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Formulation and Evaluation of Osmotic Sustained Release Budesonide Tablet for Colon Targeting

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KEYWORDS
Osmotic Sustained, Budesonide Tablet, Colon Targeting

ABSTRACT:

In order to improve therapeutic efficacy in the treatment of inflammatory bowel illnesses (IBD), including Crohn's disease and ulcerative colitis, the current study focuses on the formulation and assessment of osmotic sustained release tablets of Budesonide for targeted drug delivery to the colon. Budesonide, a glucocorticoid with strong anti-inflammatory effects, needs to be delivered locally to minimise systemic adverse effects and enhance site-specific impact because it has a high first-pass metabolism.

Budesonide was released gradually and under control using osmotic pump technology. The bilayer core of the tablets, which had an osmotic push layer and a medication layer, was coated with a cellulose acetate semipermeable membrane that included pore formers such as polyethylene glycol (PEG 400). By assessing factors like hardness, friability, homogeneity of drug content, in vitro drug release, and swelling index, several formulations were created and improved. Additionally, the effects of membrane thickness and orifice size on drug release were investigated.

To mimic gastrointestinal transit, in vitro dissolution experiments were carried out in successive pH media. Successful targeting was shown by the optimised formulation's limited drug release in intestinal and gastric pH settings and its considerable release that started at colonic pH. A zero-order release profile that is mostly controlled by osmotic pressure and membrane properties was proposed using kinetic modelling.

The findings highlight the potential of osmotic pump tablets as a dependable method for delivering Budesonide specifically to the colon, providing a viable treatment option for colonic inflammatory diseases with increased patient adherence and fewer doses.

INTRODUCTION

Colon diseases impact millions of people worldwide and include Crohn's disease (CD), ulcerative colitis (UC), irritable bowel syndrome (IBS), amoebiasis, chronic pancreatitis, and colorectal cancer. Because of their sometimes chronic and incurable nature, as well as their poorly known aetiology and pathophysiology, these disorders are becoming more common and present serious public health challenges. Due in large part to the shortcomings of traditional drug delivery techniques that ineffectively target the colon, effective management of these illnesses is still difficult[1].

The possibility of colon-targeted drug delivery systems (CDDS) to improve outcomes from treatment for colonic illnesses while reducing systemic adverse effects has drawn more and more interest. With the help of these systems, pharmaceuticals that would otherwise be broken down in the upper gastrointestinal (GI) tract can be absorbed systemically and inflammatory disorders like IBD can be treated locally. For instance, when properly preserved and administered, proteins and peptides which are normally unstable in the stomach's acidic environment or broken down by enzymes in the

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small intestine can be efficiently absorbed through the colonic mucosa[2-5].

Numerous cutting-edge techniques, including as pH-sensitive polymer coatings, time-dependent release systems, microbiologically triggered systems, and pressure-controlled drug delivery mechanisms, have been developed to accomplish such tailored delivery. By preventing early drug release or degradation, these strategies make sure that the active pharmaceutical ingredient (API) is only released once the medicine reaches the colon.

Budesonide, a strong glucocorticoid frequently used to treat inflammatory bowel disorders, is one such medicinal drug of interest. Conventional administration methods, including immediate-release pills, sometimes fall short of maintaining adequate medication concentrations at the colon's inflammatory site. Advanced delivery technologies, such as osmotic drug delivery systems (ODDS), which use osmotic pressure to regulate the API's release rate, have been developed in response to this difficulty. In order to maximise treatment efficacy and minimise systemic side effects, ODDS can be designed for colon-specific administration and offer prolonged release profiles.

The development and evaluation of a colon-targeted osmotic drug delivery system for budesonide is the main objective of this study. By using this method, we hope to improve colonic illness management, increase local drug delivery to the colon, and further the development of focused therapeutic approaches.

