable. A UV-visible spectrophotometer was used for evaluating each sample's absorbance at 261 nm, using 0.1N HCl as the blank.

$$\%\text{Drug Release} = \left(\frac{\text{Absorbance of sample} \times \text{Dilution Factor} \times 100}{\text{Label Claim} \times \text{Standard Absorbance}}\right)$$

RESULTS AND DISSCUSION

Pre-Compression parameters

Table No. 2: Pre-compression parameters for Procyclidine HCl optimized formula blend.

Code	B.D (g/ml)	T.D (g/ml)	Hausner's ratio	Carr's index (%)	Angle of repose (ɵ)	Flow property
F1	0.525	0.652	1.24	19.48	30º 65'	GOOD
F2	0.531	0.657	1.24	19.18	30º 30'	GOOD
F3	0.519	0.649	1.25	20.03	29º 55'	GOOD
F4	0.521	0.653	1.25	20.21	29º 95'	GOOD
F5	0.524	0.647	1.23	19.01	28º 54'	GOOD

Drugs and Excipient compatibility studies using FTIR

In IR spectroscopy-based drug-excipient compatibility investigations, the active pharmaceutical ingredient (API) and excipients are both analyzed. A hydraulic press with KBr is used to compress the samples—including crumbled mixtures—into pellets. Prior to analysis, the pellets are scanned between 400 and 4000 cm^{-1} at room temperature. Spectral smoothing and baseline correction are then accomplished. Procyclidine HCl and its lubricating blend with excipients have been examined in this study to evaluate any possible chemical or physical interactions. As shown in Fig. No. 2 and No. 3, FTIR spectral analysis showed no notable modifications or removal of characteristic peaks, indicating that Procyclidine HCl is compatible with the recommended excipients.

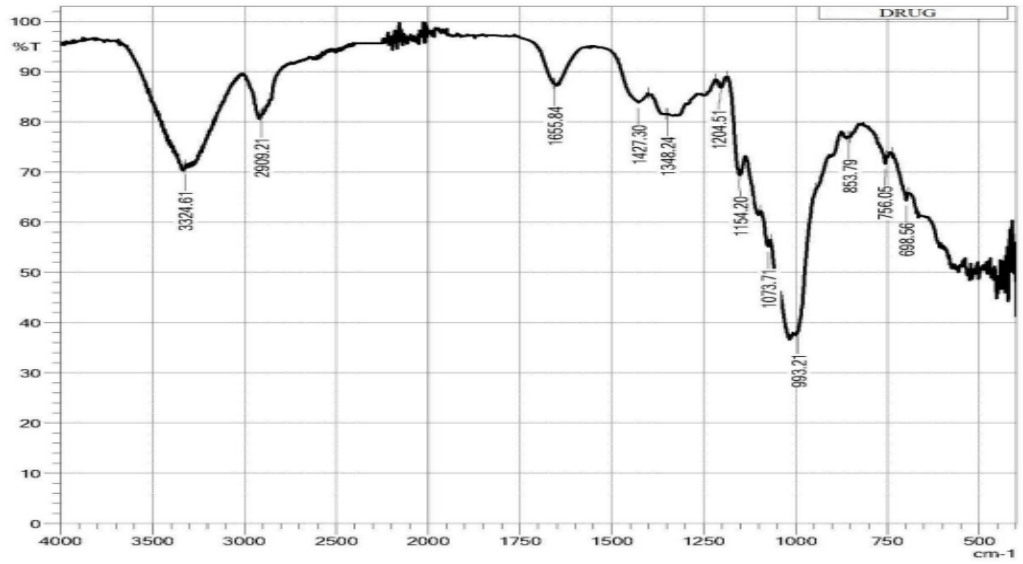

Fig. No. 2: Pure Procyclidine HCl FTIR Spectra.

