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RESEARCH ARTICLE

Development and assessment of pantoprazole sodium fast-dissolving tablets: A promising tablet dosage form

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Abstract: Pantoprazole is a proton pump inhibitor belongs to group of benzimidazole which has been widely used in the treatment of gastric, duodenal ulcer and also in gastro-esophageal reflux disease (GERD), Zollinger Ellison syndrome. It suppresses the acid production by inhibiting the H+ K+ ATPase. In this present study, an effort has been made to formulate and evaluate of fast dissolving or rapid release tablets, of Pantoprazole Sodium using three different Superdisintegrants like Sodium starch glycolate (SSG), Croscarmellose Sodium (CCS) and Crospovidone (CP) by direct compression method using different concentration (5%, 7.5%, & 10%). The prepared tablets were evaluated pre and post compression parameter. The pre-compression parameter like Angle of repose, bulk density, tapped density, compressibility index, Hausners ratio, solubility, and melting point. The post-compression parameter like thickness, hardness, friability, weight variation, wetting time, weight volume, drug content uniformity, water absortion ratio, in-vitro disintegration time, in-vitro dispersion time, in vitro dissolution study and stability study. The formulated tablets were evaluated for various parameter mention in above and compiled with the limits. Among all the formulations F9 containing Crospovidone with a concentration of 10% produce the least disintegrating time 24.53 sec. and dispersion time 31.71 sec. resulting in higher drug release rate 96.42% in 10 minutes. Hence it is considered an optimized formulation. The present study revealed that the Crospovidone showed better disintegrating properties then the most widely used superdisintegrants like sodium starch glycolate and croscarmellose sodium in the formulation of fast dissolving tablets.
Keywords: Pantoprazole; Proton pump inhibitor; Superdisintegrants; Fast dissolving; Direct Compression Method.

1. Introduction

Oral route is considered most natural, uncomplicated, convenient and safe due to its ease of administration, patient acceptance and cost-effective manufacturing process. Up to 50-60% of all dosage forms are administered by oral methods, which are well accepted. Solid dose forms are preferred because they are simple to administer, accurate in their amount, enable for self-medication, pain avoidance and, most significantly, increase patient compliance. Tablets and capsules are the most widely used solid dose forms; yet, for some individuals, these dosage forms are challenging to swallow. Drinking water is crucial to successfully swallowing oral dose forms. People frequently find it difficult to take conventional dosage forms like tablets when water is not available, when they have motion sickness (kinetosis), or when they suddenly start coughing due to the common cold, an allergic reaction, or bronchitis. For this reason, tablets that can rapidly dissolve or disintegrate in the oral cavity have attracted a great deal of attention. Or fast dissolving tablets are not only indicated for people who have swallowing difficulties, but also are ideal for active people. [1,2]

Fast dissolving pills are also known as mouth-dissolving tablets, melt-in-mouth tablets, Oro dispersible tablets, rapid melts, porous tablets, quick dissolving tablets, and so on. When placed on the tongue, fast dissolving pills dissolve quickly. Immediately breakdown, releasing the medication, which dissolves or disperses in the saliva. [3]

According to the Indian Pharmacopoeia Pharmaceutical tablets are solid, flat or biconvex dishes, unit dosage form, prepared by compressing a drug or a mixture of drugs, with or without diluents. Tablets are defined as compressed solid dosage forms containing medication with or without excipients. They varies in shape and differ greatly in size and weight, depending on the amount of medicinal substance used and the intended mode of administration. Tablets are the most preferred dosage forms since ages because of their low cost, ease of administration, high availability, and acceptability for a wide range of disease, better patient's compliance, better contents stability etc. [4]

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1.1 Mechanism of action (PPI)

Pantoprazole's mechanism of action first involves getting absorbed into the parietal cellsof the stomach, which are the cells that are responsible for secreting hydrochloric acid (HCl). At this point, pantoprazole is inactive. However, pantoprazole is then secreted intothe secretory canaliculus of the parietal cells, which is the space from which acid secretionoccurs. Here, acid secretion is mediated by the energy-dependent acid pumps, called hydrogen potassium adenosine triphosphatase (H^+/K^+ ATPase) pumps. These enzymatic pumps have cysteine amino acid residues. After being activated by gastric (stomach) acidto a reactive sulfenamide intermediate, rabeprazole permanently binds the cysteine residues, forming covalent disulfide bonds. This action fundamentally alters the configuration of the acid pump, thereby inhibiting its activity. Thus, acid can no longer besecreted into the gastric lumen (the empty space of the stomach), and the pH of the stomach increases (decrease in the concentration of hydrogen ions, H^+). Due to the permanent inhibition of the individual proton pump that each molecule of pantoprazole is bound to, acid secretion is effectively suppressed until new proton pumps are produced by parietal cell. [5-7]

2. Material and methods

Pantoprazole Sodium was obtained from Swapnaroop drugs and pharmaceutical (Maharashtra, India). All the other reagents and chemicals are of analytical grade.

2.1 Preformulation studies

2.1.1 Identification of Pantoprazole Sodium by UV spectrophotometry

Derivation of drug spectrum

10 mg of Pantoprazole Sodium was accurately weighed and dissolved in 100 ml of pH 6.8 phosphate buffer to obtain a stock solution of concentration 100 µg/ml. The solution was analysed in UV spectrophotometer using phosphate buffer as blank. The λmax (peak point denoting maximum wavelength) of this stock solution and the absorbance at that point was noted from the formed wavelength vs absorbance graph[8-10]. The standard λmax for Pantoprazole Sodium should be between 287-295 nm.

Preparation of calibration curve of Pantoprazole Sodium in pH 6.8 phosphate buffer

From standard stock solution 100 µg/ml 0.2, 0.4, 0.6, 0.8, 1 and 1.2 mL has withdrawn and diluted up to 10 mL with pH 6.8 phosphate buffer in 10 mL volumetric flask to get concentration of 2µg, 4µg, 6µg, 8µg, 10µg and 12µg respectively. The absorbance of each solution was measured by UV-visible spectrophotometer at 288 nm using the phosphate buffer (pH 6.8) as blank.

