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Research Article

Formulation and Evaluation of Floating Tablets of Pantoprazole

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Abstract

Background: Pantoprazole is a protein pump inhibitor (PPI) used to treat acute duodenal ulcers, acute benign gastric ulcers, gastroesophageal reflux disease (GERD), and as a preventative measure for duodenal ulcer. It has a local effect on the stomach and works by competitively inhibiting the enzyme H+/K+ ATP, which is found in the gastric parietal cells. For acute duodenal ulcers, acute benign gastric ulcers, and gastroesophageal reflux disease (GERD), the usual oral dosage recommendation is 45 mg, and it is taken for 8–12 weeks.

Objectives: The preparation of pantoprazole floating tablets was attempted in the current investigation and optimize the formulation using different excipients like Hydroxy ethyl cellulose (HEC), cyclodextrin, sodium bicarbonate, citric acid and microcrystalline cellulose were used in the direct compression method to create pantoprazole floating tablets (250 mg).

Methods: The direct compression method has been used in the current effort to create floating tablets. The active ingredient, sodium bicarbonate, citric acid, microcrystalline cellulose, and hydroxy ethyl cellulose were sieved through sieve no. 60 and blended uniformly with a mortar and pestle. Using a Rotary tablet punch machine, the powder was compacted into tablets after talc and magnesium stearate were added as lubricants

Results: Preformulation studies were conducted to select suitable excipients, drug/polymer interactions were validated by the FTIR investigation. The manufactured floating tablets were assessed for hardness, weight fluctuation, thickness, friability, drug content homogeneity, floating lag time, and in vitro dissolution experiment studies was conducted. The results were within the limit and were compared with the marketed formulation.

Conclusion: According to the observations of the current investigation, a floating pantoprazole tablet increases the stomach residence time and bioavailability, increasing therapeutic efficacy. Formulations F1, F2, F4, F5, F7, and F8 showed good floating, but Formulations F3, and F6 showed moderate floating throughout all 8 formulations. The stability analyses that were done for all the formulations showed that the F7 and F8 formulations had good stability.

Keywords: Pantoprazole, Floating tablet, Hydroxy ethyl cellulose (HEC), Cyclodextrin, In-vitro drug release studies.

INTRODUCTION:

Gastro retentive drug delivery systems are created to be retained in the stomach for an extended period of time while releasing their active ingredients, allowing for sustained and prolonged medication input to the upper section of the gastrointestinal tract [1,2]. Drugs that act locally in the stomach, have an absorption window in the stomach or upper part of the small intestine, are unstable in the intestinal or colonic environments, or have low solubility at high pH values are of particular interest for modified release drug delivery systems with prolonged residence times in the stomach [3]. Since they are buoyant in the stomach for a longer duration without changing the gastric emptying rate, floating medication delivery methods have a lower bulk density than gastric fluids [4]. Drug delivery by the oral route is the most practical and popular method. The polymers utilized in these systems and the formulations for controlled drug delivery have advanced significantly in recent years, enabling them to perform functions other than merely extending the drug's release time. These are designed to distribute the drug's active component gradually and predictably over a 12- to 24-hour period. Through more reliable medicine delivery, diminished side effects, increased convenience, and improved rates of patient compliance, they offer greater effectiveness in the treatment of chronic illness conditions. When a polymer, natural or synthetic, is correctly coupled with a drug or other active agent so that the active medication is delivered in a predetermined manner, this is known as controlled drug delivery. Less absorption, potential toxicity, and the creation of unfavorable byproducts are some drawbacks of these goods, notwithstanding their benefits. Floating drug delivery systems and other delivery methods with extended gastric residence times were developed to solve these problems. These systems fall under the category of gastro-retentive dosage forms, which are retained in the stomach for longer periods of time, assisting in the absorption of the drug for the intended duration of time. The floating system is an extensively used technique in this. Most often, the non-effervescent approach was used to prepare floating systems [.

When dissolved in water, hydroxyethyl cellulose, also known as hydroxypropyl methylcellulose (HPMC), creates a colloid solution. It is a semi-synthetic, inert, and viscoelastic polymer. It functions as a binder during the granulation process and in modified release formulations as well as a thickening agent, coating polymer, bio adhesive, solubility enhancer in solid dispersions, and binder. It is frequently employed as a delivery element in oral pharmaceutical products to give the controlled release of a drug, effectively increasing the time of release to extend the therapeutic effects of a drug [6].

Pantoprazole is a protein pump inhibitor (PPI) used to treat acute duodenal ulcers, acute benign gastric ulcers, gastroesophageal reflux disease (GERD), and as a preventative measure for duodenal ulcer. It has a local effect on the stomach and works by competitively inhibiting the enzyme H+/K+ ATP, which is found in the gastric parietal cells. For acute duodenal ulcers, acute benign gastric ulcers, and gastroesophageal reflux disease (GERD), the usual oral dosage recommendation is 45 mg, and it is taken for 8–12 weeks. The drug is suitable for FDDS due to short biological half-life (1-2 h) and local activity in stomach [7].

Floating system

Floating drug delivery systems (FDDS) float in the stomach without slowing down the gastric emptying rate since their bulk density is lower than that of gastric fluids. The medicine is slowly withdrawn from the system at the desired rate while the body is floating on the contents of the stomach. The stomach's residual system is emptied following medication release [8].

Classification of Floating Drug Delivery System:

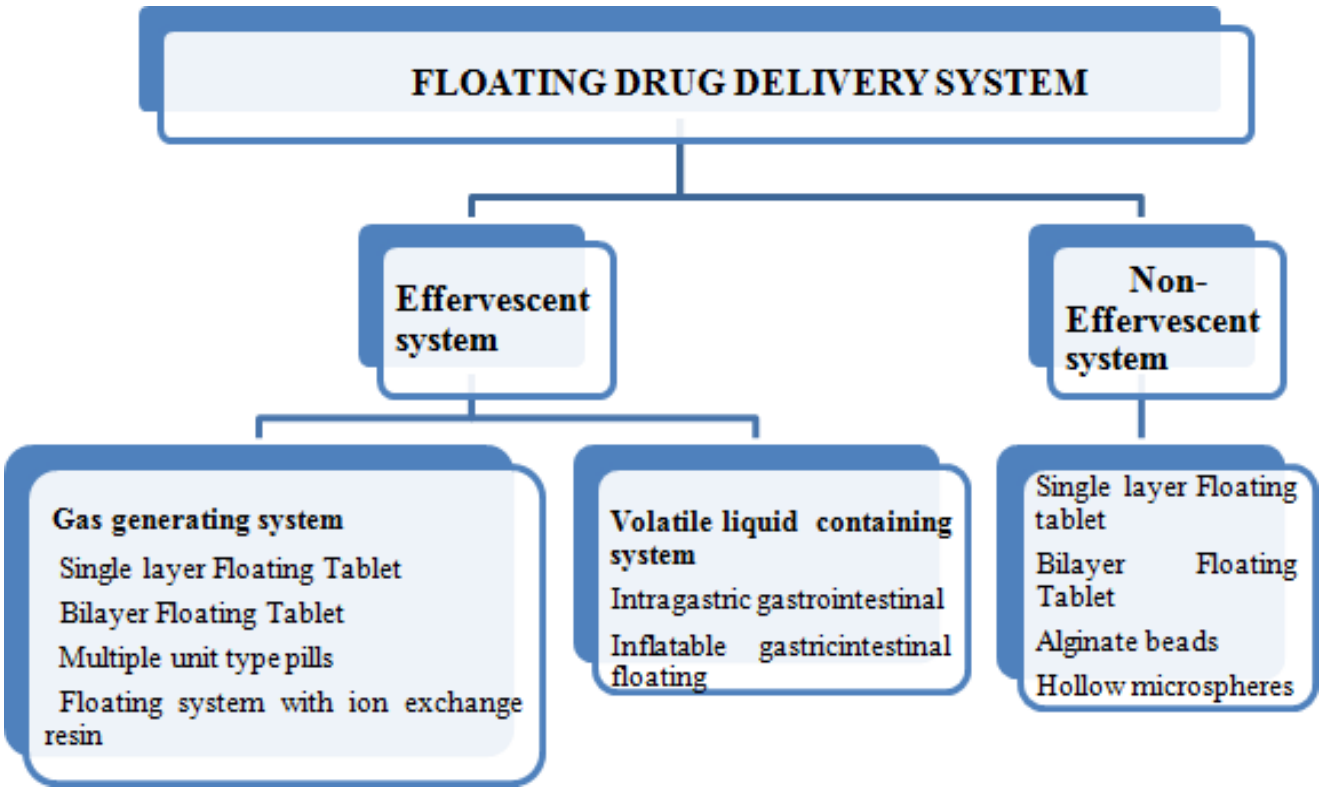

Figure 1: Schematic diagram classification of floating drug delivery system

DRUG AND EXCIPIENTS PROFILE:

Pantoprazole [9,10]

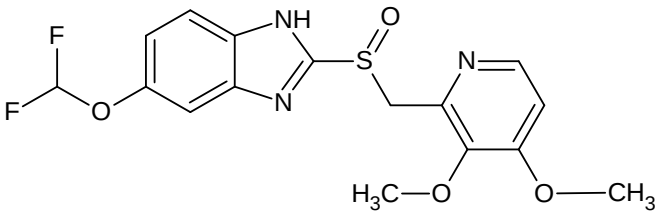

Figure 2: Pantoprazole

Chemical formula : $C_{16}H_{15}F_2N_3O_4S$

Chemical name : 6-(difluoro methoxy)-2-[(3,4-dimethoxy pyridine-2yl)methane sulfinyl]-1H-1,3benzodiazole.

Molecular weight: 383.4 g/ml

Category : Acid reducer

Solubility : Freely soluble in water

Mechanism of action

A proton pump inhibitor (PPI), pantoprazole covalently binds to the (H+, K+)-ATP enzyme system at the secretory surface of the gastric parietal cell to block the last stage of stomach acid generation. Regardless of the stimulus, this action results in the suppression of both basal and induced stomach acid secretion. For all of the studied doses, the binding to the (H+, K+)-ATPase causes an antisecretory action to last longer than 24 hours.

Pharmacokinetics:

To ensure that pantoprazole is only absorbed once the tablet has left the stomach, pantoprazole sodium is produced as an enteric-coated tablet. From 10 mg to 80 mg, the peak serum

concentration (Cmax) and area under the serum concentration-time curve (AUC) both rise proportionally to oral and intravenous dosages. Multiple daily doses of pantoprazole have no effect on its pharmacokinetics or ability to accumulate. The max of pantoprazole increases considerably and is extremely variable when administered with meals.

Absorption:

To ensure that pantoprazole is only absorbed once the tablet has left the stomach, pantoprazole sodium is produced as an enteric-coated tablet. From 10 mg to 80 mg, the peak serum concentration (Cmax) and area under the serum concentration-time curve (AUC) both rise proportionally to oral and intravenous dosages. Multiple daily doses of pantoprazole have no effect on its pharmacokinetics or ability to accumulate. The max of pantoprazole increases considerably and is extremely variable when administered with meals.

Distribution:

Pantoprazole appears to be distributed in a volume between 11.0 and 23.6 liters, mostly in extracellular fluid. About 98% of pantoprazole's serum protein binding is to albumin.

Metabolism:

Through the cytochrome P450 (CYP) system, pantoprazole is extensively metabolized in the liver. The method of administration has no effect on how pantoprazole is metabolized (intravenous or oral). The primary metabolic mechanism is demethylation by CYP2C19 followed by sulfation. CYP3A4 is another metabolic pathway. Even though these slow pantoprazole metabolizer subpopulations have elimination half-lives of 3.5 to 10.0 h, they nevertheless accumulate very little (23%) with once-daily dosage.

Elimination:

The amount of pantoprazole that was eliminated after a single oral or intravenous dose in healthy, normally metabolizing volunteers was roughly 71% in the urine and 18% in the feces as a result of biliary excretion. The unaltered drug pantoprazole was not excreted by the kidneys.

Drug-drug interactions:

Pantoprazole may be lowering plasma concentrations when used with atazanavir, indinavir, and nelfinavir. Atazanavir should not be administered together. Itraconazole and ketoconazole plasma levels may be affected; if at all possible, stay away from this combination. Digoxin serum levels may rise in response to proton pump inhibitors. Pantoprazole and zinc cannot be combined.

MATERIALS AND METHODS:

MATERIALS:

All the materials used in the formulation and evaluation of floating tablets of pantoprazole are listed below, distilled water was used for all preparations.