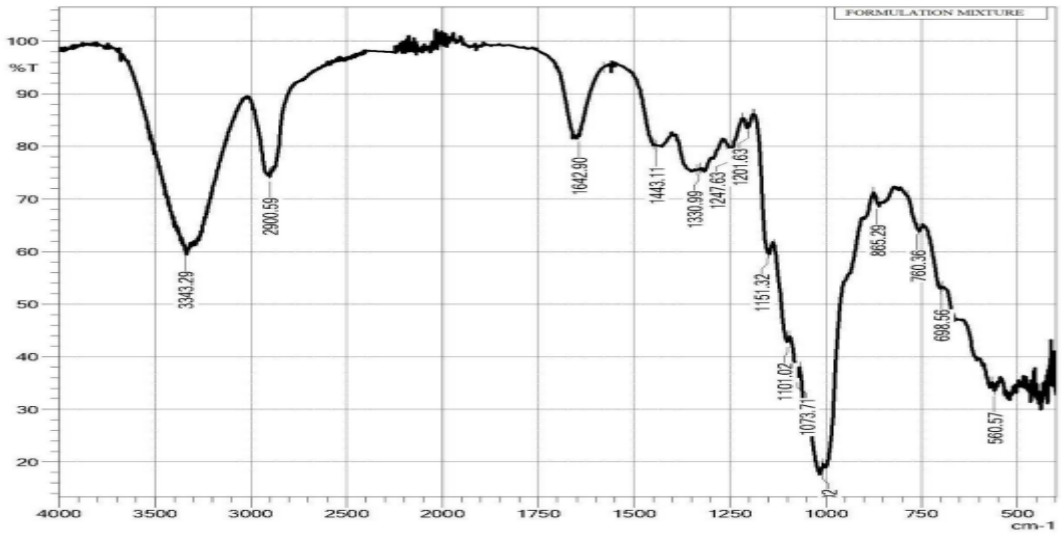

Fig. No. 3: Optimized formula blend Procyclidine HCl FTIR Spectra.

Post compression parameters

Table No 3: Evaluation of Procyclidine HCl Gastroretentive Floating Tablets(F1 to F5).

S,No	Test Parameter	F1	F2	F3	F4	F5
1	Weight Variation (mg)	300 ± 3.2	299 ± 2.9	301 ± 3.0	300 ± 2.8	300 ± 3.1
2	Thickness (mm)	4.5 ± 0.2	4.6 ± 0.1	4.7 ± 0.1	4.5 ± 0.2	4.6 ± 0.2
3	Diameter (mm)	9.0 ± 0.1	9.1 ± 0.1	9.0 ± 0.2	9.0 ± 0.1	9.1 ± 0.1
4	Hardness (kg/cm²)	5.2 ± 0.3	5.6 ± 0.4	5.8 ± 0.5	5.9 ± 0.5	5.5 ± 0.3
5	Friability (%)	0.52	0.48	0.41	0.39	0.44
6	Drug Content (%)	98.6 ± 1.2	99.1 ± 0.9	99.5 ± 1.0	98.9 ± 1.1	98.7 ± 0.8
7	Floating Lag Time (sec)	42	38	35	30	34
8	Total Floating Time (h)	Above 12	Above 12	Above 12	Above 12	Above 12
9	Swelling Index (% at 6 h)	125	140	150	160	145

Dissolution studies

According to the USP,[10] the amount of Procyclidine HCl Gastroretentive Floating Tablets release at different time points.

Table No. 4: Comparative *In-vitro* release data for Procyclidine HCl F1 to F5 formulations.

The percentage of drug release in 0.1 M HCl was evaluated over a 12-hour period						
S.No	**Time (h)**	**F1(%)**	**F2(%)**	**F3(%)**	**F4(%)**	**F5(%)**
1	1	24.2	21.5	18.9	17.4	19.6
2	2	38.1	34.7	30.5	27.6	32.4
3	4	57.3	52.6	47.1	42.8	49.6
4	6	72.8	67.5	61.2	57.1	64.3
5	8	86.5	80.3	75.6	70.4	78.1
6	10	95.3	89.6	86.1	85.7	88.2
7	12	98.7	94.2	92.5	97.4	93.7

The Procyclidine HCl gastroretentive floating tablets from formulation F4 exhibited the most excellent drug release out of the five formulation trials that were examined. At 1, 2, 4, 6, 8, 10, and 12 hours, the total drug release rates seemed 17.4%, 27.6%, 42.8%, 57.1%, 70.4%, 85.7%, and 97.7%, in that order. The Procyclidine HCl solid dispersion tablets' in vitro drug release profile for formulation F4 is shown in Fig No 4.