MATERIAL AND METHODS

MATERIALS : The drug Budesonide was a kind gift sample by Yarrow chem products Pvt.Ltd. Sodium starch glycolate, Croscarmellose sodium, Eudragit S-100, Micro-crystalline cellulose, Magnesium stearate, Talc, Guar gum, Hydroxypropyl methyl (HPMC), Pectin, Hydroxy ethyl cellulose (HEC), Cellulose acetate phthalate (CAP), Castor oil, Acetone was obtained by India mart. All other chemicals obtained were used as supplied by the standard pharmaceutical manufacturers**.** Weigh all the ingredients including the drug and polymer dissolved in alcohol and to evaporate. Microparticles forms then blended for 20 min in morter and pestle. Pass through mesh no. 40. Add other ingredients and mixed uniformly for 2 min. The prepared blend of formulation was compressed using flat punches tableting machine with 10 mm diameter[6-8].

METHODS OF PREPRATION:

Budesonide core tablets: Using croscarmellose sodium as a super disintegrant, the direct compression method was used to create Budesonide core tablets. Every component, including the medication and excipients, was precisely weighed in accordance with the batch formula **(Table 1)**. Using a stainless-steel spatula, the medication and all of the ingredients—aside from lubricants—were placed on a piece of butter paper. The ingredients were then combined in increasing weight order and blended for ten minutes in a mortar and pestle. Lubricants were added and blended again for two minutes after the materials had been evenly combined[9]. In a rotating tablet press, a punch was used to compress the prepared formulation blend into 100 mg.

Compression-coated tablet preparation: Using the direct compression method, Budesonide tablets were compression-coated with HPMC, HEC as time-dependent polymers, and pectin and guar gum as enzyme-dependent polymers. As indicated in **Table 2**, 200 mg of compression coating materials were applied to the core tablets. After placing the core tablet over the coating material and about half of the coat formulation in the die cavity, the remaining coat formulation was positioned over the core tablet. It was then compacted into the tablet with the compression coating[10-12].

Enteric coating of prepared compression-coated tablets: Using the dip coating technique, enteric coating polymers were applied to Budesonide compression-coated tablets. A magnetic stirrer was used to dissolve the necessary amounts of ES 100 and CAP in acetone, as indicated in **Table 3**. Castor oil (10% w/w of dry polymer) was applied as a plasticiser once the polymer had completely dissolved. After adding talc (0.1% w/v) as an anti-adherent, the mixture was agitated for fifteen minutes. Tablets with pre-weighted compression coatings were dipped three to five times in the solution until they gained 10% of their weight.

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Table 1: Formulation of core tablet of budesonide

Ingredients	Quantity (mg/tablet)
Budesonide	9mg
Microcrystalline cellulose	65mg
Croscarmellose sodium/ Sodium starch glycolate	5mg
Mannitol	12mg
Starch (Assam bora rice)	5mg
Talc	2mg
Magnesium stearate	2mg

Table 2: Formulation of compression coat

Ingredients	Quantity(mg/tablet)
Pectin	30mg
Guar gum	40mg
Hydroxymethyl cellulose (HPMC)	10mg
Hydroxy ethyl cellulose (HEC)	20mg
Microcrystalline cellulose (MCC)	100mg

Table 3: Composition of enteric coating

Ingredients	Quantity (mg)
Eudragit S-100	500mg
Cellulose acetate phthalate (CAP)	500mg
Castor oil	100mg
Talc	50mg
Acetone	Up to 10ml

Polymer drug interaction by FTIR study:

Evaluation of Drug-Polymer Interaction and Post-Compression Parameters: Drug-polymer compatibility was assessed using FTIR spectroscopy. Post-compression evaluation of tablets included:

- **Hardness:** Measured using a Monsanto Hardness Tester; average values were calculated from three tablets per batch.
- **Friability:** Assessed using a Roche friabilator at 25 rpm for 100 revolutions. Percentage weight loss was calculated to determine mechanical resistance.
- **Thickness and Diameter:** Determined using a digital vernier caliper.
- **Weight Variation:** Evaluated as per IP standards by weighing 20 randomly selected tablets and calculating the mean and percent deviation.
- **Drug Content Uniformity:** Five tablets were powdered, and a quantity equivalent to 9 mg of Budesonide was analysed using UV spectrophotometry at 245 nm in phosphate buffer (pH 7.4).
- **In Vitro Drug Release of Budesonide:** Conducted using a USP Type II Dissolution Apparatus at 37 ± 0.5°C and 100 rpm. Tablets were tested sequentially in simulated gastric fluid (pH 1.2 for 2 h), intestinal fluid (pH 6.8 for 4 h), and colonic fluid (pH 7.4). Samples were analysed at intervals using UV spectrophotometry, maintaining sink conditions.
- **Drug Release kinetics:** In vitro drug release data were analysed using various kinetic models, including Zero-order, First-order, Higuchi, Korsmeyer-Peppas, and Hixson-Crowell, using Microsoft Excel. The model best describing the release mechanism was identified based on the highest regression coefficient (R^2) value[13-15].

RESULT AND DISCUSSION

The present study was done on enteric coating sustained release tablets of Budesonide with different formulations. Budesonide tablets were prepared by direct compression method using different concentrations of excipients and polymers. Eudragit S-100 and Cellulose acetate phthalate (CAP) was used as

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an enteric coating polymer, which prevents the drug from gastric pH and releases it on colonic pH only.

FTIR:

Budesonide's compatibility with important formulation polymers, such as pectin, HPMC K-100, HEC, CAP, Eudragit S-100, and guar gum, was evaluated using Fourier-transform infrared (FT-IR) spectroscopy. With each polymer, spectra were acquired for both the physical mixes and the pure drug. In the polymer mixtures, the distinctive absorption peaks that correspond to the functional groups of Budesonide (such as O–H, C=O, and C–H stretching) did not change, suggesting that there was no meaningful chemical interaction. This substantiated Budesonide's stability in the formulation and validated its compatibility with the chosen excipients.

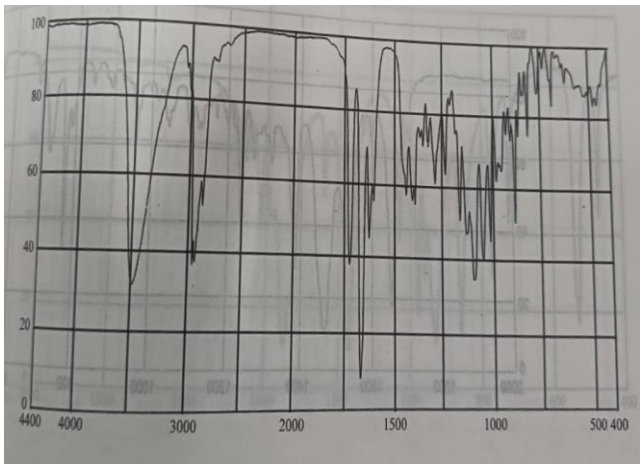

Figure 1: FTIR of Budesonide as per IP.