2.1.2 Melting point of Pantoprazole Sodium: Melting point of Pantoprazole Sodium was determined using electric melting point apparatus. [11,12]

2.1.3 Solubility: Solubility of Pantoprazole Sodium was determined in water, methanol, ethanol, chloroform, acetone, ether and n-hexane by gravimetric method of analysis. 5 mg of Pantoprazole Sodium was added to 10 ml of the 7 solvents each in separate conical flasks with constant stirring till saturated solutions were obtained. The solutions were filtered and 5 ml of the filtrates were pipetted out into separate pre-weighed watch glasses. The watch glasses containing 5 ml of filtrates were separately weighed. Then the filtrates were allowed to evaporate and air dry. The drying was continued till constant weights were obtained. [13,14]

2.2. Drug-Excipients Compatibility Studies

2.2.1 FTIR Spectroscopy

The FTIR spectrum of Pantoprazole Sodium was obtained in a KBr pellet (2% dispersion level) using a Perkin-Elmer 410 infrared spectrophotometer. The presence or absence of characteristic drug peaks are analyzed to determine the drug excipient incompatibility [15-16]

2.2.2 Differential Scanning Calorimetry

The thermal behavior of pantoprazole sodium was examined by DSC, using a TA Instruments model 910S differential scanning calorimeter calibrated with indium [17]. Pantoprazole Sodium sample ranging from 5 to 10 mg were run at a heating rate of $5^{O}C$/min over a temperature range of $50^{o}C$ to $179^{o}C$.

2.2.3 Thermogravimetric Analysis

Thermogravimetric (TG) Analysis of Pantoprazole Sodium was condected obtained using of TA Instruments model 951 thermogravimetric analyzer system, calibrated using indium [18]. The thermograms were carried out at a heating rate of $10^{O}C$/min, the sample size used ranged 5 to 10 mg , and the samples were heated over a temperature range of $50^{o}C$ to $400^{o}C$

2.2.4 X-Ray Powder Diffraction studies

The X-ray powder diffraction pattern of Pantoprazole Sodium was obtained using a Philips diffractometer system (Model PW 105-81 goniometer and PW 1729 generation). The pattern was obtained using nickel filtered copper radiation (λ = 1.5405 Å) [19]

2.3. Formulation of Fast Dissolving Tablets of Pantoprazole Sodium

Fast dissolving tablets of Pantoprazole Sodium is compressed by the direct compression method as per the composition of Table 1. Pantoprazole Sodium fast dissolving tablets were prepared by direct compression method [15-22] according to formulation given in the table blend can be prepared by passing the ingredients through 60-mesh sieve separately and collected [20].

Table 1 Formulation Table of Fast Dissolving Tablets of Pantoprazole Sodium

Ingredients used	Formulation batch code and quantity of ingredients per tablet (mg)								
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
Pantoprazole Sodium	20	20	20	20	20	20	20	20	20
Sodium Starch Glycolate	10	15	20	–	–	–	–	–	–
Croscarmellose Sodium	–	–	–	10	15	20	–	–	–
Crospovidone	–	–	–	–	–	–	10	15	20
Microcrystalline Cellulose	2	2.5	3.5	2	2.5	3.5	2	2.5	3.5
Magnesium Stearate	4	4	4	4	4	4	4	4	4
Magnesium Oxide	20	20	20	20	20	20	20	20	20
Mannitol	63.25	63.25	63.25	63.25	63.25	63.25	63.25	63.25	63.25
Lactose	74.75	69.25	63.25	74.75	69.25	63.25	74.75	69.25	63.25
Talc	6	6	6	6	6	6	6	6	6
Flavour Strawberry	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.
Total weight of each tablet = 200 mg									

2.4. Precompression studies

2.4.1 Bulk density

Bulk density is a characteristic of a powder rather than individual particles and is given by the mass, M, of the powder occupying a known volume, Vo. It is expressed in g/ml. An accurately weighed quantity of granules was transferred into a 50 ml measuring cylinder with the aid of the funnel. The unsettled apparent volume, to the nearest graduated unit occupied by the granules was measured [21]. Bulk density was determined using the formula

$$\varrho bulk = m/Vo$$

Where, ϱbulk = Bulk density; m = Mass of the blend; Vo = Untapped Volume

2.4.2 *Tapped density*

Tapped density is achieved by mechanically tapping a measuring cylinder containing a powder sample. After observing the initial volume, the cylinder is mechanically tapped, and volume readings are taken until little further volume change is observed [22]. The measuring cylinder containing a weighed quantity of granules (after measurement of bulk density) was subjected to 50 taps in tapped density tester (Electro Lab USP II).

The tapped density was calculated by using the formula,

$$\varrho t = m/Vt$$

Where, ϱt = Tapped density; m = Mass of the granules; Vt = Final tapped volume.

2.4.3 Carr's compressibility index

Compressibility index is a measure of the tendency for arch formation and the case with which the arches will fail. In below table shows the relationship between compressibility index and flowability [23]. It is calculated by using the formula

$$CI = \varrho t - \varrho bulk / \varrho t \times 100$$

Where, CI = Compressibility index; ϱbulk = Bulk density; ϱt = Tapped density

2.4.4 Hausner's ratio

Hausner found that the ratio ϱt / ϱbulk was related to interparticle friction and, as such could be used to predict powder flow properties. He showed that powders with low interparticle friction, such as coarse spheres, had ratios of approximately 1.2; whereas more cohesive, less free flowing powders such as flakes have values greater than 1.6. In below table shows the flow characters and corresponding Hausner's ratio. It is calculated using the formula:

$$\text{Hausner's Ratio} = \varrho t / \varrho bulk$$

Where, ϱbulk = Bulk density; ϱt = Tapped density

2.4.5 Angle of repose

Angle of Repose (θ) is the maximum angle between the surface of a pile of powder and horizontal plane. It is usually determined by fixed funnel method and is the measure the flowability of powder/granules. The angle is a measure of the cohesiveness of the powder, as it represents the point at which the interparticle attraction exceeds the gravitational pull on a particle. Shows the flow properties and corresponding angle of repose [24].