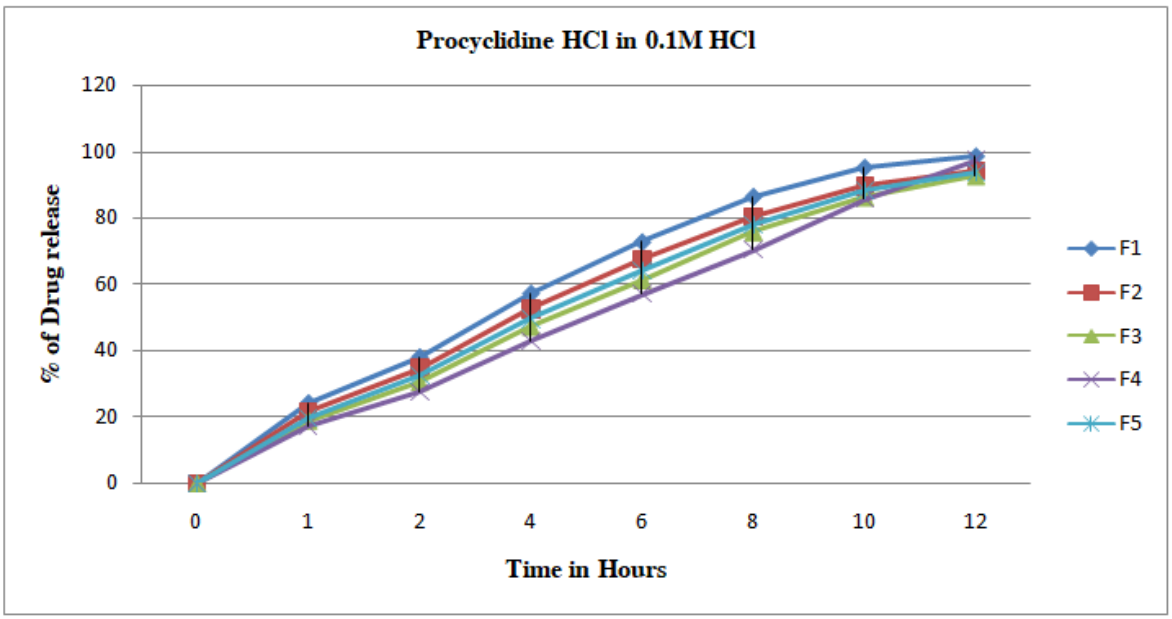

Fig. No. 4: The *in-vitro* drug release variables associated with formulations F1 through F5 have been shown in the graph.

