RESEARCH PAPER

Formulation and Evaluation of Gastroretentive Bilayer Floating Tablets of Aceclofenac and Famotidine

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ABSTRACT
Peptic ulcer disease results from an infection of the bacterium Helicobacter pylori. Aceclofenac is usually used to manage inflammatory disorders; however, long-term use of the drug may cause gastric irritation and ulceration. To minimize these effects on the gastric system, an attempt was made to develop a gastroretentive bilayer floating tablet of aceclofenac and famotidine and evaluate it. The bilayer tablet has an immediate release layer containing aceclofenac and a floating layer containing famotidine. By utilizing the polymers and gas-forming agents, the tablets were prepared by wet granulation. Following the success of the synthesis, preformulation studies were carried out, which included solubility, micromeritic properties and drug-excipient compatibility studies. The tablets that were previously produced were evaluated for weight variation, hardness, thickness, friability, drug content, floating behaviour and in-vitro dissolution studies. The formulated floating tablet that was developed had satisfactory physical parameters. The formulation showed good buoyancy with an acceptable floating lag time and a sustained release pattern for 10 hours. The gastroretentive bilayer tablet as per study can provide immediate analgesic action and sustained gastroprotection which can enhance patient compliance.

Keywords: Aceclofenac, Famotidine, Bilayer Tablet, Gastroretentive Drug Delivery System, Floating Tablets, Sustained Release.
How to cite this article: Dhatwalia A, Thakur R, Prakash D, Devi A. Formulation and Evaluation of Gastroretentive Bilayer Floating Tablets of Aceclofenac and Famotidine. Int J Drug Deliv Technol. 2026;16(59s): 644-651. DOI: 10.25258/ijddt.16.59s.78
Source of support: Nil
Conflict of interest: None

1. Introduction

Peptic ulcer disease (PUD) is an illness that makes sores happen on the gastric or duodenal mucosa. When the offensive forces outweigh the defensive forces, the illness develops. Gastric acid, pepsin, Helicobacter pylori infection, and bile salts and pancreatic secretions in ileal reflux are aggressive elements. The secretions of mucus, bicarbonate, mucosal blood flow, resistance of mucosa to injury, and cellular regeneration are defense factors. Non-steroidal anti-inflammatory drugs (NSAIDs) usually treat inflammatory and musculoskeletal disorders. Long-term use, on the other hand, causes gastrointestinal complications like gastric irritation, ulceration and bleeding [1]. Aceclofenac is a commonly prescribed non-steroidal anti-inflammatory drug (NSAID) used to treat osteoarthritis, rheumatoid arthritis and other musculoskeletal disorders. However, sustained therapy may cause harm to the gastric mucosa. Famotidine is an anti-ulcer medicine used to prevent and treat peptic ulcer diseases and GERD. A histamine H2-receptor block may reduce gastric acid secretion. Histamine H2-receptor antagonists inhibit the parietal cells' histamine receptors in the stomach [2]. In the latest years, the gastro-retentive dosage form has advanced rapidly. A gastroretentive dosage form stays in the gastric region for an extended time period. It maintains the dosage form in the gastric area for a longer time and helps in bioavailability improvement of the drug. A bi-layer tablet involves two separate layers of materials, each performing different functions [3]. A formulation technology that involves two layers, one for immediate release and one for sustain release. Each layer could be an entirely different formulation. In this set of formulation, two drugs are involved. In the present work, bilayer floating tablets containing the famotidine as a sustained release floating layer and aceclofenac as an immediate release layer were developed and evaluated

simultaneously to obtain immediate analgesic effect and gastric protection. Gastroretentive drug delivery systems have experienced tremendous research interest in recent years. A variety of drug delivery systems manage to prevent drugs from being released at once, which is referred to as controlled drug release. Gastro-retentive floating tablets lie in the gastric fluid for a longer duration of time [4]. The controlled release helps to help of the drug from tablet. The bilayer tablet technology allows for different types of drugs to be incorporated into a single tablet dosage form. For example, one layer may give an initial dose of the drug whereas the other layer may give a sustained dose or controlled effect. Tablet formulations enhance the effectiveness of therapy and/or reduce the frequency of dosing. For the current study, they prepared and evaluated tablets that floated and had Two layers [5]. The first layer had famotidine which released slowly while the second layer rapidly released aceclofenac. Hopefully, this will give rapid analgesic action of aceclofenac while the sustained release of famotidine will provide prolonged gastric protection [6].

