https://doi.org/10.47552/ijam.v16iS2.6170 ISSN No: 0976-5921

Int J. of Ayurvedic Med, "Natural to Synthetic: The Convergence of Traditional Medicine to Modern Medicine" Supplement 2025

Gastro Retentive Drug Delivery System of Perindopril using Natural Polymer - Development and Optimization

Research Article

Divya Chavhan[1], Ram D Bawankar[1*], Mundhada DR[1]

1. Department of Pharmaceutics, Agnihotri College of Pharmacy, Bapuji Wadi, Ramnagar, Wardha – 442001. Maharashtra. India.

Abstract

Gastro retentive floating matrix tablet provides drug delivery at the controlled rate, improve bioavailability and prolong the retention of dosage forms in gastrointestinal tract. Okra gum, a mucilage-rich extract derived from the okra plant (*Abelmoschus esculentus*), holds significant value in both Ayurvedic medicine and modern pharmaceutical sciences. Knowing the importance of Okra gum, aim of present investigation is to develop gastro retentive floating matrix tablet of Perindopril using Avicel pH 102 as a directly compressible material; Citric acid for production of acidic microenvironment and sodium-bi-Carbonate as gas generating agent. Pre-compression parameters of powdered blend as well as prepared batches were studied and found within the range. FTIR of physical mixture (Perindopril, Okra gum and HPMCK4M) suggesting no incompatibility. Formulation batch F8 floated, and remained buoyant without disintegration with swelling index value 42.32%, released Perindopril 92.92% about 12 hours might be due to combine use of HPMCK4M & Okra gum; showed higher correlation coefficient (r^2-value) followed Korsmeyer Peppas release kinetics. DSC thermogram of F8 confirms uniform dispersion of drug in an amorphous form as endothermic peak was below 126.0^0. No significant changes in physiochemical properties, drug release profile as well as drug content of optimized F8 batch when subjected to stability at 40± 2^0 temperature with relative humidity 75±5% for three months, indicating there was no degradation and change in the matrix system.

Keywords: Gastroretentive Drug Delivery System, Perindopril, Hypertension, FTIR, DSC.

Introduction

Oral sustained drug delivery system is complicated by limited gastric residence time. Rapid gastrointestinal transit can prevent complete drug release in the absorption zone and reduce the efficacy of administered dose, since the majority of drugs are absorbed in stomach or the upper part of small intestine Floating drug delivery offers several applications for drugs having poor bioavailability because of the narrow absorption window in the upper part of the gastrointestinal tract. It retains the dosage form at the site of absorption and thus enhances the bioavailability (1).

Okra gum, a mucilage-rich extract derived from the okra plant (Abelmoschus esculentus), holds significant value in both Ayurvedic medicine and modern pharmaceutical sciences. In Ayurveda, its snigdha (unctuous) and sheetala (cooling) qualities make it beneficial for soothing the gastrointestinal tract, helping to pacify aggravated Pitta and Vata doshas, and managing conditions such as gastritis and acid reflux. As a functional food, it supports digestive health and overall wellness due to its demulcent and nourishing nature.From a pharmaceutical perspective, okra gum is gaining attention as a natural excipient, particularly for its role as a binder in tablet formulations. Its biocompatibility, non-toxicity, and gel-forming ability make it a promising candidate in drug delivery systems, offering a plant-based alternative to synthetic binders while aligning with the principles of green pharmacy and Ayurvedic herbal formulation.

In present investigation attempt has been made to develop and evaluate gastro retentive floating tablets of Perindopril, (as have short elimination time 1.2 hr and can sustain the release), by direct compression method (as Avicel pH 102 as a directly compressible material) using Okra gum and HPMCK4M polymer ratio in single or in combination to achieve controlled drug release with reduced frequency of drug administration, reduced side effects, patient compliance as well as to prolong the drug release in GIT and consequently into the plasma. Perindopril, used for the treatment of hypertensionand heart failure and is suitable candidate for controlled release administration.

Materials And Methods

Perindopril was gift sample procured from Hetero Drugs Ltd., Hyderabad. Okra gum procured from Gold king Biogene Private Ltd., Ahmedabad. HPMCK4M procured from Mahalaxmi Chemicals, Hyderabad, whereas Sodium bicarbonate, Citric Acid, Micro-crystalline Cellulose, Magnesium stearate and Talc are procured from Samar Chemicals, Nagpur.

*** Corresponding Author:**

Ram D Bawankar

Department of Pharmaceutics,
Agnihotri College of Pharmacy, Bapuji Wadi,
Ramnagar, Wardha – 442001 (Maharashtra), India.
Email Id: rambawankar2008@rediffmail.com

Organoleptic Properties

Organoleptic properties such as colour, taste, odour and melting point has been determined.