SUMMERY AND CONCLUSION

SUMMARY

In order to enhance the duration of stomach residence time and facilitate prolonged drug release, the present research has concentrated on development and evaluation of gastroretentive floating tablets containing procyclidine HCl. A gastroretentive device was created to improve bioavailability, therapeutic efficacy, and patient compliance because of the medication's limited window to stay absorption in the upper gastrointestinal tract and its anticholinergic effects. Using HPMC K100M as the main matrix polymer, Xanthan gum for swelling and matrix stability, and sodium bicarbonate as an effervescent ingredient that ensures buoyancy, five formulations (F1–F5) were made by wet granulation. PVP K30, MCC, Colloidal anhydrous silica, and magnesium stearate were among the other excipients added to improve tablet uniformity, binding, and compressibility. Excellent flow characteristics were validated by pre-compression experiments, and post-compression assessments revealed that the medication content and friability met pharmacopoeial criteria. The tablets showed sustained buoyancy for more than 12 hours, with a rapid getting started of floating within 30 to 42 seconds. With higher polymer concentration, swelling indices got higher, with F4 demonstrating the most expansion (160%). During in vitro evaluations in 0.1N HCl, formulation F4 demonstrated the most stable and sustained drug release profile over a 12-hour period because of the combined therapeutic effects of HPMC and xanthan gum. The Korsmeyer-Peppas model was followed by the drug release kinetics, suggesting a non-Fickian diffusion mechanism controlled by the simultaneous drug diffusion and polymer swelling. Three months of accelerated stability testing of F4 conducted in accordance with ICH criteria verified the formulation's stability, showing no appreciable changes in its physical or release capabilities.

CONCLUSION

This work effectively created a gastroretentive floating tablet method for Procyclidine HCl, which uses effervescent agents and hydrophilic polymers to extend gastric retention and enable controlled drug release. F4 was determined to be the best batch out of the five evaluated formulations due to its exceptional mechanical strength, minimal friability, 12-hour sustained drug release, robust buoyancy, and increased swelling capacity. For patients with Parkinson's disease, these characteristics improve therapeutic effects by increasing bioavailability and lowering dose frequency. In addition, under accelerated environments, the improved formulation demonstrated stability, indicating a favorable shelf life. This method

offers a patient-friendly and efficient oral drug delivery strategy for Procyclidine HCl, and its remarkable performance holds great promise for in vivo investigations and clinical applications.

REFERENCE

1. Ratnaparkhi MP, Gupta Jyoti P. Sustained release oral drug delivery system-an overview. Terminology, 2013; 3(4): 10-22270.
2. Mandal UK, Chatterjee B, Senjoti FG. Gastro-retentive drug delivery systems and their in vivo success: A recent update. asian journal of pharmaceutical sciences, 2016 Oct 1; 11(5): 575-84.
3. Cazzola M, Centanni S, Donner CF. Anticholinergic agents. Pulmonary pharmacology & therapeutics, 1998 Oct 1; 11(5-6): 381-92.
4. Zanke AA, Gangurde HH, Ghonge AB, Chavan PS. Recent Advance in Gastroretantive Drug Delivery System (GRDDS). Asian Journal of Pharmaceutical Research, 2022; 12(2): 143-9.
5. Mehta A. Ultraviolet-Visible (UV-Vis) Spectroscopy-Wooward-Fieser Rules to Calculate Wavelength of Maximum Absorption (Lambdamax) of Conjugated Dienes and Polyenes. Notes, 2012; 2: 3.
6. Gaber RA, Hassan NY, Ramadan NK, Ragab MT. Solid-contact ion-selective sensor for the direct determination of procyclidine HCl and application of in-line dissolution profiling of its tablets. Electroanalysis, 2024 Aug; 36(8): 202300363.
7. Kumar AP, Kumar D. Determination of pharmaceuticals by UV-visible spectrophotometry. Current Pharmaceutical Analysis, 2021 Oct 1; 17(9): 1156-70.
8. Brocks DR. Anticholinergic drugs used in Parkinson's disease: An overlooked class of drugs from a pharmacokinetic perspective. J Pharm Pharm Sci., 1999 May 1; 2(2): 39-46.
9. Vinarov Z, Abdallah M, Agundez JA, Allegaert K, Basit AW, Braeckmans M, Ceulemans J, Corsetti M, Griffin BT, Grimm M, Keszthelyi D. Impact of gastrointestinal tract variability on oral drug absorption and pharmacokinetics: An UNGAP review. European Journal of Pharmaceutical Sciences, 2021 Jul 1; 162: 105812.
10. Shohin IE, Grebenkin DY, Malashenko EA, Stanishevskii YM, Ramenskaya GV. A brief review of the FDA dissolution methods database. Dissolution Technol., 2016 Aug 1; 23(3): 6-10.