Table 1: List of materials used with suppliers

SL.NO	Materials used	Grade	Manufacturer
1.	Pantoprazole	Pharma grade	R.P Pharma MUMBAI
2.	Hydroxyethyl cellulose	LR	Yarrow chem Mumbai
3.	Ethyl cellulose	LR	Central drug house New Delhi
4.	B-Cyclodextrin	LR	Himedia Laboratories Mumbai
5.	Microcrystalline cellulose	LR	Mylo-chem Mumbai
6.	Citric acid	LR	Qualigens chemicals Mumbai
7.	Sodium bicarbonate	LR	Mylo-chem Mumbai
8.	Talc	LR	Powder pack chem. Mumbai
9.	Magnesium stearate	LR	Mylo-chem Mumbai

METHODS:

Standard calibration curve for pantoprazole in Distilled water:

Solution 1st:

Pantoprazole (pure medication), accurately weighed at 100 mg, was diluted in distilled water in a volumetric flask with a capacity of 100 mL (1000 g/mL). The stock solution was further diluted to a concentration of 100 g/ml [11].

Solution 2nd:

1 ml of this first stock solution was pipette out into a 100 ml volumetric flask, and the remaining volume was made up with distilled water that had a concentration of 10 g/ml from the second stock solution. From this pipette, measure out (1, 2, 3, 4 and 5 ml) evenly into a 10 ml volumetric flask, and add distilled water to make up the difference. Using a UV-visible double beam spectrophotometer, the absorbance of these solutions was determined in comparison to a blank sample at (291nm). The concentration in g/ml was then plotted on the X-axis and the absorbance on the Y-axis to create a calibration curve [12].

Preparation of Floating Tablets:

The direct compression method has been used in the current effort to create floating tablets. The active ingredient, sodium bicarbonate, citric acid, microcrystalline cellulose, and hydroxy ethyl cellulose were sieved through sieve no. 60 and blended uniformly with a mortar and pestle. Using a Rotary tablet punch machine, the powder was compacted into tablets after talc and magnesium stearate were added as lubricants [13].

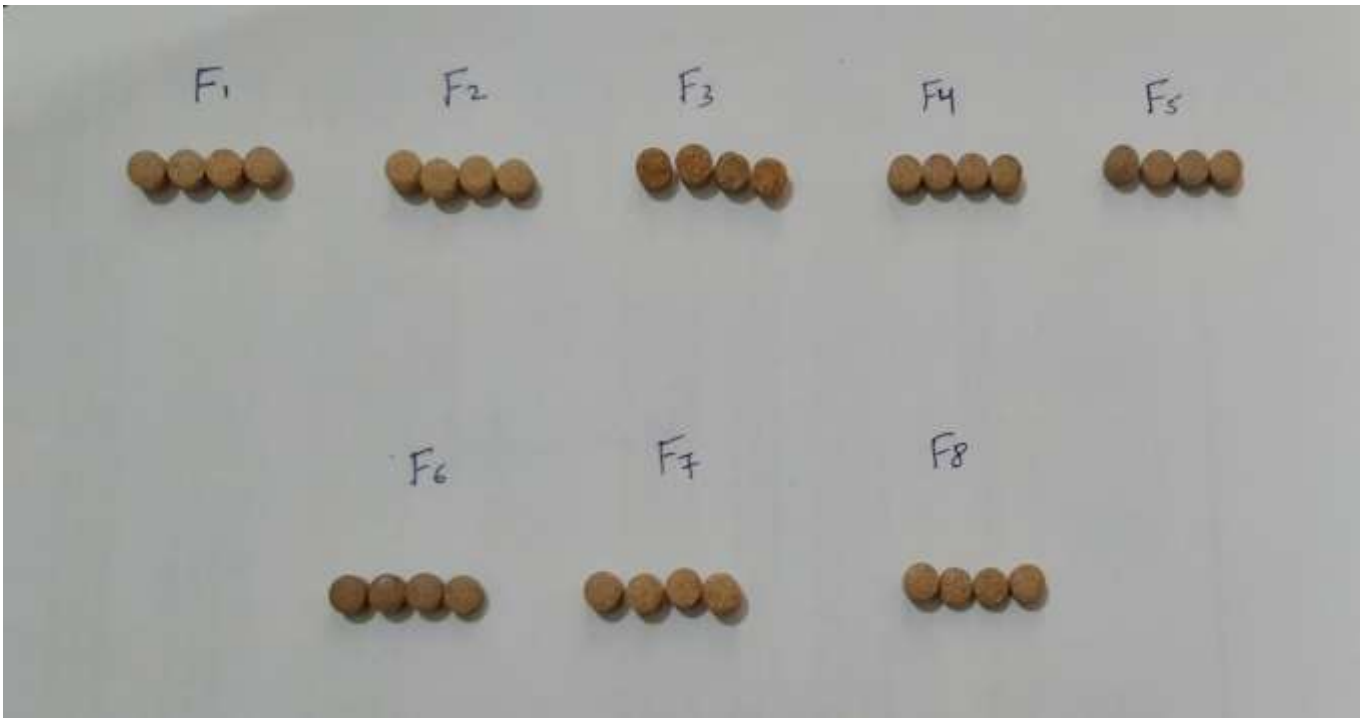

Figure 3: Formulated floating pantoprazole tablets

Table 2: Formulation; Ratio of polymers (1:2:3) quantity taken in (mg).

Ingredients	F1	F2	F3	F4	F5	F6	F7	F8
Pantoprazole	40	40	40	40	40	40	40	40
HEC	40	80	120	-	-	-	80	40
Ethylcellulose	40	40	40	40	40	40	20	20
β-cyclodextrin,	-	-	-	40	80	120	40	80
MCC	80	40	20	80	40	20	20	20
Citric acid	20	20	20	20	20	20	20	20
Na HCO3	20	20	10	20	20	10	20	20
Talc	5	5	5	5	5	5	5	5
Mg. stearate	5	5	5	5	5	5	5	5
Total weight. (mg)	250	250	250	250	250	250	250	250

Evaluation of pre-compression parameters of powder:

The angle of repose: The fixed funnel and free-standing cone approach both make use of a funnel with its tip fixed at a specific height, h, which was maintained above graph paper that was laid out on a level horizontal surface. The following equation can be used to calculate the angle of repose, where r is the radius of the conical pile.