Weighed quantity of granules was passed through a funnel kept at a height of 2 cm for the base. The powder is passed till it forms heap and touches the tip of the funnel. The height of the heap formed and radius of the base of the heap was measured. Angle of repose was calculated by using the formula

$$\theta = \tan^{-1}(h/r)$$

Where, θ = Angle of repose; h = height of the heap of pile; r = radius of base of pile.

2.5. Post-Compression Parameter

Post-compression studies consisted of various tests performed on fabricated fast dissolving tablets of Pantoprazole Sodium: - Organoleptic characteristics, shape, thickness, hardness, friability, wetting time and wetting volume, water adsorption ratio, weight variation test, content of active ingredient, uniformity of dispersion, In- vitro dispersion time, In- vitro disintegration time, *in-vitro* dissolution studies, and stability studies[25-28].

2.6. *In-vitro* dissolution or drug release studies

In-vitro dissolution studies were successfully carried out for all formulations of Fast dissolving tablets. Paddle type dissolution apparatus was used to carry out in-vitro drug release studies. 900 mL of pH 6.8 phosphate buffer, maintained at 37±0.5°C, was filled in each basket and then dropped one tablet in each. 2 mL of samples were withdrawn separately from each batch at different intervals like (1min, 2min., 3min., 5min., 7min., 9min. and 10min.) then sample 2 ml of Fresh dissolution medium was replaced after each time of withdrawal of sample. The samples filtered, diluted, and then were analysed spectrophotometrically at 288 nm for the drug release against the respective buffer blank [29].

2.7 Stability Studies

In the present study, stability studies were carried out on all the formulations under the conditions for one-month period as prescribed by ICH guidelines for accelerated studies [30]. The samples were packed in an aluminium foil and placed in an air tight plastic container. The tablets were stored in three different temperature and humidity conditions. The tablets were withdrawn after a period of 15, 30, 45, and 30 days and analyzed for physical characterization, dissolution, and drug content studies.

3. Results

The results obtained from the above studies are discussed in the following sections.

3.1. Identification of Pantoprazole Sodium by UV spectrophotometry

Derivation of drug spectrum

The prepared stock solution of Pantoprazole Sodium (100µg/mL) in pH 6.8 phosphate buffer represented maximum wavelength peak (λmax) at 288 nm as shown in Figure 1.

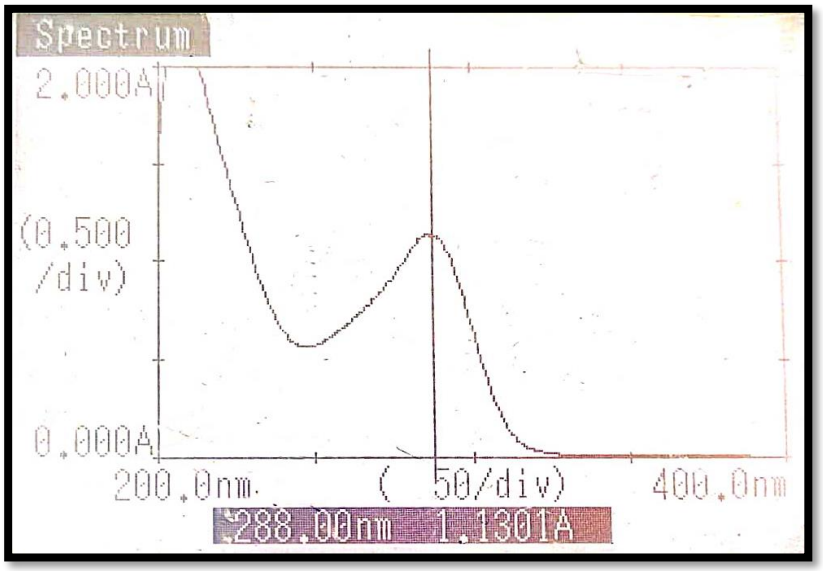

Figure 1 Spectrum of Pantoprazole Sodium in 6.8 Phosphate buffer

Preparation of calibration curve of Pantoprazole Sodium in 6.8 phosphate buffer

A calibration curve of Pantoprazole Sodium in phosphate buffer was derived using UV spectrophotometer at 288 nm and 6 dilutions of stock solution (2-12 µg/mL). The curve derived is depicted in Figure 2.

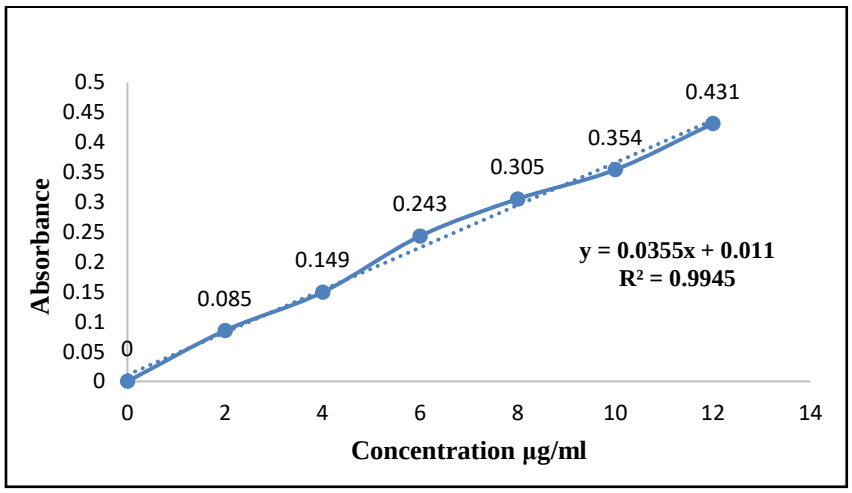

Figure 2 Standard graph of Pantoprazole Sodium in phosphate buffer (pH 6.8)

3.2. FTIR Studies

Pre-formulation studies has been performed to study the nature of API and compatibility of API with excipients by physical observation and FT-IR studies [31]. The results showed that there was no interaction between API and all the excipients selected. The FT-IR spectra of the crude drug samples and the drug-excipient mixtures are as shown below in Tables 2, 3 and Figures 3-7