2. Materials and Methods

2.1. Materials

Aceclofenac and famotidine were used as active pharmaceutical ingredients in the present study. Microcrystalline cellulose (MCC), sodium starch glycolate, sodium bicarbonate, magnesium stearate, talc, lactose, and polyvinyl pyrrolidone (PVP K-30) were used as excipients for the preparation of bilayer tablets. All chemicals and reagents used in this study were of pharmaceutical or analytical grade and were obtained from reliable sources.

2.1.1. Drugs

The drugs used in the study included:

- **Aceclofenac:** A non-steroidal anti-inflammatory drug (NSAID) used for the treatment of inflammatory and musculoskeletal disorders.
- **Famotidine:** A histamine H_2-receptor antagonist used to reduce gastric acid secretion and prevent gastric ulcer formation [1].

2.1.2 Polymers

Polymers were used in the formulation to control drug release and maintain the floating behavior of the tablets in the gastric environment.

2.1.3 Excipients

The following excipients were used in the formulation:

- Microcrystalline cellulose (MCC) – Diluent and binder
- Sodium starch glycolate – Superdisintegrant
- Sodium bicarbonate – Gas-generating agent for floating property
- Magnesium stearate – Lubricant
- Talc – Glidant
- Polyvinyl pyrrolidone (PVP K-30) – Binder

2.1.4 Chemicals and Reagents

All chemicals and reagents used during the study were of analytical grade and are listed in Table

Table 1 chemical list

Chemicals	Category	Manufacturer / Supplier
Aceclofenac	API	Vivimed Labs
Famotidine	API	Vivimed Labs
HPMC	Polymer	Central Drug House
Sodium starch glycolate	Disintegrant	Loba Chemie
Microcrystalline cellulose (MCC)	Diluent	JR Drugchem Pvt. Ltd
Sodium bicarbonate	Gas generating agent	Molychem
Lactose	Diluent	Reckon Organics Pvt. Ltd
Magnesium stearate	Lubricant	Molychem
Talc	Glidant	Molychem

2.2 Equipment and Instruments

Various instruments were used for the preparation and evaluation of gastroretentive bilayer tablets. These included a UV–visible spectrophotometer, tablet compression machine, hardness tester, friabilator, dissolution apparatus, melting point apparatus, FT-IR spectrophotometer, and hot air oven. The list of equipment used is provided in Table 2

Table 2 Equipment list

Equipment	Manufacturer / Supplier
Electronic balance	Citizen
Tablet compression machine	Pharma Chem Machineries
Hardness tester	Monsanto
Friabilator	Roche Friabilator
pH meter	Sky Technology STI-431
Hot air oven	Nihar Instruments
Dissolution apparatus	Labindia
UV-Visible spectrophotometer	Shimadzu UV-1800
FT-IR Spectrophotometer	PerkinElmer ES Version 10.6.2

2.3 Preparation of Calibration Curve

2.3.1 Standard Calibration Curve

Calibration curves for aceclofenac and famotidine were prepared using UV-visible spectrophotometry. A stock solution sample of 1000 µg/mL was prepared taking aceclofenac 100 mg dissolved in ethanol in a 100 mL volumetric flask. A one-milliliter portion of the resulting solution was moved to a fresh 100-milliliter flask [7]. Ethanol was added up to the mark in order to get a secondary solution. To achieve the concentrations of 5, 10, 15 and 20 µg/mL, further dilutions were made. The UV-Vis spectrophotometer was used to find out the absorbance of every solution at respective λmax. A calibration curve was achieved by plotting absorbance against concentration. Another calibration curve was prepared for famotidine [8].