Preparation of Stock solution

20 mg of Perindopril was accurately weighed in a 100 ml volumetric flask then the volume was made up to 100 ml with 0.1N HCl.

Determination of wavelength maxima (λ_{max}) and Standard Calibration Curve of Perindopril

The solution of 10µg/ml in 0.1N HCl was prepared and scanned in the range of 200-400 nm and wavelength maxima was determined. For standard calibration curve, from the stock solution, 10 ml was pipetted out and transferred in to a 100 ml volumetric flask and volume was made up to 100 ml with 0.1N HCl containing concentration of 20 µg/ml. From this solution, aliquots 1, 2, 3, 4, …….10ml were pipetted out in to a series of 10 ml volumetric flask and volume was made up to 10 ml with 0.1 N HCl so as to make final concentration equivalent to 2-20 µg. The absorbance of these solutions was measured against 0.1 N HCl as blank at 215 nm using Shimadzu UV-Visible double beam spectrophotometer (2).

Solubility study

The solubility of Perindopril was determined in solvents of different polarities. The solubility of Perindopril is usually determined by the equilibrium solubility method (3), which employs a saturated solution of Perindopril, obtained by adding an excess amount of Perindopril in the solvent to promote drug precipitation, and then stirring for two hours until equilibrium was reached. The mixture was filtered and amount of Perindopril was determined by using UV Spectrophotometer at 215 nm.

Drug Excipient Compatibility Study using Fourier Transform Infrared Spectroscopy

The samples were crushed with KBr to make pellets under hydraulic pressure of 10 tons, and then the FTIR spectra were recorded between 400 and 4000 cm^{-1}. It was used to study the interactions between the drug and polymer. The drug and polymer must be compatible with one another to produce a stable product. Drug and polymer interactions were studied by using FTIR (4,5).

Evaluation of powder parameters

Parameters including bulk density, tapped density, Carr's index, Hausner ratio and angle of repose of powder were evaluated according to the procedure given in Indian Pharmacopoeia, 2014 (3).

Development and optimization of Perindopril floating matrix tablets

Perindopril, selected polymers, sodium bicarbonate, citric acid and Avicel pH 102 were taken in required quantities and passed through 60 meshes separately. In dry state, the drug with other ingredients (for each batch containing blend of 50 tablets) along with Avicel pH 102 as a directly compressible material was mixed for the period of 10 min in mortar to get uniform mixture powder. The mixture was blended with Magnesium stearate and talc for 2-3 min to improve flow property. The powder materials were compressed using 8 mm diameter, round, biconcave punches on a Fluid pack multi station rotary tablet machine. The tablet weight was kept 120 mg and hardness between 5-7 kg/cm^2. The weights of the tablets were kept constant for all formulations as shown in Table 1.

Table 1: Composition of floating tablets of Perindopril

Sr. No.	Ingredients	F1	F2	F3	F4	F5	F6	F7	F8	F9
1	Perindopril	8	8	8	8	8	8	8	8	8
2	Okra Gum	4	8	12	--	--	--	4	8	12
3	$HPMCK_4M$	--	--	--	4	8	12	4	8	12
5	Sodium Bi-Carbonate	8	8	8	8	8	8	8	8	8
6	Citric Acid	4	4	4	4	4	4	4	4	4
7	Avicel pH 102	93	89	85	93	89	85	89	81	73
8	Magnesium-stearate	2	2	2	2	2	2	2	2	2
9	Talc	1	1	1	1	1	1	1	1	1
10	Total (mg)	120	120	120	120	120	120	120	120	120

Evaluation of Post Compression Parameter of Floating Tablets

Floating tablets parameters like taste, color, size, thickness, shape, hardness, friability, weight variation and drug content were determined as per the procedures given in Indian Pharmacopoeia (3).

Tablet Density

Tablet density was an important parameter for floating tablets. The tablet would float only when its density was less than that of gastric fluid (1.004). The density was determined using following relationship.

$$V = pr^2h \qquad d = m/v$$

Where, v = volume of tablet (cc), r = radius of tablet (cm), h = crown thickness of tablet (g/cc), m = mass of tablet

Floating lag time

The lag time was carried out in beaker containing 100ml of 0.1 N HCl as a testing medium maintained at

37 ± 0.5^0. The time required for the tablet to rise to the surface and float was determined as floating lag time.

Floating time/Buoyancy Study

The tablets were placed in a 100 ml beaker containing 0.1N HCl. The time required for the tablet to rise to the surface and float was taken floating lag time.