Table 2 Assignments for the Infrared Absorption Bands of Pantoprazole Sodium

Energy (cm^{-1})	**Assignments**
3010	C-H aromatic stretching
2941 and 2835	C-H aliphatic stretching
1588	C=N stretching
1492, 1466, 1452 and 1428	C=C stretching in aromatic ring
1362 and 1384	C-H bending of CH_2, CH_3
1304	CF2 stretching
1070	S=O stretching
805, 1027 and 1040	C-O of -OCH_3

Table 3 Drug- Excipients Compatibility

S. No.	**Composition details**	**Initial**	**Storage Condition/ Duration**	**Comments**
			25°C/4°C/40°C/ 60 days	
1	API (Pantoprazole Sodium)	White to off white crystalline powder	No Characteristic Change	Compatible
2	API + Crospovidone	White to off white crystalline powder	No Characteristic Change	Compatible
3	API + Microcrystalline Cellulose	White to off white crystalline powder	No Characteristic Change	Compatible
4	API + Magnesium Stearate	White to off white crystalline powder	No Characteristic Change	Compatible
5	API + Mannitol	White to off white crystalline powder	No Characteristic Change	Compatible

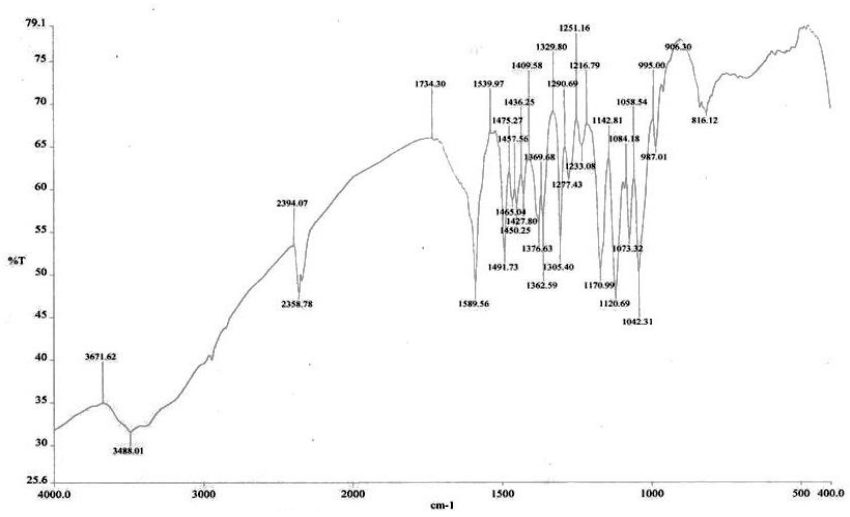

Figure 3 FT-IR spectra of Pantoprazole Sodium pure drug

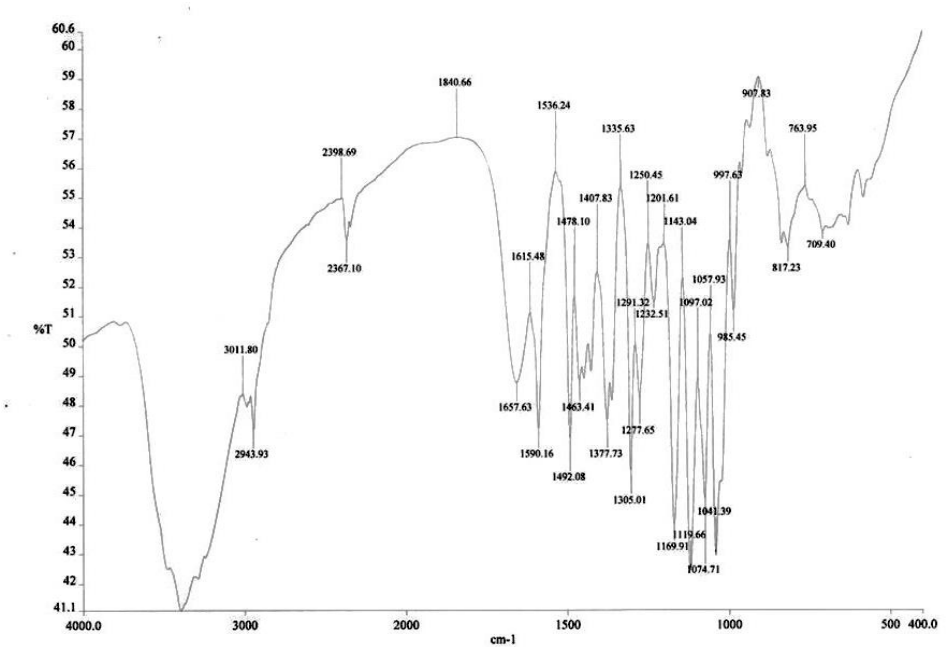

Figure 4 FT-IR Spectra of Pantoprazole Sodium +Crospovidone

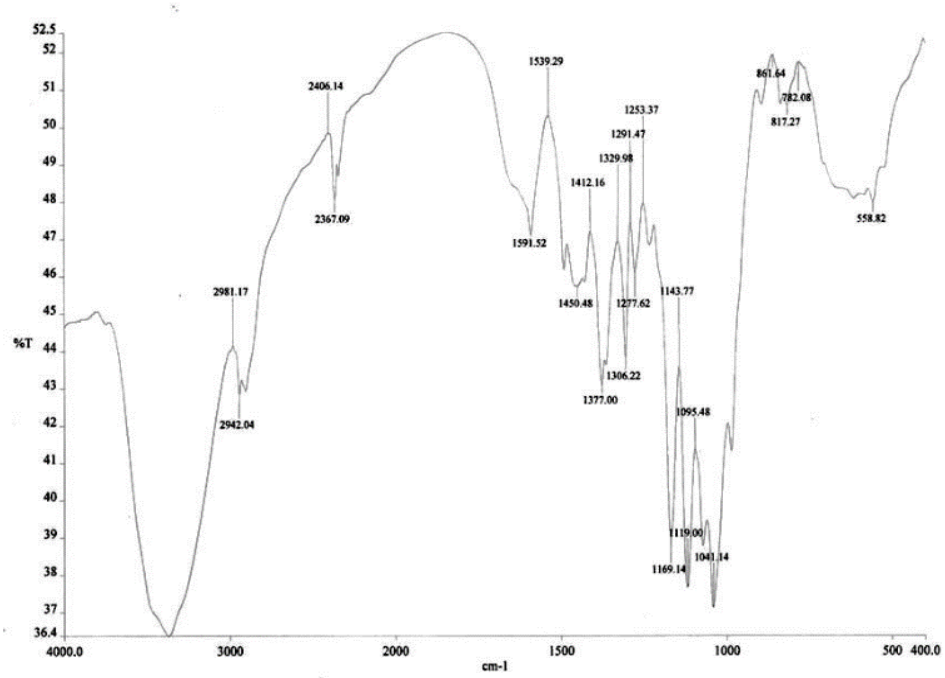

Figure 5 FT-IR Spectra of Pantoprazole Sodium + Microcrystalline Cellulose

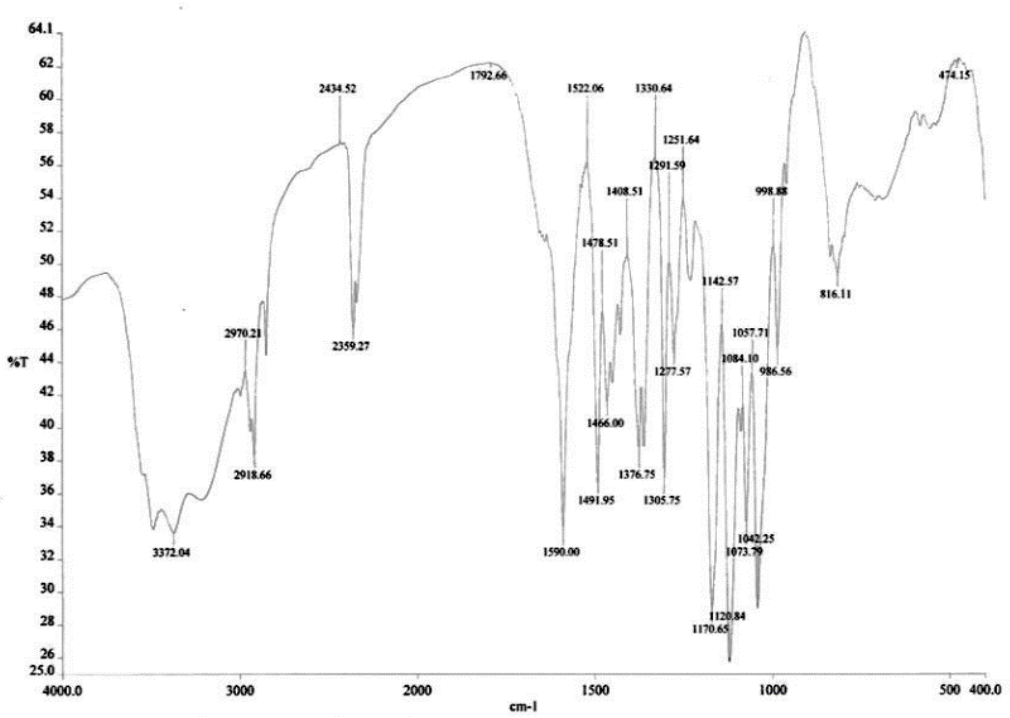

Figure 6 FT-IR Spectra of Pantoprazole Sodium + Magnesium Stearate

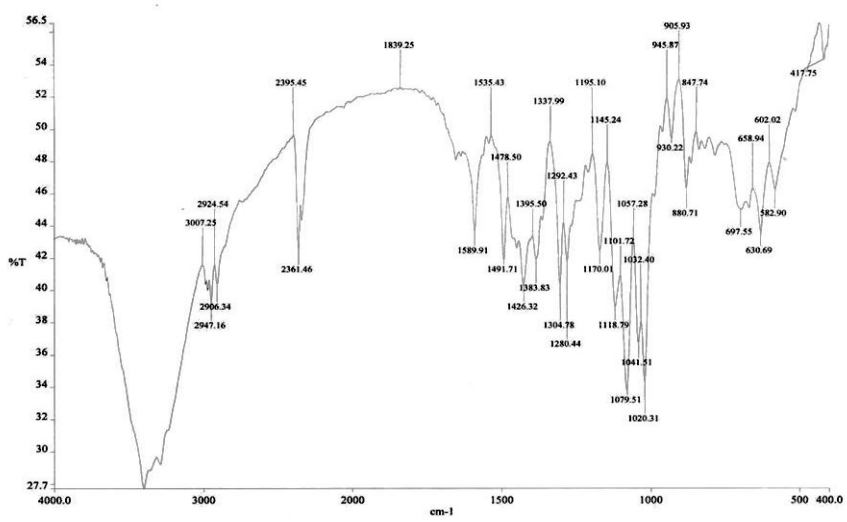

Figure 7 FT-IR Spectra of Pantoprazole Sodium + Mannitol

3.3. X Ray diffraction studies

The results of X ray diffraction are shown in Table 4 and Figure 8 below

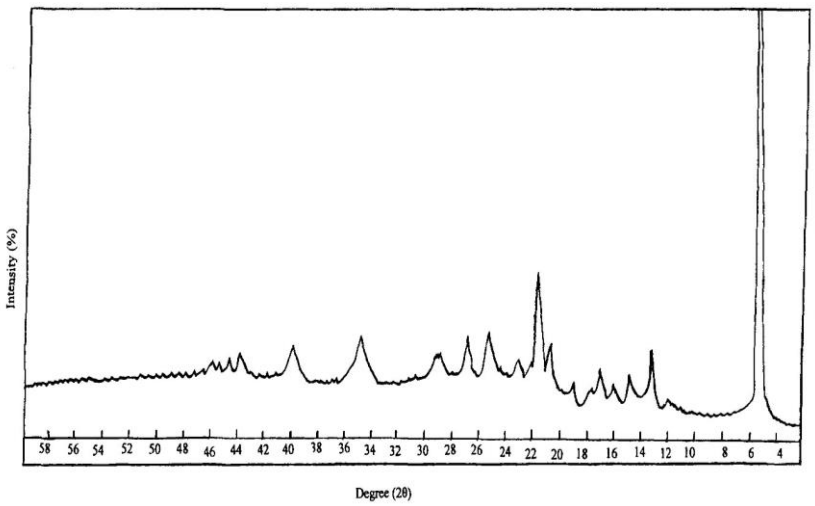

Figure 8 X-Ray Powder Diffraction Pattern of Pantoprazole Sodium

Table 4 Scattering Angles, Interplanar d-Spacings, and Relative Intensities in the X-Ray Powder Diffraction of Pantoprazole Sodium