$\theta = Tan - 1(h/r)$

Where, θ is the angle of repose, h-is height of pile, r is radius of base of the pile

Table 3: Angle of Repose

Angle of repose (θ) degree	Flow
≤25	Excellent
25-30	Good
30-40	Passable
40≥	Poor

Bulk density & Tapped density: The bulk density as well as the tapped bulk density were calculated. Granules weighing 2gm from each formula were added to the 10ml measuring cylinder after being lightly shaken to break up any formed agglomerates. The cylinder was allowed to drop down from a height of 2.5 cm at intervals of 2 seconds after its initial volume was recorded. Up until there was no longer any loudness change, the tapping was continued.

$$\textbf{LBD} = \frac{\text{Weight of the powder}}{\text{Volume of the packing}}$$

$$\textbf{TBD} = \frac{\text{Weight of the powder}}{\text{Tapped volume of the packing}}$$

Carr's index: The compressibility index of the granules was determined by Carr's compressibility index

$$\text{Carrs Index (\%)} = \frac{\text{TBD} - \text{LBD} \times 100}{\text{TBD}}$$

Hausner's ratio: Hausner's ratio is an indirect index of case of

powder flow.

Hausner's ratio can be determined by the following equation.

Hausner's ratio = $\boldsymbol{\rho t / \rho d}$

Where = ρt is tapped density and ρd is bulk density [14].

Table 4: Hausner's Ratio

Hausner's ratio	Types of flow
Less than 1.25	Good flow
Greater than1.25	Poor flow
Between 1.25-1.5	The addition of a glidant normally improves the flow

Evaluation of post compression parameters of floating tablets of Pantoprazole:

1. Appearance
2. Thickness
3. Hardness
4. Weight variation test
5. Friability test
6. Drug content uniformity
7. In vitro dissolution study
8. In vitro residence time
9. Drug-polymer interaction by FT-IR
10. Differential scanning calorimetry (DSC)
11. Stability studies

1. **Shape of the tablet:** Tablets from each formulation batch were examined under a microscope and revealed to have a round shape without any cracks.
2. **Thickness:** The crown thickness of each tablet was measured by a Vernier caliper.
3. **Hardness:** The Monsanto hardness tester is used to assess the tablet's hardness. Each tablet formulation's observed hardness ranged from 3.8 to 5.1 kg/cm2. This guarantees that all compositions have good handling properties.
4. **Weight variation test:** Using an electronic balance, five pills of each formulation were weighed separately. Based on that, the average weight was determined. By comparing the weight of each tablet with the average tablet weight, the percent deviation was computed.
5. **Friability test:** Three pills of each formulation were weighed precisely and put inside the friability chamber. 100 rotations of the apparatus were made. The tablets were reweighed after rotations to determine the weight reduction. The weight reduction shouldn't decrease by more than 1%.
6. **Drug content uniformity:** Each formulation's five pills are weighed, then they are ground up in a mortar and combined. The 100ml volumetric flask then received 10mg of the substance. The pantoprazole concentration in ug/ml was determined by using a standard calibration curve of the drug. The drug was allowed to dissolve in the solvent (0.1N HCL), the solution was filtered, 1ml of the filtrate was taken in 50ml of volumetric flask, diluted up to 50ml mark with 0.1NHCL, and then analyzed spectrophotometrically at 291nm [15].
7. **In vitro dissolution studies:** The paddle method of the USP dissolution test apparatus was used to calculate the in vitro release of pantoprazole floating tablet. At 370 0.50c and 100 rpm, the dissolving test was conducted using 900ml of 0.1nhcl. Five millilitres of the solution were taken out of the dissolving equipment and replaced with a new dissolution medium. A u-v visible spectrophotometer was used to test the samples' absorbance at 291 nm after they had been filtered. To calculate the release profile, the cumulative percentage of drug release was plotted against time [16].
8. **In vitro residence time:** The amount of time needed for the tablet to float and ascend to the surface is known as the buoyancy lag time. The entire floating time for floating tablets was measured using the floating lag time test, and the floating behavior was checked. Floating lag time was used to determine the in vitro residence period. The tablets were dropped into the dissolution medium, which is 0.1NHCL, and the time it took for them to float to the surface of the dissolution media was recorded [17,18].
9. **Drug-polymer interaction by FT-IR:** FT-IR was used to research drug polymer interaction. IR spectra of pantoprazole, HEC, and -cyclodextrin [19].

RESULTS AND DISCUSSION:

The main goal of this research was to create novel floating pantoprazole pills that would float in the stomach for a long duration, increasing their oral bioavailability by extending their gastric residence time.

Pre-formulation Studies:

Appearance: Physical appearance of the drug was found to be cream color powder drug was freely soluble in distilled water and insoluble in n-hexane**.**

The calibration curve of pantoprazole was obtained in distilled water at 291nm and Absorbance data for the calibration curve of pantoprazole in distilled water.

Table 5: Spectrophotometric data for estimation of pantoprazole

SL. No	Concentration (µg/ml)	Absorbance
1.	0	0
2.	1	0.201
3.	2	0.274
4.	3	0.384
5.	4	0.487
6.	5	0.577

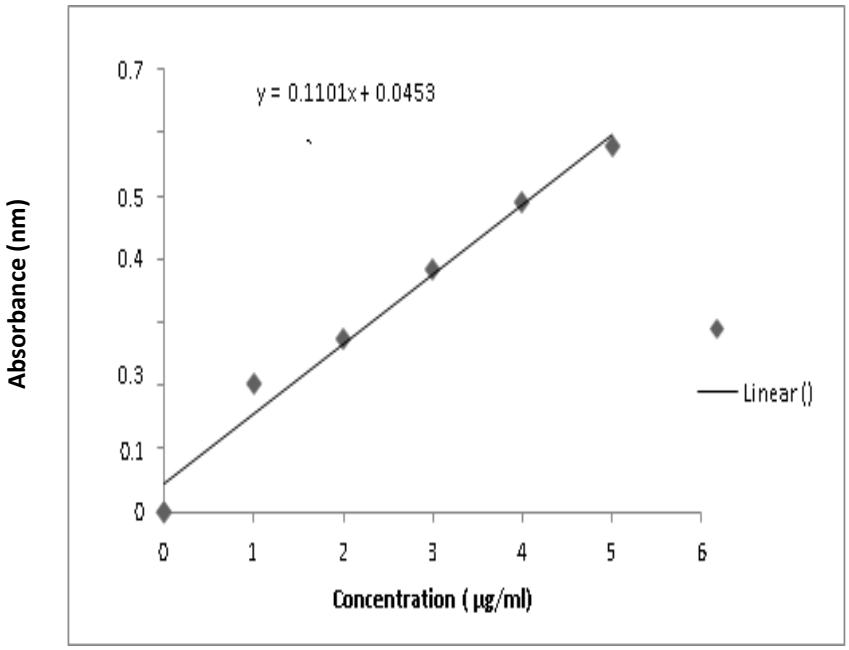

Figure 4: Standard calibration curve of pantoprazole in distilled water

Pre-Compression Evaluation of Pantoprazole Floating Tablets:

Table 6: Pre-compression parameters of pantoprazole floating tablet

Formulations	Angle of repose	Bulk density	Tapped density	Carr's Index	Hausner's ratio
F1	38.41	0.58	0.70	17.14	1.20
F2	32.61	0.60	0.73	17.80	1.21
F3	33.82	0.60	0.73	17.80	1.21
F4	36.50	0.55	0.65	15.38	1.18
F5	32.61	0.56	0.66	15.15	1.17
F6	33.02	0.57	0.67	14.92	1.17
F7	32.61	0.57	0.75	24	1.13
F8	33.42	0.57	0.68	16.17	1.19

Table 7: Evaluation data of pantoprazole floating tablet

Formulation	Thickness (mm) n=20	Weight variation (mg)	Hard ness (kg/cm)	Friability (%)	Drug content (%)	Floating time (hrs)	Floating lag time (sec)
F1	3.845±0.045	245±05	4.9±0.11	0.81±0.09	97	12	63
F2	4.045±0.045	246±05	4.80±0.19	0.41±0.08	90.35	14	72
F3	5.04±0.040	248±05	4.70±0.38	0.28±0.04	94.1	12	83
F4	4.73±0.023	235±05	5.9±0.36	0.85±0.03	99.6	14	92
F5	4.385±0.0385	246±05	5.8±0.31	0.41±0.01	98.05	18	88
F6	4.41±0.041	247±05	5.9±0.32	0.35±0.02	97.1	7	86
F7	4.345±0.345	244±05	5.3±0.33	0.21±0.03	89.9	8	72
F8	4.14±0.141	248±05	5.1±0.28	0.36±0.07	89.6	11	68

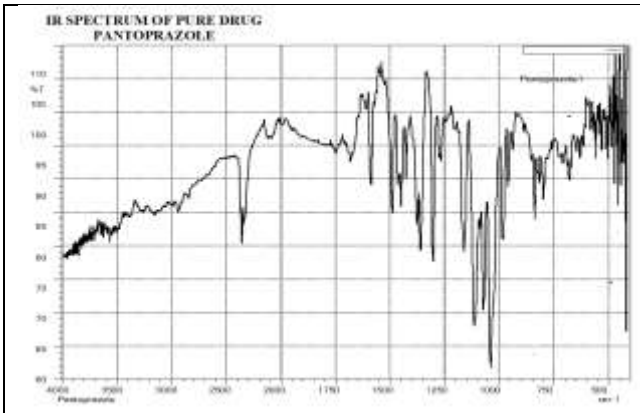

Figure 5: FTIR Spectra of pure drug Pantoprazole

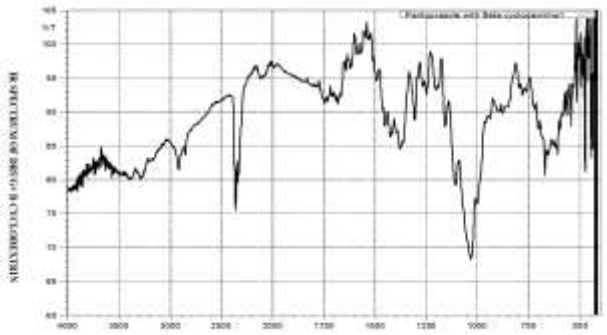

Figure 7: FTIR Spectra of pure drug Pantoprazole with Beta Cyclodextrin

Figure 6: FTIR Spectra of Pure Drug Pantoprazole with Hydroxy Ethylcellulose

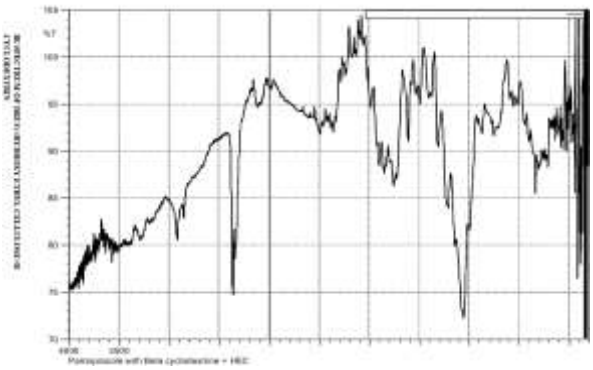

Figure 8: FTIR Spectra of Pure Drug Pantoprazole with Hydroxy Ethyl Cellulose + Beta Cyclodextrin

The FT-IR study was carried out to find out the possible interaction between selected drug pantoprazole and polymers hydroxypropyl methylcellulose, Cassava starch and polyvinyl pyrrolidone. FT-IR of pantoprazole showed the following peaks at 3483.56, 3358.18, 3176.87, 2960.83, 1591.33, 1373.36 and 1049.31nm due to N-H, O-H, CH_2, CH_3, C-O, C-F and S=O functional groups shown in figure 5,6,7 and 8. F1 to F8 formulations were optimized based on floating time and drug release profile. The floating study of prepared tablets was carried out in 0.1N HCL buffer and the results are shown in table-8 and 9.

The main aim of this work was to develop new floating tablets of Pantoprazole to increase its oral bioavailability by prolonging its gastric residence time and allowed to float in the stomach for a long period.