Swelling Characteristics

The swelling properties of matrix tablet containing drug were determined by placing the tablet matrices in the glass beaker containing 200ml of 0.1N HCl and incubated at 37±1^0. At regular 1hr time interval until 10hrs, the tablet was removed from beaker and the excess surface liquid was removed carefully using the filter paper. The swollen tablet was then re-weighted. Swelling characteristics (5,6) were expressed in term of percentage water uptake (WU %) according to the equation given below:-

$$\text{Swelling Index} = \frac{\text{Wt. of swollen tablet- Initial wt. of tablet}}{\text{Initial wt. of tablet}} \times 100$$

In-Vitro drug release study

The dissolution rate of Perindopril from floating matrix tablets was determined using 0.1 N HCl as dissolution medium to determine the drug release by using USP type II (Paddle apparatus) (Electro lab India) containing 900 ml. The tablet was placed in dissolution flask containing dissolution medium, maintained at 37±0.5^{0}C and the agitation speed was 50 rpm. A solution of (1.0 ml) of the dissolution medium was withdrawn at 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 hour time intervals and the same amount was replaced with the fresh medium. Absorbance of these solutions was measured by UV spectrophotometer at the $\lambda_{max}$of 215 nm. The cumulative percentage drug release was expressed as each value is determined and results were summarized.

Dissolution Kinetic Model

Model dependent methods (Table 2) are based on different mathematical functions, which describe the dissolution profile. Once a suitable function has been selected the dissolution profiles are evaluated depending on the derived model parameters (5,7).

Table 2: Mathematical models for drug dissolution curves

Sr. No.	Models	Equation
1	Zero Order release Equation	$Q_t = Q_0 + K_0 t$
2	First Order release Equation	$\ln Q_t = \ln Q_0 + K_1 t$
3	Higuchi Plot Equation	$Q_t = K_H t_{1/2}$
4	Hixson – Crowell Equation	$Q_{01/3} - Q_{t1/3} = K_s t$
5	Korsmeyer-Peppas Equation	Log (M t / M f) = Log k + n Log t

N	Mechanism
0.5	Fickian diffusion (Higuchi Matrix)
0.5 < n < 1	Non-Fickian diffusion
1	Case II transport

Differential Scanning Calorimetry (DSC)

Thermal properties of pure Perindopril and the optimized formulation were analyzed using DSC (8). The samples were heated in a hermetically sealed aluminum pans. Heat runs for each sample were set from 30^0 to 35^0 at a heating rate of 10^{0}min, using nitrogen as blanket gas.

Stability Studies

The optimized tablet batch was selected and wrapped in aluminum foil of thickness 0.04 mm and stored at temperature 40± 2^{0}with relative humidity of 75±5%. The sampling was done after every one month and evaluated for appearance, thickness, hardness, friability, drug content and cumulative % drug release (4,5,9).

Results and Discussion

Perindopril evaluated for parameters like color, odor, taste and melting point was found to be complying the specifications given in the Indian Pharmacopoeia (10). Perindopril, a BCS Class III drug, is highly soluble but suffers from low permeability and a short half-life. It is primarily absorbed in the upper GI tract, was observed to be white colored, odorless and tasteless powder with melting point of 126-128^0.The solution of 10µg/ml in 0.1N HCl was prepared and scanned in the range of 200-400 nm and wavelength maxima (fig.1) was found to be 215 nm.In order to prepare standard calibration curve of Perindopril (fig. 2), absorbance values of different concentrations of Perindopril were determined (Table 3). Solubility of Perindopril in water, 0.1N HCl and ethanol was found to be 28.82mg/ml, 14.70 mg/ml and 20.77 mg/ml respectively.

Table 3: Absorbance values of perindopril in 0.1 NHCl

Concentration (µg\ml)	Absorbance
0	0
2.0	0.074±0.04
4.0	0.151±0.07
6.0	0.234±0.02
8.0	0.299±0.05
10.0	0.378±0.07
12.0	0.456±0.09
14.0	0.528±0.04
16.0	0.603±0.05
18.0	0.677±0.07
20.0	0.755±0.04

(n=03)

Fig. 1: Determination of wavelength maxima (λ^{max}) of Perindopril in 0.1N HCl (Abs= Absorbance)