2.4. Preformulation Studies

Preformulation studies were carried out to determine the physicochemical characteristics of aceclofenac and famotidine, which are essential for selecting suitable excipients and formulation techniques. The studies performed included:

- Solubility studies

- Melting point determination
- Flow property analysis
- Drug–excipient compatibility studies

2.4.1 Solubility Study

Aceclofenac and famotidine solubility in different solvents was determined. Excess amounts of both aceclofenac and famotidine were taken. They were added to 10 mL of different solvents and mixed properly for about 5 min. It was then filtered with Whatman filter paper No. 41. The drug solubility was analysed.

2.4.2 Melting Point Determination

The melting point of the drugs was determined using a melting point apparatus by the capillary tube method. This test was carried out to confirm the identification and purity of the drugs.

2.4.3 Flow Properties of Powder Blend

The flow properties of the powder blends were evaluated using the following parameters:

- Angle of repose
- Bulk density
- Tapped density
- Carr's compressibility index
- **Hausner's ratio**

Angle of Repose

The angle of repose is defined as the maximum angle between the surface of the powder heap and the horizontal plane and is used to evaluate powder flow properties.

Bulk Density

Bulk density was calculated using the following equation:

Bulk Density = M / V_0

Where

M = Mass of powder

V_0 = Bulk volume

Tapped Density

Tapped density was determined by tapping a graduated cylinder containing the powder sample until a constant volume was obtained.

Carr's Compressibility Index

Carr's index was calculated to determine the compressibility and flow characteristics of the powder blend.

Hausner's Ratio

Hausner's ratio was determined to evaluate powder flowability.

2.4.4 Drug–Excipient Compatibility Study

FT-IR Analysis

Fourier Transform Infrared Spectroscopy (FT-IR) was used to evaluate possible interactions between the drugs and excipients.

Procedure

1. The drug and excipients were mixed physically.
2. The mixture was blended with potassium bromide (KBr).
3. The mixture was compressed to form a thin disc.
4. The infrared spectrum was recorded using an FT-IR spectrophotometer.

2.5. Formulation of Bilayer Floating Tablets

Utilizing the wet granulation approach, gastroretentive bilayer floating tablet containing aceclofenac and famotidine was assembled. Aceclofenac is included in an immediate-release layer, while famotidine is incorporated into the sustained-release floating layer. Initially, granulation takes place and later steps are drying, lubrication.

2.5.1. Preparation of Immediate Release Layer

The layer of aceclofenac which releases first quickly will have a fast drug action. Sodium starch glycolate, lactose, microcrystalline cellulose, talc and magnesium stearate were mixed to aceclofenac. The binder solution was prepared by dissolving PVP K-30 in isopropyl alcohol. The wet mass was produced by adding the mixed powder in the binder solution. The wet mass was sieved to obtain the granules. The granules were dried to obtain granules suitable for compression.

2.5.2 Preparation of Sustained Release Floating Layer

The sustained-release floating layer was prepared using the wet granulation technique. The designated amount of famotidine was taken and added to lactose, sodium bicarbonate and microcrystalline cellulose. A wet mass was prepared by adding a solution of 5% PVP K-30 in isopropyl alcohol into the powder. The wet material was screened through mesh 12 to change into granules form and dried in hot air oven of 50^{o}C for 30 to 40 minutes. To obtain a uniform particle size, the dried granules were passed through Sieve.

2.5.3 Compression of Bilayer Tablets

A double rotary tablet compression machine was used to prepare bilayer tablets. Magnesium stearate and talc were used as lubricants for the dried granules, which were mixed for 5 minutes. Initially, the die cavity filled with the sustained release famotidine layer and was lightly compressed. The bi-layer tablets were prepared by adding aceclofenac granules and compressed again. In addition, the preparation was made of bi-layer tablets using caplet-shaped punches (18.6 × 9 mm) having an average weight of around 510 mg.