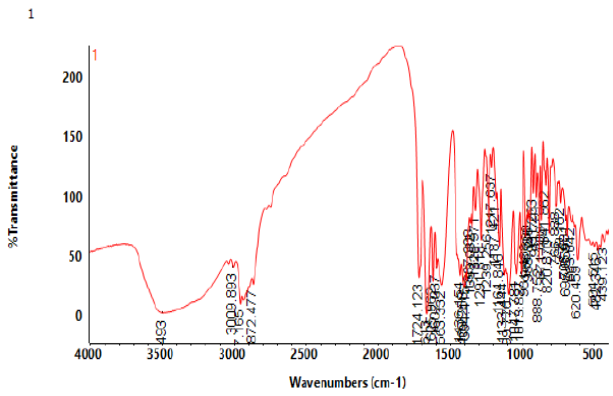

Figure 2: FTIR of Budesonide

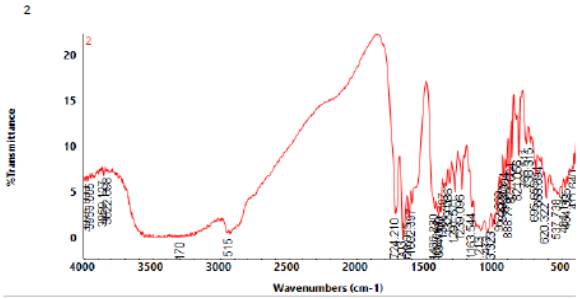

Figure 3: FTIR of Budesonide and Pectin

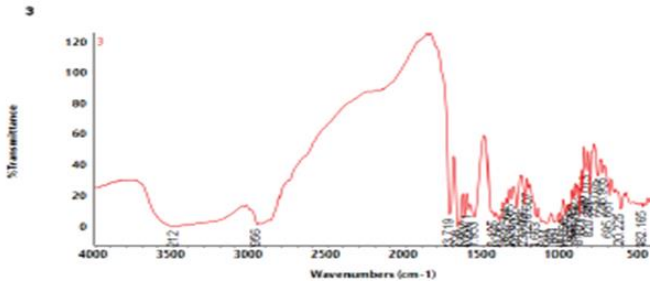

Figure 4: FTIR of Budesonide and HPMC

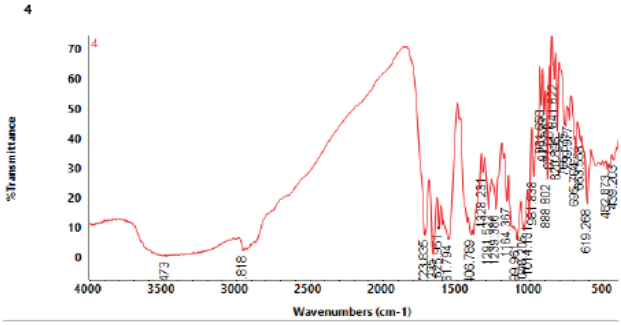

Figure 5: FTIR of Budesonide and HEC

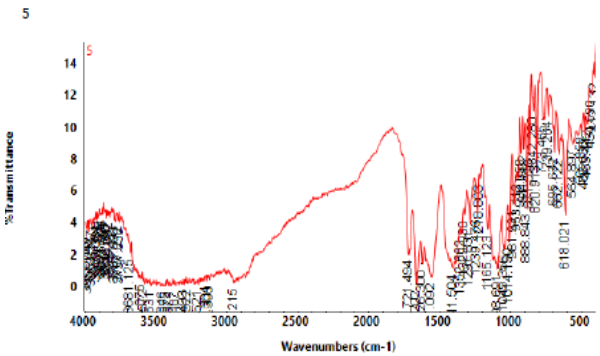

Figure 6: FTIR of Budesonide and CAP

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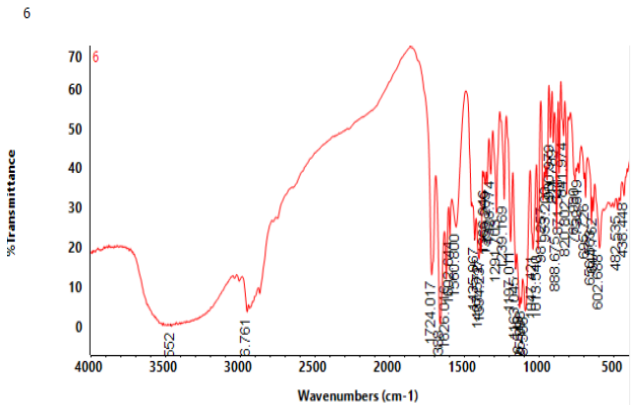

Figure 7: FTIR of Budesonide and Eudragit.