Scattering Angles (deg. 2-θ)	d-Spacings (Å)	Relative Intensities (I/I_0)
5.3	16.673	100.0
13.3	6.657	15.0
15.0	5.606	7.9
17.2	5.155	10.4
19.2	4.623	5.0
20.8	4.270	14.2
21.9	4.058	35.0
25.4	3.507	17.5
27.0	3.302	14.6
29.0	3.079	10.8
34.7	2.285	12.9
39.8	2.285	8.8
43.6	20.76	7.5

3.4. DSC studies

The DSC thermogram of Pantoprazole Sodium shown in figure no. 11 consisted of a single endothermic peak, assigned to the melting transition [32], and, having a peak maximum at 148^{O}C.

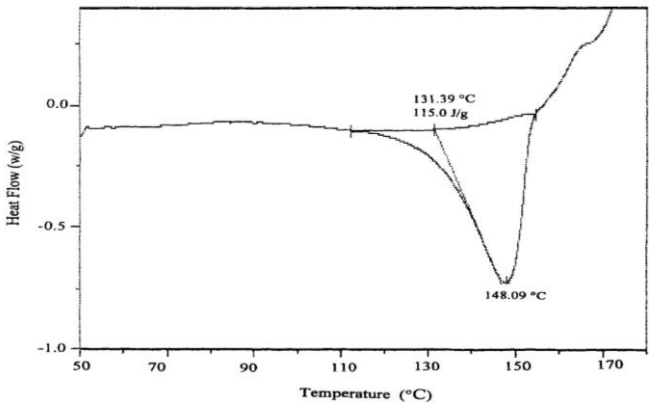

Figure 9 Differential Scanning Calorimetry thermogram of Pantoprazole Sodium

The TG thermogram shown in figure- 12 for pantoprazole Sodium showns a mass loss due to evolution of water equal to 3.1% at temperature above the onset temperature of Pantoprazole Sodium (131°C). At higher temperatures, the compound starts to decompose [33], reaching about a 40% mass loss at temperature above 300°C.

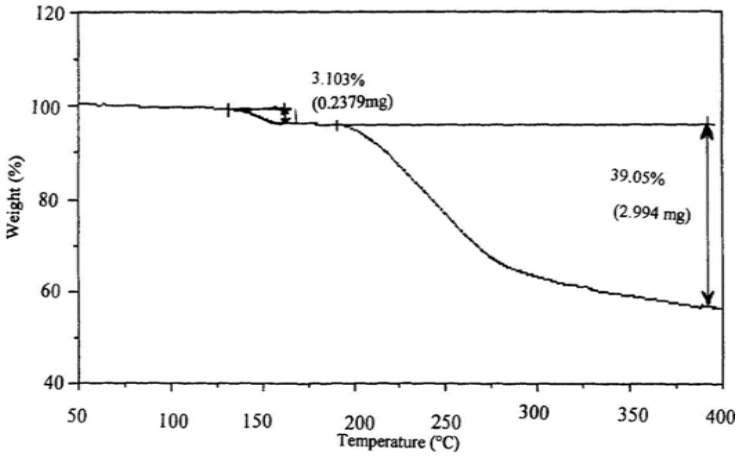

Figure 10 Thermogravimetric Analysis of Pantoprazole Sodium

3.5. Melting point of Pantoprazole Sodium

The average reading of three trails was recorded as the final reading and it was found to be 153°C.

3.6. Solubility of Pantoprazole Sodium

The solubility studies of Pantoprazole Sodium in different solvent are show in table 5

Table 5 Solubility of Pantoprazole Sodium in Different Solvents

Solvent	Solubility value(mg/ml)	Solubility description
Methanol	≥1000	Very Soluble
Distilled Water	100-1000	Freely Soluble
Ethanol	100-1000	Freely Soluble
Acetone	33-100	Soluble
Chloroform	10-33	Sparingly soluble
Dichloromethane	1-10	Slightly soluble
Diethyl ether	≤ 0.1	Practically insoluble
n-hexane	≤ 0.1	Practically insoluble

3.7. Preformulation properties

The bulk density and tapped density of powder blend has been evaluated. The angle of repose for the entire formulation blend was found to be in the range 30.14 to 33.42. Hausner's ratio was found to be in the range 1.10 to 1.15 and that indicated that all formulation has good flow properties [34].

Table 6 Flow Properties of all Batches of Powder Blend

Formulation Code	Angle of repose (Θ)	Bulk density (g/ml)	Tapped density (g/ml)	Carr's index (%)	Hausner's ratio
F1	32.21±0.24	0.721±0.02	0.824±0.2	12.34±0.34	1.13±0.32
F2	33.42±0.27	0.756±0.01	0.813±0.3	11.76±0.37	1.15±0.26
F3	32.11±0.34	0.814±0.02	0.783±0.2	11.52±0.40	1.13±0.31
F4	31.33±0.21	0.724±0.01	0.902±0.2	12.41±0.33	1.12±0.29
F5	31.71±0.28	0.815±0.03	0.874±0.1	11.64±0.38	1.13±0.41
F6	33.34±0.23	0.794±0.02	0.921±0.3	10.87±0.37	1.15±0.38
F7	30.82±0.25	0.711±0.02	0.851±0.1	11.15±0.40	1.11±0.40
F8	32.54±0.31	0.687±0.01	0.736±0.3	10.64±0.37	1.14±0.34
F9	30.14±0.22	0.673±0.02	0.714±0.3	10.21±0.39	1.10±36