2.6 Evaluation of Bilayer Tablets

2.6.1 Physical Appearance

The prepared tablets were visually inspected for color, shape, surface texture, and absence of defects such as cracks or chipping.

2.6.2 Weight Variation Test

The weight variation test was performed according to Indian Pharmacopoeia guidelines to ensure uniformity in tablet weight.

2.6.3 Hardness Test

Tablet hardness was measured to determine the mechanical strength of the tablets.

2.6.4 Thickness

Tablet thickness was measured using a vernier caliper to ensure uniformity of tablet size.

2.6.5 Friability Test

Friability testing was carried out using a friabilator to determine the resistance of tablets to abrasion.

2.6.6 Drug Content Uniformity

Drug content uniformity was determined by analyzing the drug concentration in the tablets using UV spectrophotometry.

2.6.7 Swelling Study

The swelling behavior of the tablets was studied in acidic medium, and the swelling index was calculated.

2.6.8 Floating Study

Floating lag time and total floating duration were determined to evaluate the buoyancy behavior of the tablets.

2.6.9 In-Vitro Dissolution Study

Drug release studies of Carbomer gels were performed by using dissolution apparatus. A 5 mL sample was withdrawn and replaced with fresh dissolution media at predetermined time intervals to maintain sink condition. Absorbance at 275 nm as well as 301 nm was measured using UV spectrophotometer and cumulative percentage drug release was calculated.

3. RESULTS

3.1 Bilayer Tablet

The produced bilayer floating tablets of aceclofenac and famotidine were effectively compressed using the wet granulation process. The pills were separated into two distinct layers: an instant release layer of aceclofenac and a sustained release floating layer of famotidine. The tablets showed acceptable physical appearance with uniform shape, smooth surface, and no visible defects.

Fig 1. Bilayer tablet

3.1. Calibration Curve

3.1.1. Aceclofenac

Ethanol was used as the solvent in the construction of the Aceclofenac calibration curve. The absorbance of several doses ranging from 5 to 30 µg/mL was measured using a UV-Visible spectrophotometer.

Table 3 Calibration Data for Aceclofenac

Concentration (µg/mL)	Measured Absorbance
5	0.234
10	0.425
15	0.694
20	0.796
25	0.999
30	1.248

The linear relation of the curve of absorbing sets calibrated indicate aceclofenac obeys Beer – Lambert Law at the concentration range selected.

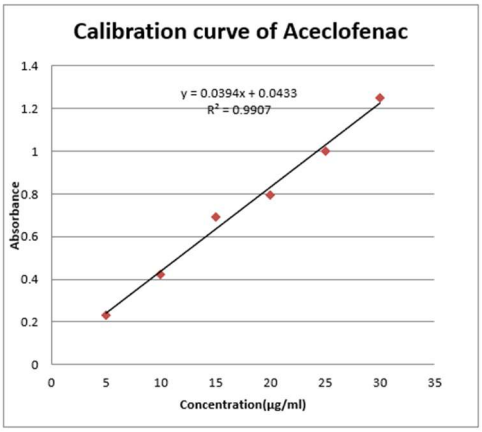

Fig 2 Standard Plot of Aceclofenac in Ethanol

3.1.2 Calibration Curve for Famotidine

Using ethanol as a solvent, a calibration curve for famotidine was created.

Table 4 Calibration Data of Famotidine

Drug Concentration (µg/mL)	Observed Absorbance
5	0.175
10	0.389
15	0.575
20	0.782
25	0.986
30	1.143

Beer-Lambert's law is also followed by famotidine, since the calibration curve showed a direct linear relationship between concentration and absorbance.