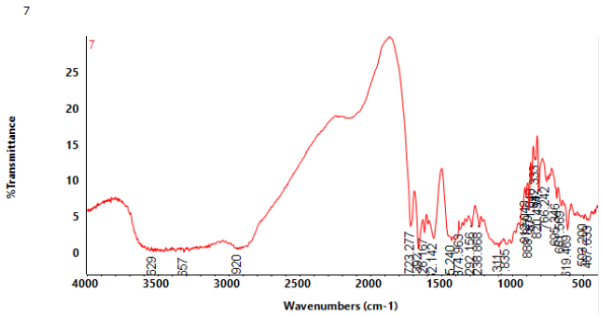

Figure 8: FTIR of Budesonide + Guar gum + HPMC + Eudragit

PRE-COMPRESSION PARAMETERS:

Budesonide powder blends prepared by direct compression were evaluated for flow properties using standard parameters. Bulk and tapped densities ranged from 0.533–0.689 g/mL and 0.607–0.833 g/mL, respectively. Flowability was confirmed by Hausner's ratio (1.10–1.26), Carr's Index (9.5–20.6%), and angle of repose (33.15°–36.92°), indicating good to acceptable flow characteristics for direct compression.

Table 4: Pre-compression studies

S. No	Bulk density (gm/ml)	Tapped density (gm/ml)	Carr's index (%)	Hausner's ratio	Angle of repose
F1	0.808	0.648	19.8	1.24	33.42
F2	0.817	0.648	20.6	1.26	36.81
F3	0.711	0.59	17.0	1.20	34.29
F4	0.833	0.667	19.9	1.25	35.67
F5	0.817	0.648	20.6	1.26	36.81
F6	0.772	0.627	18.7	1.23	36.43
F7	0.729	0.618	15.2	1.18	34.85
F8	0.686	0.610	11.0	1.12	35.21
F9	0.806	0.681	15.5	1.18	33.19
F10	0.607	0.533	12.1	1.13	36.92

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F11	0.761	0.648	14.8	1.17	34.51
F12	0.820	0.689	15.9	1.19	35.89
F13	0.716	0.594	17.0	1.20	33.67
F14	0.687	0.615	10.4	1.11	36.19
F15	0.666	0.580	12.9	1.14	34.93
F16	0.776	0.660	14.9	1.17	35.44
F17	0.737	0.626	15.0	1.17	33.41
F18	0.749	0.633	15.4	1.18	36.78
F19	0.679	0.597	12.0	1.13	34.27
F20	0.792	0.640	19.1	1.23	35.63
F21	0.638	0.566	11.2	1.12	33.85
F22	0.694	0.628	9.5	1.10	36.45
F23	0.778	0.629	19.1	1.23	34.83
F24	0.725	0.642	11.4	1.13	35.25
F25	0.667	0.581	12.8	1.14	33.15
F26	0.805	0.676	16.0	1.19	36.95

POST COMPRESSION PARAMETERS:

The prepared Budesonide tablets were evaluated for key post-compression parameters. Hardness ranged from 5 to 6.5 kg/cm², indicating good mechanical strength. Friability was below 1% w/w (0.6–1.0%), within acceptable limits. Tablet thickness ranged from 6.2 to 7.1 mm and was consistent across batches. All formulations passed the weight variation test, with average tablet weights falling within acceptable limits. Overall, the tablets exhibited satisfactory physical properties.

Table 4: post compression studies

F1	Passed	6	6.8	0.83
F2	Passed	5.5	5.9	0.67
F3	Passed	6.5	7.1	0.95

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F4	Passed	45	6.2	0.72
F5	Passed	5.5	6.9	0.67
F6	Passed	5.5	5.8	0.61
F7	Passed	5	6.4	0.98
F8	Passed	6.5	6.4	0.75
F9	Passed	6	7.0	0.82
F10	Passed	5.5	6.1	0.91
F11	Passed	5	6.6	0.69
F12	Passed	5.5	5.9	0.85
F13	Passed	6.5	6.8	0.63
F14	Passed	6	7.0	0.96
F15	Passed	5.5	6.3	0.79
F16	Passed	5.5	6.5	0.87
F17	Passed	5	5.9	0.65
F18	Passed	6.5	6.8	0.94
F19	Passed	6	7.1	0.71
F20	Passed	5.5	6.2	0.89
F21	Passed	4.5	6.7	0.62
F22	Passed	5	5.8	0.97
F23	Passed	6.5	6.4	0.76
F24	Passed	6	7.0	0.84
F25	Passed	5.5	6.1	0.93
F26	Passed	5	6.6	0.68