3.8. Organoleptic characteristics

The tablets were formulated using Direct Compression technique which is considered as the most convenient and simple tablet manufacturing technique till date [35]. Tablets form every batch was minutely observed for their color, appearance, shape, odor, and taste. The results for every tablet obtained from each batch were all the same except F4, F5 & F6 and are described in Table 7

Table 7 Organoleptic characteristics of Fast Dissolving Tablets

Characteristic	Description
Appearance/ Texture	Smooth and clean evenly colored tablets
Color	White (F4-F6 Pale Yellow)
Shape	Circular
Odor	Faint smell of Strawberry Flavorant
Taste	Appreciably sweet

3.9. Thickness, Hardness, Friability, and Weight variation

The batches showed low hardness 3.07 and higher 3.74. F7 show higher friability 0.60 and F9 show low friability F6 0.41. All parameter shows weight variation, thickness, disintegration time (sec) within standard limit. The average thickness of tablets, measured using vernier calipers, and measured the average hardness, weight variation, and friability values of tablets from each batch are given in Table 8

Table 8 Thickness, Hardness, Friability, and Weight variation

Formulation code	Thickness (mm)	Hardness (Kg/cm2)	Friability (%)	Weight variation (mg) ± S.D.
F1	3.22±0.24	3.34±0.07	0.51±0.29	206±0.24
F2	3.25±0.29	3.46±0.05	0.55±0.24	204±0.18
F3	3.30±0.31	3.40±0.10	0.52±0.22	199±0.12
F4	3.19±0.27	3.57±0.21	0.49±0.33	208±0.20
F5	3.23±0.36	3.62±0.13	0.44±0.21	201±0.17
F6	3.32±0.41	3.74±0.08	0.53±0.27	206±0.14
F7	3.29±0.37	2.98±0.11	0.60±0.36	199±0.12
F8	3.27±0.29	3.35±0.21	0.49±0.31	203±0.16
F9	3.17±0.30	3.07±0.29	0.41±0.34	199±0.22

3.10. Water absorption ratio, Wetting time, and Wetting volume

The average readings of these tests are recorded in Table 9

Table 9 Water absorption ratio, Wetting time, and Wetting volume

Formulation code	Water absorption ratio (%)	Wetting time (sec)	Wetting volume (mL)	Content of active ingredient (%)
F1	92.24±0.22	17.02±0.26	4.47±0.31	96.24±0.36
F2	86.12±0.27	18.63±0.31	4.59±0.35	98.31±0.41
F3	89.07±0.31	18.12±0.35	4.51±0.27	95.87±0.27
F4	77.26±0.29	20.34±0.39	4.62±0.34	99.11±0.39
F5	81.54±0.32	19.84±0.41	4.45±0.22	102.34±0.25
F6	87.24±0.24	17.34±0.32	4.28±0.28	97.72±0.21
F7	91.43±0.32	16.21±0.29	4.34±0.31	100.21±0.28
F8	94.82±0.30	14.45±0.33	4.21±0.37	98.64±0.33
F9	97.69±0.34	13.89±0.42	4.07±0.41	99.59±0.49

3.11. Uniformity of dispersion

Tablets from every batch passed the test for uniformity of dispersion as there was no residue left on the sieve screen.

3.12. Content of active ingredient

The content uniformity test for every batch of fast dissolving tablets of Pantoprazole Sodium was carried out accurately. The results were found to be within the I.P. limits [90%-110%]. The drug was distributed uniformly throughout the tablets. The drug content values are represented batch-wise in Table-9

3.13. *In-vitro* disintegration time and *In-vitro* dispersion time

The result of these tests was within the desired limits and the average reading is given in Figure 11

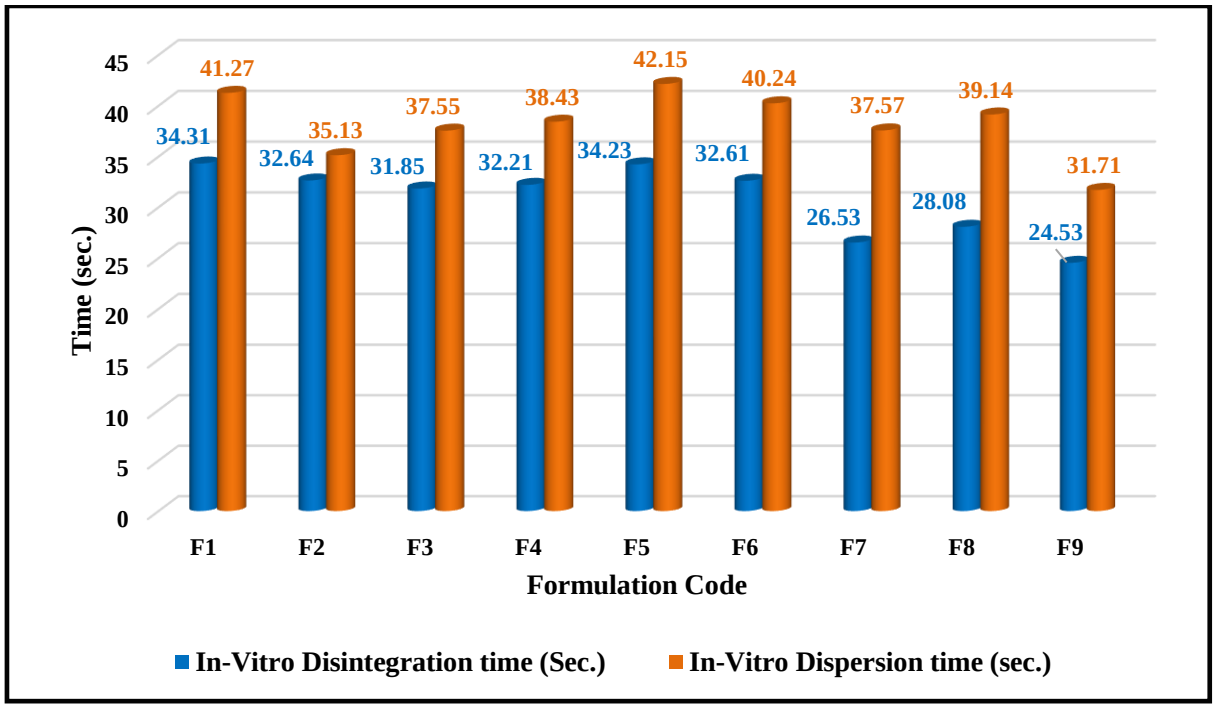

Figure 11 Graph Showing a Comparison between In-Vitro Disintegration and In- Vitro Dispersion Time of the Nine Formulations