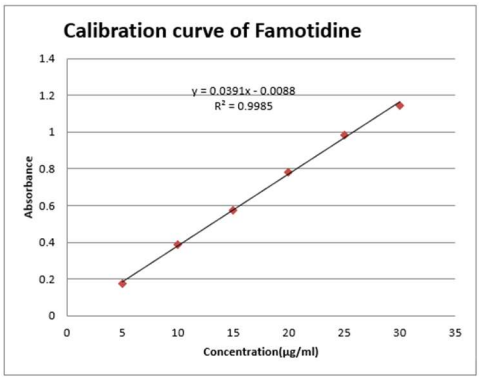

Fig 3. Standard plot of Famotidine

3.2 Preformulation Studies

The physicochemical properties of aceclofenac and famotidine were assessed through preformulation studies. These studies included solubility determination, flow property evaluation, and compatibility studies.

3.2.1. Solubility Study

Aceclofenac and famotidine's solubility in various solvents was assessed.

Table 5. Solubility Profile of Aceclofenac and Famotidine in Different Media

Solvent / Medium	Solubility of Aceclofenac	Solubility of Famotidine
Distilled Water	Soluble	Soluble
Methanol	Freely soluble	Freely soluble
Ethanol	Slightly soluble	Slightly soluble
Chloroform	Insoluble	Soluble
0.1 N Hydrochloric Acid	Soluble	Soluble
Phosphate Buffer (pH 7.4)	Soluble	Sparingly soluble

According to the findings, both medications are acceptable candidates for gastroretentive drug delivery systems intended for stomach retention because they are soluble in an acidic solution (0.1 N HCl).

3.3. Micromeritic Evaluation

The powder mixtures' flow characteristics were examined according to the parameters like angle of repose, bulk density, tapped density, Carr's index and the Hausner's ratio.

Table 6. Pre-Compression Evaluation of Aceclofenac Immediate Release Layer Granules

Batch Code	Angle of Repose (°)	Bulk Density (g/cm³)	Tapped Density (g/cm³)	Compressibility Index (%)	Hausner Ratio
F1	24.78	0.328	0.398	17.5	1.21
F2	25.23	0.317	0.376	15.6	1.18
F3	27.71	0.342	0.410	16.5	1.19
F4	25.76	0.275	0.338	18.6	1.22
F5	28.34	0.426	0.502	15.1	1.17

Table 7. Pre-Compression Evaluation of Aceclofenac Immediate Release Layer Granules

Batch Code	Angle of Repose (°)	Bulk Density (g/cm³)	Tapped Density (g/cm³)	Compressibility Index (%)	Hausner Ratio
F1	21.14	0.314	0.381	17.5	1.21
F2	21.22	0.327	0.387	15.5	1.18
F3	24.42	0.284	0.339	16.2	1.19
F4	24.29	0.319	0.391	18.4	1.22
F5	25.68	0.349	0.403	13.3	1.15

According to the results from the angle of repose experiments the values of the powder mixes were within acceptable limits. Moreover, the properties of Hausner's ratio and Carr's index indicated acceptable flowability and compressibility suitable for tablet compression.

6.4 Compatibility Studies

FT-IR spectroscopy was used to assess the drug's compatibility with the excipients.

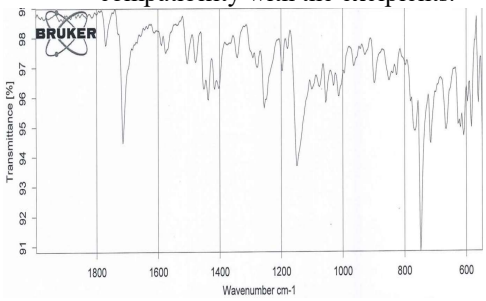

Figure 4: Spectum of aceclofenac pure substance FT-IR.