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***IN-VITRO* DRUG RELEASE STUDIES :**

The in vitro release of osmotic sustained release Budesonide tablets was evaluated using USP Dissolution Apparatus II under sequential pH conditions: 0.1N HCl (pH 1.2) for 2 hours, phosphate buffer pH 6.8 for 3 hours, and phosphate buffer pH 7.4 for the remaining period, completing a 12-hour study. The formulations incorporated various release-modifying agents including Mannitol (osmotic agent), Guar gum (pore former), HPMC (time-dependent polymer), and Eudragit and CAP (pH-dependent polymers). All formulations demonstrated sustained drug release profiles. Notably, formulation F6 achieved the highest release (98.64% at 12 hours), indicating effective sustained and targeted delivery. Formulations F15 and F17 also showed desirable sustained release profiles, with 94.31% and 97.89% drug release respectively at 12 hours. These findings confirm the effectiveness of the multi-mechanism approach for controlled colonic delivery of Budesonide.

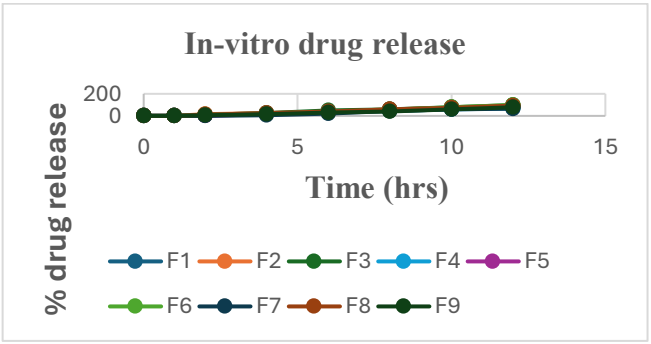

Figure 9: In-vitro drug release of formulation F1 to F9

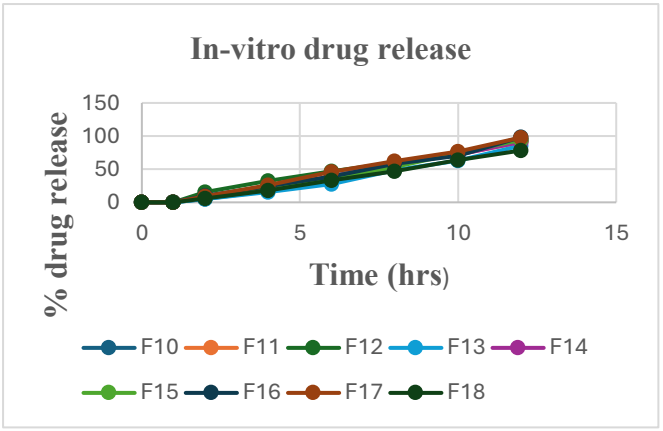

Figure 10: In-vitro drug release of formulation F10 to F18

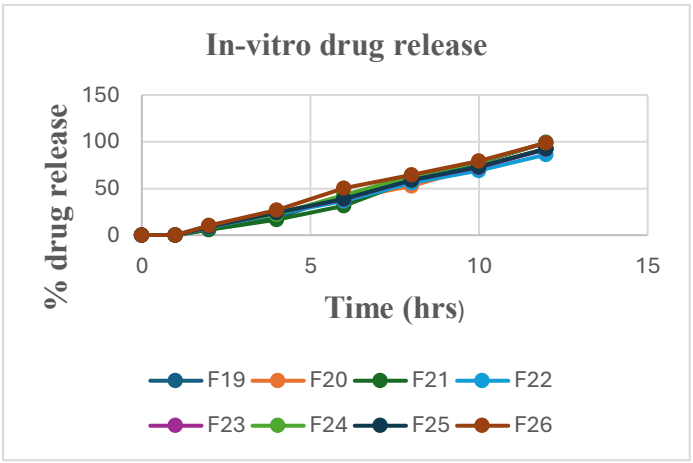

Figure 11: In-vitro drug release of formulation F19 to F26

Table 5: Drug release data

% Drug release	**Time**						
	1	**2**	**4**	**6**	**8**	**10**	**12**
F1	0	7.81	21.38	34.43	52.96	64.39	81.59
F2	0	16.5	23.31	37.43	57.3	71.35	88.19
F3	0	10.55	25.82	47.71	61.33	78.63	97.67

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F4	0	5.53	18.87	33.71	45.83	57.16	67.32
F5	0	0	15.22	32.81	55.29	72.15	84.85
F6	0	5.83	19.85	36.74	56.29	76.23	98.64
F7	0	0	7.98	2.67	45.51	57.93	65.32
F8	0	8.72	23.68	37.91	57.86	74.88	93.32
F9	0	4.99	13.87	28.96	41.53	58.11	78.11