Table 8: In vitro drug release of formulation F1, F2, F3, F4

Sl. No	Time (hrs)	Square root of time (hrs)	Log Time (hrs)	F1		F2		F3		F4	
				% drug released	Log % drug released	% Drug released	Log % drug released	% drug released	Log % drug released	% drug released	Log % drug released
1	0.0	0.000	0.000	0	0	0	0	0	0	0	0
2	0.5	0.707	0.301	11.35	1.05	11.90	1.07	12.05	1.08	9.77	0.98
3	1.0	1.000	0.000	19.7	1.29	17.68	1.24	18.65	1.27	16.34	1.21
4	1.5	1.225	0.176	26.03	1.41	24.31	1.38	27.31	1.43	26.5	1.42
5	2.0	1.414	0.301	34.24	1.53	31.52	1.49	35.11	1.54	31.17	1.49
6	3.0	1.732	0.477	41.60	1.61	39.58	1.59	42.36	1.62	39.18	1.59
7	4.0	2.000	0.602	48.92	1.68	47.51	1.67	47.55	1.67	44.57	1.64
8	5.0	2.236	0.698	54.29	1.73	52.68	1.72	53.11	1.72	49.34	1.69
9	6.0	2.449	0.778	58.95	1.77	56.37	1.75	58.13	1.76	55.61	1.74
10	7.0	2.646	0.845	64.08	1.80	61.01	1.78	65.77	1.81	61.37	1.78
11	8.0	2.828	0.903	68.06	1.83	66.17	1.82	71.33	1.5	68.11	1.83
12	10	3.102	1.000	73.35	1.86	71.77	1.85	77.78	1.89	74.37	1.87
13	12	3.464	1.079	79.68	1.90	76.88	1.88	81.01	1.90	76.92	1.88

Table 9: In vitro drug release of formulation F5, F6, F7, F8

Sl. No	Time (hrs)	Square root of time (hrs)	Log Time (hrs)	F5		F6		F7		F8	
				% drug released	Log % drug released	% Drug released	Log % drug released	% drug released	Log % drug released	% drug released	Log % drug released
1	0.0	0.000	0.000	0	0	0	0	0	0	0	0
2	0.5	0.707	0.301	8.99	0.95	10.37	1.01	13.45	1.12	12.69	1.10
3	1.0	1.000	0.000	17.31	1.23	16.33	1.21	21.35	1.32	24.42	1.38
4	1.5	1.225	0.176	23.45	1.37	21.45	1.33	27.81	1.44	31.45	1.49
5	2.0	1.414	0.301	30.11	1.47	28.11	1.44	31.48	1.49	39.11	1.59
6	3.0	1.732	0.477	36.12	1.55	34.44	1.53	39.68	1.59	46.62	1.66
7	4.0	2.000	0.602	42.17	1.62	41.36	1.61	45.31	1.65	53.11	1.72
8	5.0	2.236	0.698	47.31	1.67	46.31	1.66	52.11	1.71	59.95	1.77
9	6.0	2.449	0.778	51.95	1.71	50.87	1.70	59.71	1.77	67.31	1.82
10	7.0	2.646	0.845	58.36	1.76	56.31	1.75	63.21	1.80	72.13	1.85
11	8.0	2.828	0.903	63.33	1.80	61.73	1.79	72.93	1.86	78.17	1.89
12	10	3.102	1.000	70.95	1.85	71.35	1.85	81.03	1.90	84.07	1.92
13	12	3.464	1.079	73.98	1.86	75.36	1.87	83.21	1.92	86.17	1.93

Table 10: Stability Studies

Sl. No	Time	F1	F2	F3	F4	F5	F6	F7	F8
1.	0	97	90.3	94.1	92.3	94.5	89.1	96.3	98.8
2.	1 month	96.5	87.0	92.6	90.1	91.	88.5	94.8	96.9

In-vitro floating time pattern of pantoprazole tablets:

In the present research floating tablets of pantoprazole were prepared by direct compression method using two polymers as Hydroxy ethyl cellulose and β-Cyclodextrin.

Pantoprazole floating tablets were prepared by using HEC and β-Cyclodextrin (F1, F2, F3, F4, F5, F6, F7, F8). The powder evaluation suggested that all the prepared powders exhibited good flow properties, as the angle of repose value were less than 300 (table-6) A good packing ability of the powder was indicated by carr's index (table-6). The weight, thickness and drug contents of all the tablets were found to be uniform. The hardness was in the range of 5.0 to 6.5kg/cm2 and friability was in the range of 0.23 to 0.95% and drug content was in the range of 0.86 to 99.6% (table-7)