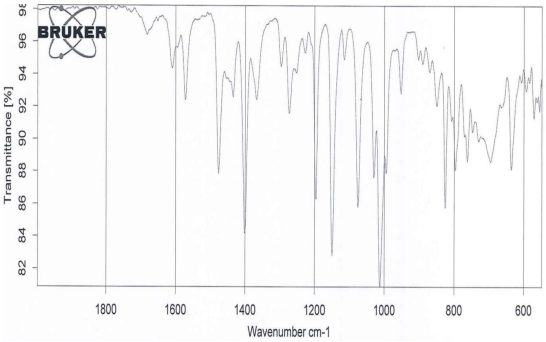

Figure 5: FT-IR Spectrum of a pure Famotidinemg Trihydrate Sample

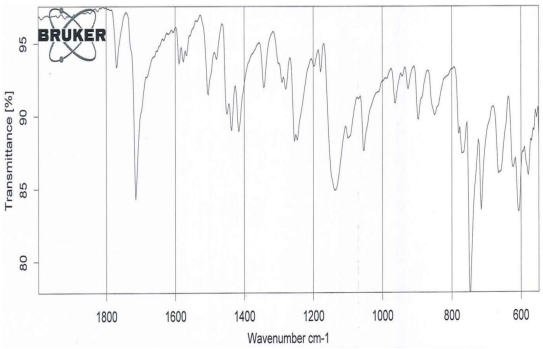

Figure 6: FT-IR Spectrum of Pure Sample Aceclofenac + Famotidinmg Trihydrate.

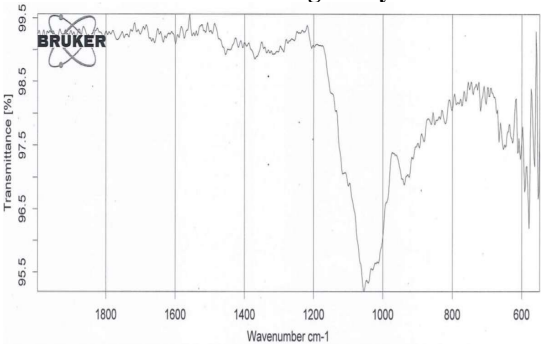

Figure 7: FT-IR Spectrum of Pure HPMC 15 CPS Sample.

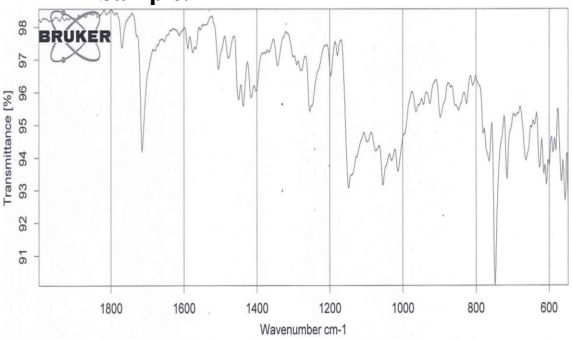

Figure 8: FT-IR Spectrum of a pure HPMC, aceclofenac, and famotidinemg trihydrate sample

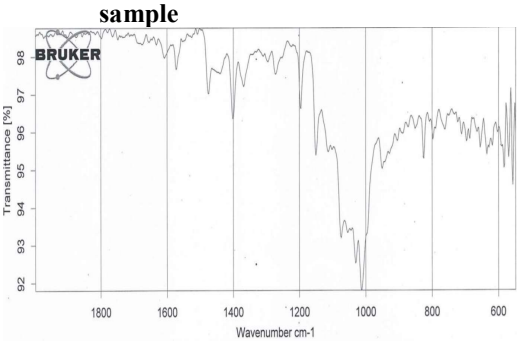

Figure 9: FT IR Spectrum of HPMC and Famotidine sample.

Table 8. FTIR Characteristic Peaks of Pure Aceclofenac

Sample	Observed Wavenumber (cm^{-1})	Assigned Functional Group
Aceclofenac	750	C–Cl stretching
	1248	Carbonyl (C=O) stretching
	1150	C–O stretching
	1770	- Carbonyl group vibration
	1720	Carboxylic acid (–COOH) group

Table 9. FTIR Characteristic Peaks of Famotidine Trihyd rate

Sample	Observed Wavenumber (cm^{-1})	Functional group assignment
Famotidine Trihydrate	1010	Sulfoxide group (S=O)
	1570	Aromatic C=C stretching
	1690	Imine group (C=N)
	1075	C–O stretching
	1404	C–H bending vibration
	1199	C–N stretching