F10	0	5.32	17.1	39.43	57.34	74.61	94.31
F11	0	8.76	23.92	38.31	58.33	72.4	90.83
F12	0	15.3	32.51	46.96	60.16	74.33	92.95
F13	0	5.45	15.72	27.89	48.53	62.92	85.81
F14	0	8.93	2.19	38.54	58.23	72.11	91.28
F15	0	7.35	24.71	35.18	53.34	74.66	94.31
F16	0	9.88	24.3	38.54	58.15	70.5	98.49
F17	0	8.95	26.17	46.33	61.9	76.42	97.89
F18	0	6.19	18.33	32.97	46.58	63.99	78.32
F19	0	6.55	18.91	41.75	62.78	77.31	99.22
F20	0	9	24.46	38.98	52.71	73.72	92.59
F21	0	5.88	16.84	31.54	58.93	73.12	92.27
F22	0	8.52	23.13	36.86	55.85	69.21	86.32
F23	0	9.23	24.23	38.51	58.63	72.85	91.94
F24	0	10.23	22.42	42.79	63.46	78.18	99.05
F25	0	9.1	24.32	38.79	59.03	73.21	92.56
F26	0	10.17	27	50.55	64.85	79.43	98.85

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KINETICS OF DRUG RELEASE.

The in vitro drug release kinetics of optimized formulations F6 and F15 were analyzed using various mathematical models. Among these, the Korsmeyer-Peppas model best described the release behavior, exhibiting the highest correlation coefficients (R^2 = 0.9995 for F6 and 0.9961 for F15). Model Selection Criteria (MSC) values were also highest for this model (5.7378 for F6 and 4.7088 for F15), confirming its suitability. These results suggest that drug release from both formulations follows a diffusion-controlled mechanism, as illustrated in Table **6-7 and Figure 12**.

Table 6: Kinetic model for formulation F6.

Kinetic model	**R.sqr obs**	**R.sqr**	**MSC**
Zero-order	0.996	0.9512	2.4916
First order	0.9685	0.8260	1.2207
Highuchi	0.9712	0.6964	0.6641
Korsmeyer-peppas	0.9986	0.9995	5.7378
Hixon-Crowell	0.9778	0.8672	1.4912

Table 7: Kinetic model for formulation F15

Kinetic model	**R.sqr obs**	**R.sqr**	**MSC**
Zero-order	0.996	0.9626	2.7320
First order	0.9722	0.8511	1.3494
Higuchi	0.9747	0.7196	0.7161
Korsmeyer-peppas	0.9982	0.9961	4.7088
Hixon-crowell	0.9803	0.8891	1.6434