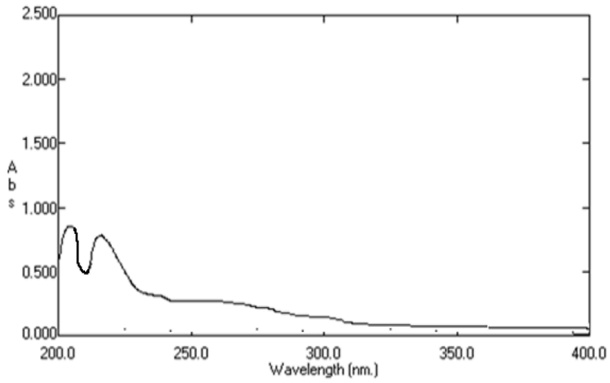
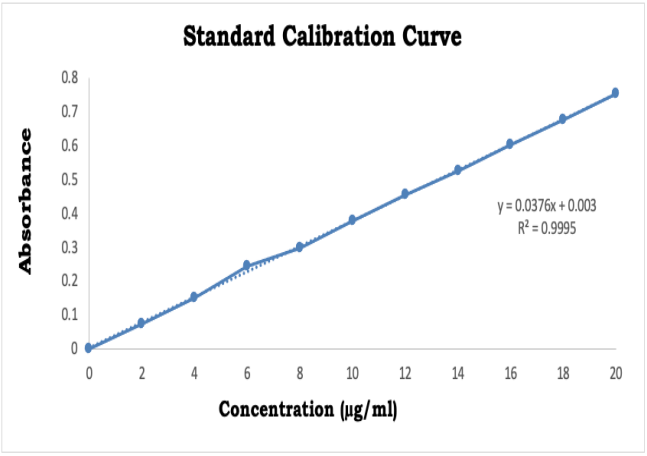


Fig. 2: Standard Calibration curve of Perindopril in 0.1 N HCl



The interaction studies of drug with polymers suggests no incompatibility.Perindopril shows retention of basic characteristics asN-H stretch at 2927.91cm^{-1}, N-H bending at 1642.01 cm$_{-1}$, C=C bonding at 1730.51, 1745.03cm^{-1}, -C-H stretch at 2747.24cm^{-1}, O-H bendingat 1390.61cm^{-1}, C=O Stretch at 1290.44cm^{-1}, C-N stretch at 1317.30cm^{-1} as shown in FTIR of drug and excipients. The typical FTIR curves shown in fig.3 [A], [B], [C] and [D] and wave number values for major peaks present of Perindopril are shown in Table 4.

Fig. 3: FTIR of [A] Perindopril, [B] Okra gum, [C] HPMCK4M, [D] Physical mixture of Perindopril with HPMCK4M and Okra gum

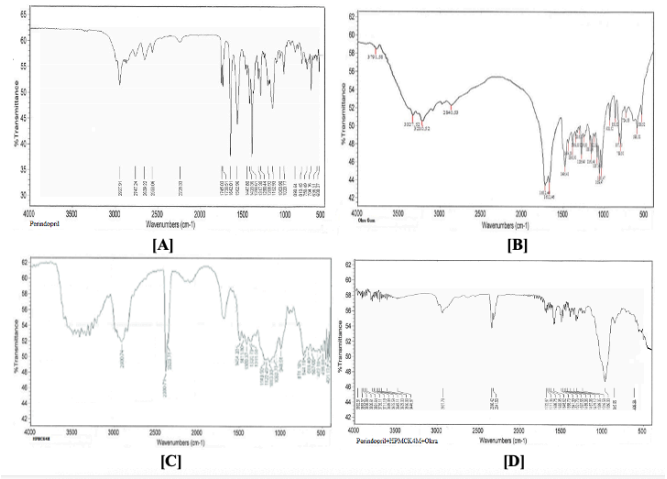


Table 4: Majorpeaks present in ir spectra of perindopril

Peak at wave number	Peak report	Peak observed
N-H stretch	2900-3600	2927.91
N-H bending	1500-1700	1642.01
C=C	1700-2000	1730.51, 1745.03
C-H stretch	2700-3300	2747.24
O-H bending	1200-1400	1390.61
C=O Stretch	1050-1300	1290.44
C-N stretch	1180-1360	1317.30

Powder characteristics were evaluated and found to be passing the tests for various batches according to the procedure given in Indian Pharmacopoeia (Table 5).Evaluation of tablets of batches F1 to F9 were carried out and thickness was found in range of 2.81±0.02 to 2.93±0.06mm; Hardness 5.25±0.17 to 5.50±0.13kg/cm^2; friability around 0.23±0.09; weight variation about 121±2.02 mg and drug content around 98.98±0.12 (Table 6). To provide good floating behavior in the stomach, the density of the device found to be less than that of the gastric contents (1.004g/cm^3). All the batches showed density below than that of gastric fluid (1.004). The values are shown in Table 7.