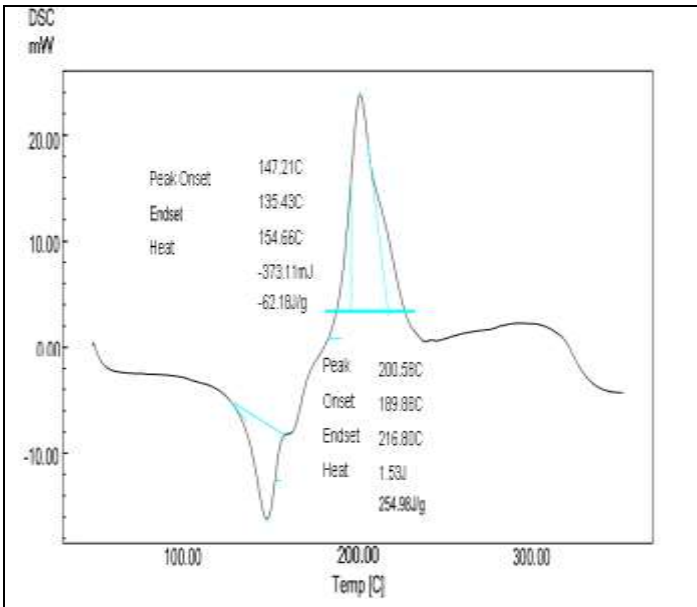

Fig-9: DSC of pure drug Pantoprazole

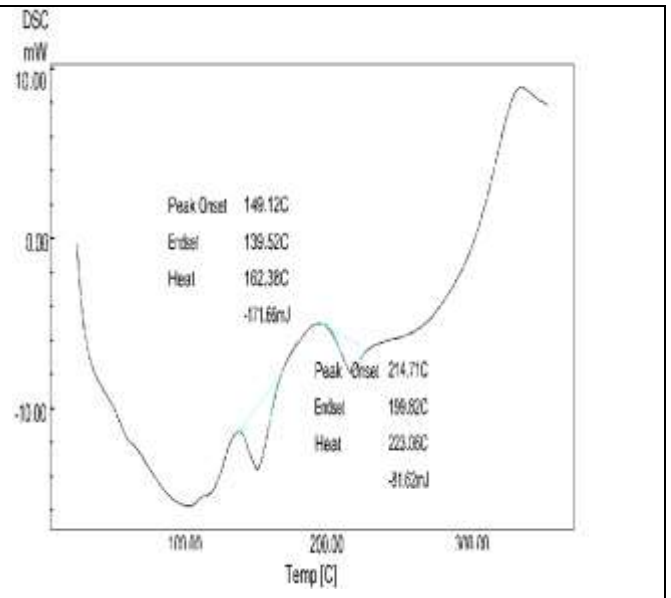

Fig-11: DSC of drug+ Beta-cyclodextrin

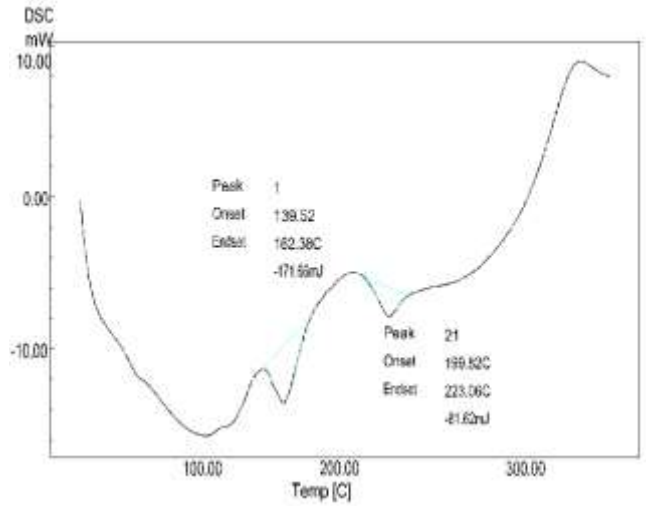

Fig-10: DSC of drug + Hydroxy ethyl cellulose

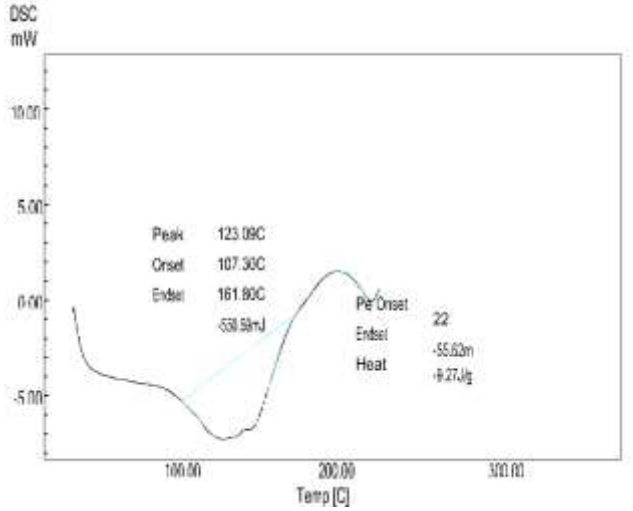

Fig-12: DSC Of Drug + Hydroxy ethyl cellulose + Beta-cyclodextrin

Table 11: Kinetic values of pantoprazole floating tablets

Formulation	Zero order equation		First order equation		Higuchi equation		Korsemeyer's equation	
	n	r	n	r	n	r	n	r
F1	15.83	0.903	64.15	0.285	-2.255	0.992	0.909	0.591
F2	14.75	0.910	65.30	0.264	-2.733	0.992	0.887	0.612
F3	15.49	0.915	64.43	0.307	-2.941	0.991	0.911	0.597
F4	13.64	0.921	66.38	0.278	-3.976	0.989	0.864	0.615
F5	12.75	0.929	67.43	0.242	-3.905	0.992	0.855	0.614
F6	11.64	0.948	68.39	0.248	-4.760	0.991	0.843	0.637
F7	14.70	0.939	65.33	0.334	-3.631	0.991	0.917	0.597
F8	18.67	0.893	61.35	0.370	-1.459	0.989	0.964	0.560

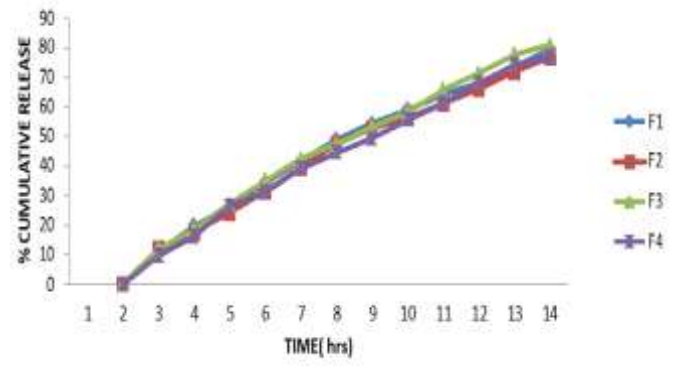

Fig-13: Cumulative % drug released Vs time plots (zero order) of formulations F1, F2, F3, F4

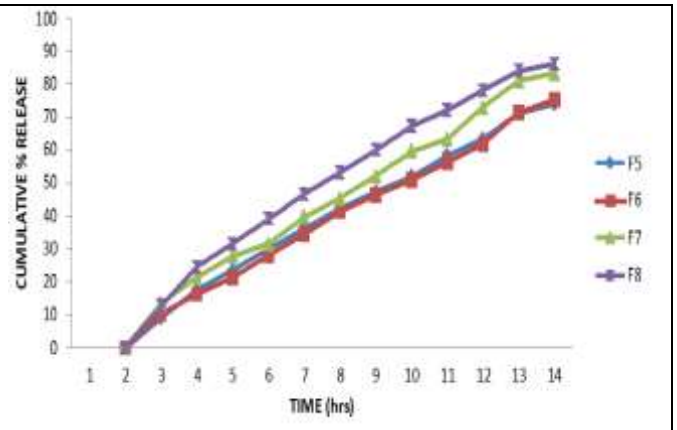

Fig-14: Cumulative % drug released Vs time plots (zero order) of formulations F5, F6, F7, F8

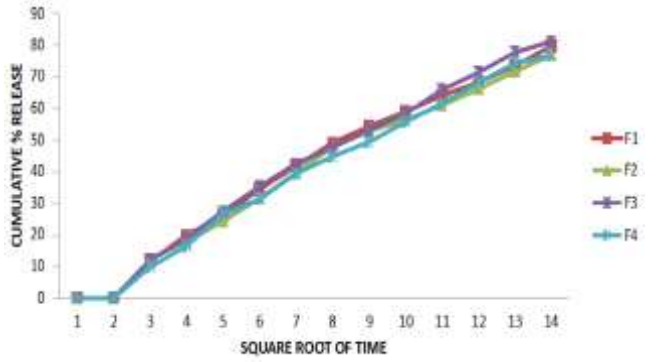

Fig-14: Cumulative % drug released Vs Square root of time (Higuchi plots) of formulations F1, F2, F3, F4