3.14. *In-Vitro* Dissolution

The in-vitro dissolution studies indicated that with increasing the quantity of superdisintegrants, rate of drug release and final % drug release increased. The maximum amount of drug release was found to be in formulation F9 containing 20 mg (10%) Crospovidone and the minimum amount was found to be in the formulation F4 containing 10 mg (5%) Croscarmellose Sodium. And also, formulation F2 containing Sodium starch glycolate 15 mg (7.5%). The order of amount of drug release was in the order – F9 > F8 > F7 > F4 > F5 > F2 > F6 > F1 > F3. Thus, from the above results, Crospovidone was found to be a better superdisintegrants than Croscarmellose Sodium and sodium starch glycolate. Results are shown in Table 10

Table 10 *In vitro* drug release studies

Time (min)	Cumulative % drug release of all formulations								
	F1	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**
0	0	0	0	0	0	0	0	0	0
1	23.41 ±0.28	27.92 ±0.24	31.87 ±0.31	39.05 ±0.33	44.27 ±0.36	41.67 ±0.29	48.68 ±0.27	46.38 ±0.33	48.21 ±0.32
2	39.67 ±0.32	34.83 ±0.31	40.22 ±0.28	46.82 ±0.27	50.42 ±0.41	52.35 ±0.31	62.52 ±0.34	58.74 ±0.41	59.33 ±0.27
3	52.21 ±0.39	46.74 ±0.39	56.74 ±0.24	58.54 ±0.41	59.11 ±0.28	64.54 ±0.37	71.04 ±0.39	67.44 ±0.29	73.54 ±0.31
5	68.32 ±0.41	62.42 ±0.44	68.06 ±0.34	73.17 ±0.29	70.04 ±0.32	72.13 ±0.41	83.42 ±0.41	81.58 ±0.32	86.02 ±0.40
7	73.41 ±0.27	78.12 ±0.35	77.34 ±0.39	84.22 ±0.44	81.23 ±0.39	81.08 ±0.37	88.34 ±0.28	88.21 ±0.37	89.67 ±0.44
9	86.13 ±0.44	84.06 ±0.40	83.08 ±0.41	89.36 ±0.31	86.44 ±0.42	87.21 ±0.46	92.07 ±0.34	93.06 ±0.44	93.23 ±0.35
10	87.52 ±0.49	90.23 ±0.37	86.38 ±0.48	92.24 ±0.39	91.02 ±0.46	89.84 ±0.40	95.11 ±0.43	95.69 ±0.27	96.42 ±0.39

3.15. Stability studies

Stability studies were performed according to the previously mentioned temperature and humidity conditions in Table- 10 The samples were packed in an aluminium foil and placed in an air tight plastic container. The tablets were stored in the stated temperature and humidity conditions, withdrawn after a period of 15, 30, 45, and 60 days and analyzed for physical characterization, dissolution, and drug content studies [36]. The results obtained after the stability testing are categorized in the following sections.

3.15.1 Organoleptic Evaluation

All tablets from optimized batch were organoleptically evaluated for stability studies at the three temperature conditions. The tablets were found to be perfectly circular in shape having a smooth and spotless white appearance with no rough or uneven edges. Thus, all the formulations were found to be organoleptically stable after stability testing.

3.15.2 Physicochemical Evaluation

Tablets were evaluated for their stability for physical characteristics like thickness, hardness, weight variation, and friability. Chemical evaluation involved parameters like content of active ingredient, in-vitro disintegration time, in-vitro dispersion time, and in-vitro dissolution testing of all the formulations kept under the mentioned stability conditions.

There were minor significant changes found in the physical and chemical properties of the tablets after stability testing. Thus, all the formulations were found to be quite stable and results were well within the acceptable limits. The results of physicochemical evaluation, at all temperature conditions, after 60 days are presented in the following sections from table no. 11

Table 11 Stability data of various parameters of optimized batch After 60 days

Physical Parameter	Formulation code		
	F9 (25±2^{O}C)	F9 (4^{O}C)	F9 (40±^{O}C)
Thickness (mm)	3.14±0.29	3.14±0.29	3.14±0.29
Hardness (Kg/Cm^{2})	3.04±0.27	3.04±0.27	3.04±0.27
Weight variation (mg)	198±0.22	198±0.22	198±0.22
Friability (%)	0.43±0.34	0.43±0.34	0.43±0.34
Content of active ingredient (%)	99.56±0.48	99.56±0.48	99.56±0.48
In-vitro disintegration time (sec)	24.16±0.23	24.16±0.23	24.16±0.23
In-vitro dispersion time (sec)	31.09±0.39	31.09±0.39	31.09±0.39

5. Conclusion

Fast dissolving tablets are innovative dosage forms developed and specially designed to overcome some of the problems that seen in conventional solid dosage form i.e., difficulty in swallowing of the tablet in geriatric and pediatric patients. Fast dissolving tablets are designed to dissolve or disintegrate quickly in the saliva generally within less than 60 seconds (Range of 5-60 seconds). Fast dissolving tablets have better patient compliance and acceptance may improve biopharmaceutical properties, bioavailability improved efficacy, convenience, and better safety compared with conventional oral dosage forms. It was concluded that Fast Dissolving Tablets of Pantoprazole sodium can be successfully prepared by direct compression technique using selected superdisintegrants for the better patient compliance and effective therapy.

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