Table 5: Preformulation studies of various batches

Batches	Angle of repose (θ) ±SD	Bulk density (g/ml) ±SD	Tapped density (g/ml) ±SD	Compressibility Index (%)±SD	Hausner's ratio±SD
F1	25.22±0.12	0.191±0.05	0.235±0.31	14.76±0.32	1.18±0.04
F2	27.30±0.28	0.185±0.25	0.266±0.05	13.89±0.16	1.12±0.07
F3	27.75±0.33	0.225±0.07	0.224±0.09	16.41±0.12	1.13±0.09
F4	26.88±0.16	0.205±0.21	0.218±0.34	14.42±0.06	1.15±0.06
F5	25.55±0.12	0.171±0.08	0.202±0.24	10.75±0.22	1.16±0.05
F6	29.11±0.09	0.205±0.05	0.199±0.16	11.63±0.17	1.19±0.04
F7	25.44±0.15	0.219±0.21	0.191±0.40	12.60±0.18	1.11±0.01
F8	26.67±0.55	0.173±0.01	0.189±0.42	12.30±0.19	1.17±0.11
F9	24.22±0.12	0.186±0.21	0.236±0.14	12.36±0.21	1.14±0.07

https://doi.org/10.47552/ijam.v16iS2.6170 ISSN No: 0976-5921

Int J. of Ayurvedic Med, "Natural to Synthetic: The Convergence of Traditional Medicine to Modern Medicine" Supplement 2025

Table 6: Physical evaluation of formulated tablet

Batches	Thickness (mm) ±SD	Hardness (kg/ cm²)±SD	Friability (%) ±SD	Weight variation (mg)	Drug content uniformity (%) ±SD
F1	2.88±0.07	5.25±0.09	0.16±0.09	120±1.05	98.25±0.21
F2	2.84±0.03	5.35±0.11	0.21±0.05	121±2.02	98.38±0.30
F3	2.81±0.02	5.50±0.08	0.19±0.06	120 ±1.23	98.30±0.24
F4	2.93±0.06	5.50±0.13	0.11±0.02	120±1.12	98.49±0.19
F5	2.91±0.05	5.45±0.12	0.19±0.04	121±0.57	98.29±0.31
F6	2.83±0.01	5.30±0.03	0.17±0.02	119 ±1.37	98.70±0.11
F7	2.88±0.04	5.25±0.17	0.14±0.08	121 ±0.17	98.98±0.12
F8	2.86±0.07	5.40±0.25	0.14±0.09	119±0.09	98.44±0.32
F9	2.83±0.04	5.35±0.35	0.23±0.06	121±1.14	98.81±0.15

Table 7: Tablet densities, buoyancy lag time and total floating time

Batches	Tablet density (g/cc)	Buoyancy lag time (Sec)	Total floating time (Hr)
F1	0.91±0.02	96±0.03	>12
F2	0.88±0.01	97±0.02	>12
F3	0.86±0.02	97±0.01	>12
F4	0.89±0.01	95±0.02	>12
F5	0.87±0.03	96±0.03	>12
F6	0.82±0.01	96±0.01	>12
F7	0.85±0.03	93±0.02	>12
F8	0.84±0.05	92±0.02	>12
F9	0.83±0.02	91±0.01	>12

(n=03)

On immersion in 0.1N HCl solution pH (1.2) at 37⁰, the optimized (F8) tablets floated, and remained buoyant without disintegration. Table 7 shows the results of Buoyancy study showing buoyancy character of prepared tablet. The formulation's rapid buoyancy and prolonged floating behavior ensured retention in the stomach, a prerequisite for improved absorption. The combination of polymers facilitated swelling and gel formation, which controlled the drug release rate. The sustained release not only aligns with the absorption window of Perindopril but also potentially reduces the frequency of administration and enhances patient compliance. Thus, a gastroretentive drug delivery system can improve its bioavailability by extending the gastric residence time.

Swelling is used to describe the process that a polymer system undergoes addition to solvent; this is a composite, and not simple, term that encompasses all of the processes viz. hydration, gelling, swelling and erosion of polymer. After 10 hours, swelling index for prepared batches was found to be 26.47% to 42.32% which was maximum for F8 batch summarized in Table 8 and figure 4.

In-vitro dissolution study of prepared tablets namely F1-F9 (Table 9, fig. 5) were carried out. Batches F1 to F6 releases Perindopril early i.e. upto ten hours in range of 99.69±0.15, might be due to use of one polymer in formulation whereas use of combination of polymers (Okra gum and HPMCK4M as a matrix forming polymer which control the release) in batches F7 to F9, releases Perindopril upto twelve hours. F8 promisingly releasing 92.92±0.12% of drug considered as optimized batch. The kinetic treatment data of dissolution profiles of formulations F1-F9 has been summarized in Table10. The *in-vitro* drug release pattern of F8 showed the highest regression value (r_2 = 0.9966) for Korsmeyer- Peppas model. The 'n' value was found to below 0.5 (i.e 0.3133) suggesting that release of drug follows Fickian diffusion (Higuchi Matrix) mechanism. Release kinetics may be following diffusion mechanism from the formulation.