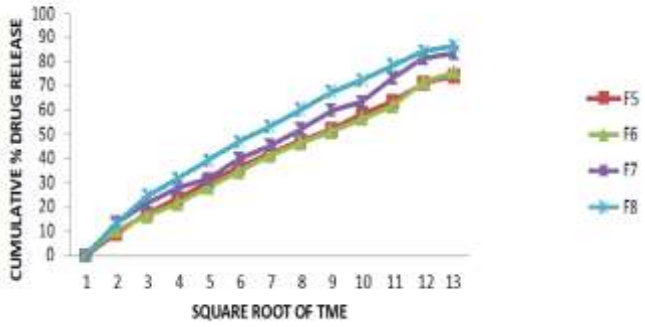

Fig-16: % Drug released Vs Square root of time (Higuchi plots) of formulations F5, F6, F7, F8

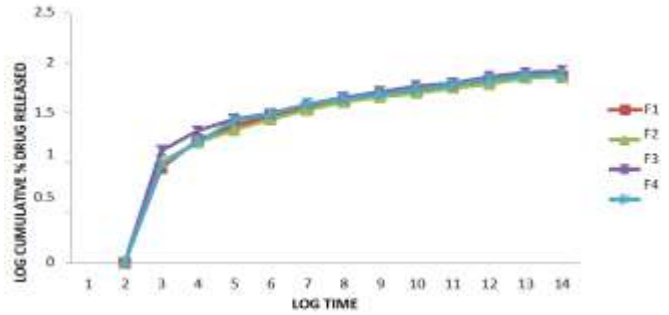

Fig-17: Log cumulative % drug released Vs log time (peppas plots) of formulations F1, F2, F3, F4

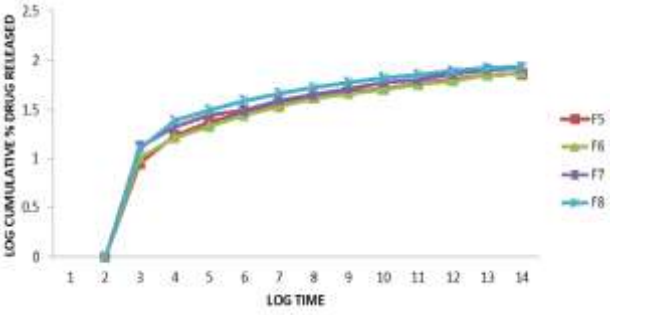

Fig-18: Log cumulative % drug released Vs log time (peppas plots) of formulations F5, F6, F7,F8

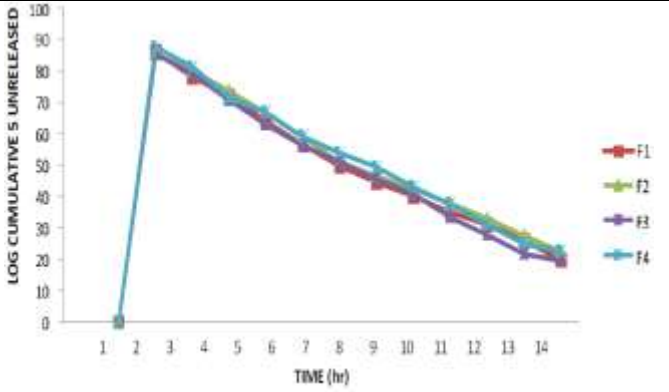

Fig-19: Log cumulative % unreleased drug Vs time plots (first order) of formulations F1, F2, F3, F4

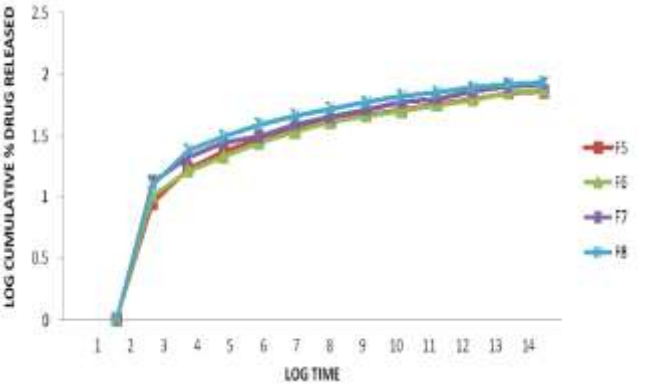

Fig-20: Log cumulative % unreleased drug Vs time plots (first order) of formulations F5, F6, F7, F8

CONCLUSION

In the current investigation, an effort was made to keep the dosage form in the stomach for longer. By creating floating drug delivery systems, this can be accomplished. These pills are made primarily by cutting down on lag time, which may also boost bioavailability. Beta-cyclodextrin was utilized as a polymer for the creation of floating tablets HEC. Talc, microcrystalline cellulose, ethyl cellulose, citric acid (a gas-generating agent), sodium bicarbonate, magnesium stearate, and other excipients are also utilized.

The absence of any interactions between the medication, polymer, and excipient was established by DSC and Fourier transform infrared spectroscopy. The manufactured floating tablets underwent tests to determine their stiffness, weight fluctuation, thickness, friability, homogeneity of the drug content, buoyancy lag time, total floating time, swelling index, and in vitro dissolution investigations. The 8 formulations F1, F2, F4, F5, F7, and F8 all exhibited strong floating characteristics, whereas F3 & F6 displayed moderate floating. Studies on stability were done for all the formulations, and F7 and F8 demonstrated good stability.

It was shown that the highest drug release from F7 & F8 was up to 86.17% within 12 hours. The following four models were tested: zero order, first order, Higuchi model, and Peppas model. It was discovered that medication release and floating ability were significantly influenced by the concentration of polymers and gas-generating agents. Thus, it may be concluded that a stable dose form for pantoprazole with controlled release can be created. The DSC investigation shows there is no drug-polymer interaction, and the stability study demonstrates the high stability of all tablet formulations.

CONFLICT OF INTERESTS

The authors declare that no financial or commercial ties that might be viewed as creating a conflict of interest existed throughout the research.

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