Table 10. FTIR Peaks of HPMC Polymer

Materials	Wavenumber (cm^{-1})	Functional Group
HPMC	1050	C–O stretching
	1370	O–H bending vibration
	1680	C=C stretching
	1205	Ether linkage (C–O)

3.5 Post-Compression Evaluation

Table 11. Physical Evaluation of Prepared Bilayer Tablets

Batch	Average Weight (mg)	Thickness (mm)	Hardness (kg/cm^2)	Friability (%)	Drug Content (%)
F1	508	5.0	3.4	1.345	88.5
F2	495	5.2	7.5	0.252	89.1
F3	504	4.9	6.2	0.498	91.4
F4	487	5.4	6.8	0.482	86.3
F5	506	5.2	5.8	0.442	94.4

The amount of hardness, thickness and drug content in all tablets found within limits. There was a minor difference in F1 for friability.

3.6. Floating Test

Table 12. Floating Performance of Bilayer Tablets

Formulation	Floating Lag Time (sec)	Total Floating Time (hrs)
F1	25	>8
F2	61	>5
F3	34	>10
F4	43	>7
F5	30	>8

Sodium bicarbonate is an effective gas generating agent since all the formulations are found to have floating behaviour.

3.7 Dissolution Studies

Table 13. In-Vitro Drug Release Profile of Famotidine Sustained Release Formulations

Time (hrs)	F1 (%)	F2 (%)	F3 (%)	F4 (%)	F5 (%)
1	23.4	9.2	12.5	11.3	17.9
2	42.8	23.2	24.6	23.2	29.8
4	62.6	37.3	35.8	33.1	42.3
6	73.7	48.7	53.6	50.4	56.5
8	89.5	59.5	72.4	63.7	77.3
10	97.4	78.7	87.3	85.6	88.7
12	-	92.3	96.7	93.4	95.6

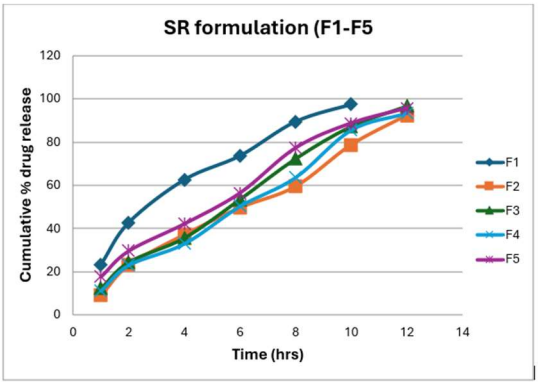

Fig 12 The graph that shows the cumulative % drug release of the drug SR layer of Trials F1F5 formulation is shown above.

Table 14: In-vitro dissolution of Aceclofenac F1-F5

Time (min)	F1 (% Release)	F2 (% Release)	F3 (% Release)	F4 (% Release)	F5 (% Release)
5	12.6	18.2	23.2	13.3	20.2
10	25.4	29.2	36.4	23.5	32.6
15	30.8	40.0	44.5	35.1	43.7
20	41.3	49.2	52.5	46.7	53.5
30	53.3	64.5	68.4	59.3	69.6
45	72.6	78.6	84.1	73.4	81.7
60	89.7	91.5	97.4	88.2	93.3

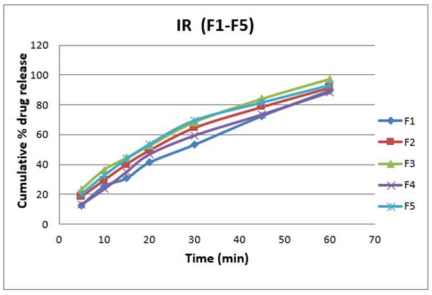

Fig 13 Drug Release Graph of IR Layer

Conclusion:

Bilayered floating tablets with an instant release formulation of aceclofenac and a sustained release formulation of famotidine using a polymer and gas producing agent were created using wet granulation technology. IR spectra analysis revealed that the medication and polymer were compatible. The granules produced underwent a series of pre-compression studies which showed good flow properties. The evaluation standards, which included content homogeneity, friability, and hardness, were all within limits for the several batches that were prepared. For the F1, F2, F3, and F5 categories of batches, the buoyancy lag and total floating time exhibited favourable behaviour. The optimized formulation has an average thickness of 5.2, an average hardness of 5.8, an average weight of 506, and a friability of 0.442. Observed for formulation F2, hardness impact on floating lag time. It was found that floating lag time increased with increase in hardness as porosity decreased. In contrast to the other batches, which were unable to maintain their release for more than 10 hours, batch F3 and F5's in vitro dissolution demonstrated a satisfactory drug release rate. The ideal formula was F5, which released famotidine at a sustained rate, with 12% being released in the first hour and the rest of the drug being released up to 10 hours. And the same formula released aceclofenac instantly within the first hour. 4. Floating properties of formulations Overall, tablets from batches F1 and F3 displayed good total floating time and a quick buoyancy lag time.

List of Abbreviations

API	Active Pharmaceutical Ingredient
ATR	Attenuated Total Reflectance
FT-IR	Fourier Transform Infrared Spectroscopy
GERD	Gastroesophageal Reflux Disease
GRDDS	Gastroretentive Drug Delivery System
HCl	Hydrochloric Acid
HPMC	Hydroxypropyl Methylcellulose
IR	Immediate Release
KBr	Potassium Bromide
MCC	Microcrystalline Cellulose
NSAIDs	Non-Steroidal Anti-Inflammatory Drugs
PUD	Peptic Ulcer Disease
PVP K-30	Polyvinyl Pyrrolidone K-30
RPM	Revolutions Per Minute
SR	Sustained Release
UV	Ultraviolet
UV-Vis	Ultraviolet–Visible Spectrophotometer
USP	United States Pharmacopeia
λmax	Maximum Wavelength
°C	Degree Celsius
µg/mL	Microgram per Milliliter
mm	Millimeter
mg	Milligram
hrs	Hours
min	Minutes

Funding
None.
Competing Interests
None.
Data Availability
Not applicable
Ethics approval
Not applicable
Consent to participate
Not applicable
Consent to publish
Not applicable
Conflict of Interest
The authors declare no conflict of interest.

Reference:

1. Brunton, L.L., B.C. Knollmann, and R. Hilal-Dandan, *Goodman & Gilman's the pharmacological basis of therapeutics*. Vol. 13. 2018: McGraw-Hill Education New York.
2. Sung, J.J., E.J. Kuipers, and H.B. El-Serag, *Systematic review: the global incidence and prevalence of peptic ulcer disease.* Aliment Pharmacol Ther, 2009. **29**(9): p. 938-46.
3. Lanas, A. and F.K.L. Chan, *Peptic ulcer disease.* Lancet, 2017. **390**(10094): p. 613-624.
4. Arora, S., et al., *Floating drug delivery systems: a review.* Aaps PharmSciTech, 2005. **6**(3): p. 47.
5. Garg, R. and G. Gupta, *Progress in controlled gastroretentive delivery systems.* Tropical journal of pharmaceutical research, 2008. **7**(3): p. 1055-1066.
6. Streubel, A., J. Siepmann, and R. Bodmeier, *Gastroretentive drug delivery systems.* Expert Opin Drug Deliv, 2006. **3**(2): p. 217-33.
7. Sen, O., et al., *Recent advances in alginate based gastroretentive technologies for drug delivery applications.* Medicine in Novel Technology and Devices, 2023. **18**: p. 100236.
8. Grewal, S., et al., *Insights into the pivotal role of calcium channel blockers and its nanoformulations in the management of hypertension.* BioNanoScience, 2023. **13**(4): p. 1437-1462.