Table 8: Swelling index of formulations

Time (Hours)	Swelling index (%) or % Hydration								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
1	19.21	18.60	20.12	21.33	29.86	25.19	22.13	23.09	27.03
2	42.52	37.36	29.64	44.41	31.87	28.11	37.26	27.26	45.14
3	41.66	42.94	37.60	49.11	37.37	42.03	50.05	41.40	46.37
4	39.22	54.32	50.51	60.02	47.50	47.12	54.58	47.61	49.12
5	32.23	51.73	53.14	58.19	46.70	45.22	50.02	52.51	37.22
6	28.21	37.38	40.19	50.09	44.06	43.91	43.10	47.51	35.32
7	23.12	31.14	38.66	42.32	41.16	37.11	40.04	42.32	34.23
8	25.11	26.86	26.47	32.65	45.22	34.10	40.04	42.32	31.52
9	28.21	26.86	26.47	32.65	48.87	34.10	40.04	42.32	31.52
10	28.21	26.86	26.47	32.65	48.87	34.10	40.04	42.32	31.52

-

Figure 4: Relationship between Swelling Index & Time of batches F1- F9 (Hrs= Hours)

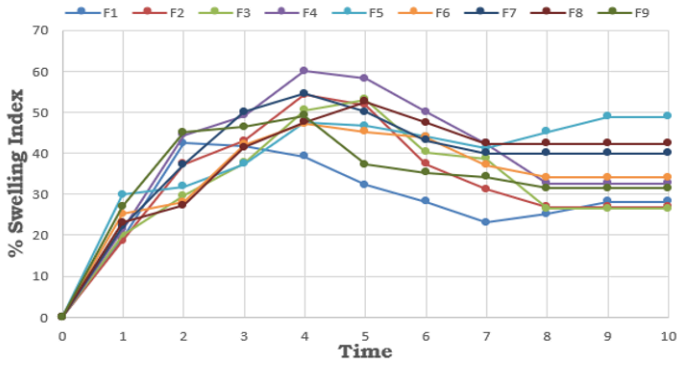


Figure 5: % cumulative Perindopril release (F1 – F9)

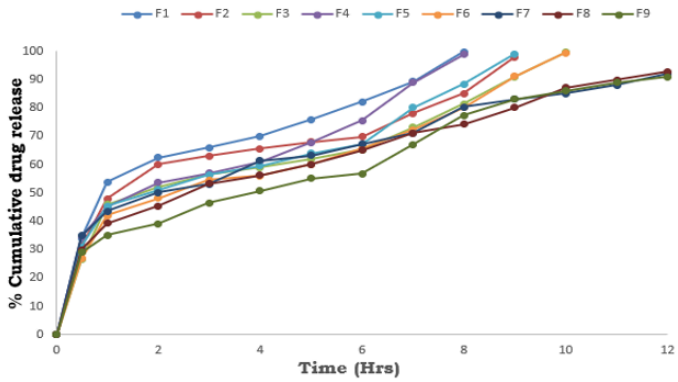


Table 9: In-vitro drug release profile of formulations

Time (Hours)	Formulations								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
0	0	0	0	0	0	0	0	0	0
0.5	33.92±0.33	31.22±0.29	26.52±0.23	34.56±0.14	31.07±0.41	26.78±0.22	35.00±0.11	30.03±0.19	29.02±0.41
1	53.87±0.89	48.06±0.35	46.01±0.29	45.00±0.21	45.36±0.34	42.15±0.48	43.48±0.18	39.40±0.23	35.11±0.12
2	62.45±0.13	60.06±0.19	52.01±0.11	53.63±0.12	51.10±0.38	48.10±0.11	50.16±0.25	45.48±0.14	39.19±0.32
3	65.96±0.11	62.99±0.12	56.65±0.28	57.00±0.06	56.45±0.43	54.55±0.15	53.04±0.43	53.24±0.43	46.56±0.45
4	69.95±0.29	65.57±0.16	59.07±0.19	60.94±0.06	59.57±0.31	56.15±0.23	61.36±0.21	56.18±0.19	50.68±0.49
5	75.91±0.22	67.99±0.02	62.01±0.21	67.86±0.09	64.00±0.40	60.08±0.22	63.19±0.23	60.12±0.57	55.15±0.19
6	82.21±0.22	69.92±0.24	65.22±0.40	75.47±0.05	67.01±0.16	65.89±0.31	67.33±0.09	65.10±0.42	56.78±0.28
7	89.30±0.66	78.07±0.17	73.11±0.41	89.02±0.06	80.11±0.41	72.17±0.38	71.11±0.21	71.07±0.16	67.19±0.77
8	99.89±0.31	85.15±0.27	81.41±0.24	98.99±0.08	88.49±0.13	80.21±0.31	80.34±0.51	74.19±0.53	77.31±0.28
9	-------	97.97±0.45	91.04±0.13	-------	99.01±0.10	91.19±0.19	83.17±0.17	80.23±0.24	83.12±0.32
10	-------	-------	99.69±0.15	-------	-------	99.42±0.22	85.04±0.48	87.21±0.51	85.98±0.11
11	-------	-------	-------	-------	-------	-------	88.04±0.12	89.89±0.22	89.01±0.16
12	-------	-------	-------	-------	-------	-------	92.03±0.23	92.92±0.12	91.04±0.32

Table 10: Kinetic treatment profiles

Batch	Variables	Zero order	First order	Hixson crowell	Korsmeyer	Higuchi plot
F1	r^2	0.8994	0.6274	0.7299	0.9907	0.9740
	n	0.1545	0.0030	0.0165	0.3133	0.2388
	K	29.515	1.0685	4.2554	0.2135	-1.9481
F2	r^2	0.8931	0.6192	0.7083	0.9894	0.9591
	n	0.1279	0.0029	0.0152	0.3018	0.2719
	K	28.880	1.0520	4.1547	0.1998	-2.2990
F3	r^2	0.9296	0.6294	0.7186	0.9890	0.9658
	n	0.1237	0.0029	0.0148	0.3194	0.2895
	K	24.831	1.0157	3.9010	0.1172	-1.9336
F4	r^2	0.9335	0.6288	0.7345	0.9928	0.9764
	n	0.1561	0.0030	0.0155	0.2859	0.2458
	K	24.049	1.0394	4.0178	0.2228	-1.1375
F5	r^2	0.9323	0.6222	0.7167	0.9921	0.9728
	n	0.1367	0.0029	0.0147	0.2840	0.2743
	K	24.437	1.0308	3.9808	0.2047	-1.7217
F6	r^2	0.9452	0.6387	0.7366	0.9943	0.9776
	n	0.1264	0.0029	0.0148	0.3231	0.2968
	K	22.970	0.9991	3.7768	0.0927	-1.8440
F7	r^2	0.9185	0.6161	0.7121	0.9899	0.9682
	n	0.0953	0.0028	0.0145	0.2538	0.3012
	K	30.314	1.0377	4.0145	0.2708	-2.6366
F8	r^2	0.9423	0.6355	0.7373	0.9966	0.9802
	n	0.1008	0.0029	0.0147	0.2973	0.3133

	K	26.422	1.0017	3.7658	0.1454	-2.3243
F9	r^2	0.9604	0.6327	0.7299	0.9957	0.9768
	n	0.1059	0.0028	0.0137	0.2738	0.3201
	K	21.952	0.9765	3.5995	0.1485	-1.4521

The DSC thermogram of Perindopril (fig.6A) records two endothermic peaks corresponding to the melting point of drug (126.0^0) whereas Perindopril Loaded optimized formulation, F8 (fig.6B), showed lesser melting point (122.4^0), suggesting the possibility of interaction. Optimized F8 formulation was studied for stability at 40 ± 2^0 and 75 ± 5% RH for about 3 months according to the ICH guidelines (Table 11). After every one month sampling, no significant changes in appearance, thickness, hardness, friability, drug content and cumulative % drug release were observed and summarized in Table 12 & Fig. 7.

Fig. 6: DSC thermogram of [A] Perindopril [B] Drug Loaded optimized formulation

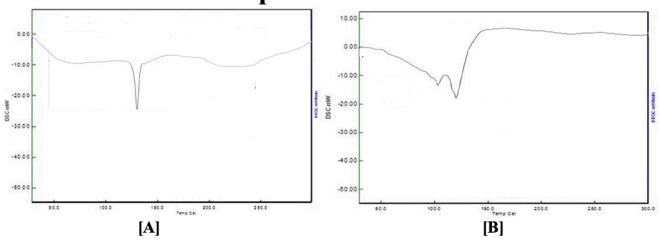


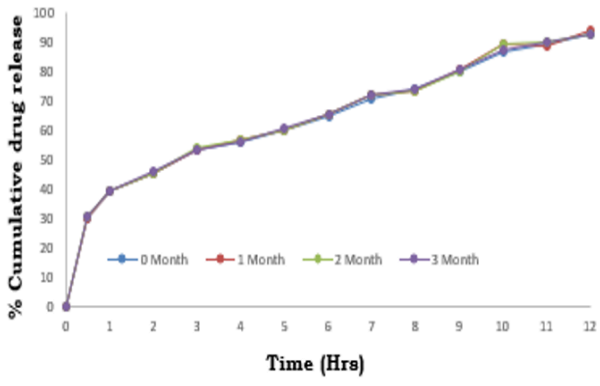
Table 11: Stability studies of formulation f8 at 40^{0}c /75% rh

Parameters	0 month	1 month	2 months	3 months
Appearance/Colour	White	White	White	White
Thickness (mm)	2.86	2.86	2.86	2.85
Hardness (Kg/cm^2)	5.40	5.30	5.30	5.30
Friability (%)	0.14	0.13	0.15	0.14
Drug content (%)	98.44	98.38	98.39	98.38

Table 12: In-vitro drug release study of formulation f8

Time (Hours)	Cumulative % Perindopril release			
	0 month	1 month	2 months	3 months
0	0	0	0	0
0.5	30.03	29.85	30.75	30.67
1	39.4	39.19	39.62	39.62
2	45.48	45.43	45.38	45.99
3	53.24	53.69	53.77	53.71
4	56.18	56.77	56.73	56.22
5	60.12	60.39	60.19	60.71
6	65.1	65.35	65.32	65.42
7	71.07	71.82	71.82	71.82
8	74.19	73.74	73.74	74.48
9	80.23	80.73	80.37	80.57
10	87.21	89.36	89.86	87.36
11	89.89	89.05	89.95	89.99
12	92.92	94.25	92.96	92.93

Fig. 7: In-vitro release profiles of formulation F8 kept for stability at 40^0 ± 2^{0}C and 75 ± 5% RH for 3 months



Conclusion

A gastro-retentive tablet formulation of Perindopril was successfully developed offering prolonged gastric retention and sustained drug release. Okra gum used in formulation is gaining attention as a natural excipient, its biocompatibility, non-toxicity, and gel-forming ability make it a promising candidate in drug delivery systems, offering a plant-based alternative to synthetic binders while aligning with the principles of Ayurvedic herbal formulation.The resulting formulation strategy can enhance the oral bioavailability of Perindopril, a BCS Class III drug, by synchronizing drug release with its narrow absorption window in the upper GI tract and demonstrated desirable characteristics, including high drug content,

optimal tablet hardness, effective floatability, a favorable swelling index, and controlled drug release behavior.

The high floating capacity of the formulation is expected to prolong its gastric residence time, potentially enhancing bioavailability, reducing dosing frequency, and minimizing both the required dose and associated side effects. Overall, this polymer-based approach for Perindopril shows promise for developing gastro-retentive drug delivery systems and has the potential to improve therapeutic outcomes and patient adherence in the management of hypertension, warranting further detailed investigation.

Acknowledgements

Authors would like to acknowledge the entire staff members of Agnihotri College of Pharmacy, Wardha – 442001 for their support during this research work.

References

1. Martha S, Development and *In-Vitro* Evaluation of Perindopril Floating Tablets. World Journal of Pharmaceutical Research. 2015; 4(1); 1010-1021.
2. Sharma YR. Elementary Organic Spectroscopy principal andchemical application, S. Chand and Company Ltd. New Delhi 2009; 4: 09-10p.
3. Lachman L, Lieberman HA. The theory and practice of Industrial Pharmacy, Special Edition. CBS Publication 2009. 296-301, 430-456p.
4. Lippincott W, Remington W. The Science andpractice of pharmacy. B.I. Publication Pvt. Ltd. 2006. 21(1): 650p.
5. Singh S, Dwivedi A, Mishra S, Gunjan A, Formulation and Evaluation of Gestroretentive Floating Tablet of Perindopril. Asian Journal of Pharmaceutical Education and Research. 2014; 3(1); 20-37.
6. Battu P.K, Tiwari A.K, Singh T, Ravali A, Formulation and Evaluation of Sustained Release Tablets of Perindopril. International Journal of Pharmacy and Natural Medicines. 2015, 3(2); 291-299.
7. Bawankar R.D, Dewani S.P, Yeole P.G, Formulation, Characterization and Evaluation of Extendedrelease Solid Dispersion of a Poorly Water Soluble drug, Journal of Scientific Research in Pharmacy, 2014; 3(3); 86-95.
8. Ughade S, Bawankar R.D, Mundhada D.R, Nifedipine Gastro Retentive Drug Delivery System: Formulation, Characterization and Evaluation, Indian Journal of Pharmaceutical Sciences, 2023; 667 – 677.
9. ICH guidelines Q1A (R2), Guidance for industry, stability testing of new drug substance and products (Available on: http:// http://www.ich.org).
10. Indian Pharmacopoeia. Government of India, Ministry of Health and Family Welfare, published by The Indian Pharmacopoeia Commission, Seventh Edition, Ghaziabad; 2014. 177-183p.

*****