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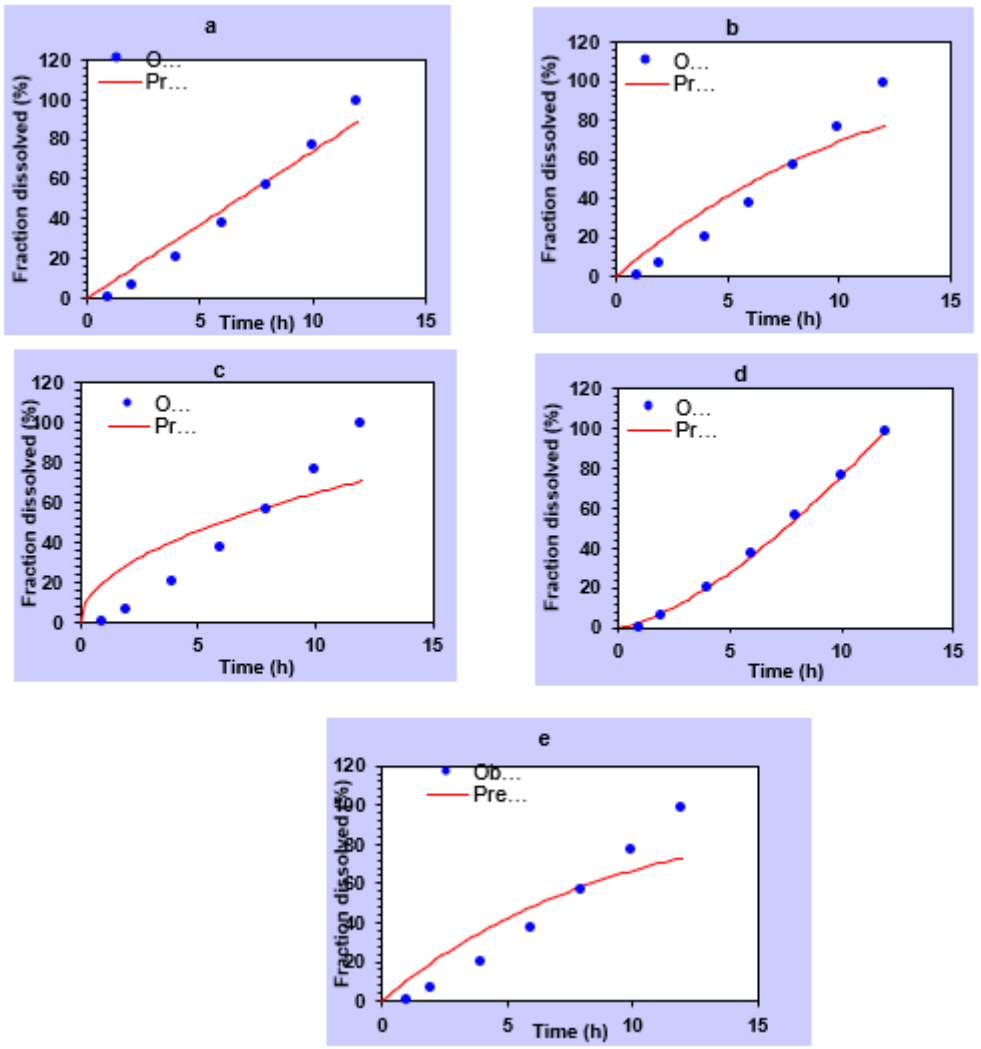

Figure 12 :Kinetic modeling study of formulation F6: a) zero order kinetics b) First order kinetics c) Higuchi kinetics d) Korsmeyer Peppas kinetics e) Hixon Crowell Kinetic

CONCLISION

Budesonide osmotic sustained-release tablets intended for colon-targeted medication administration were effectively developed and assessed in this study. The devised technology efficiently protected budesonide from degradation in the upper gastrointestinal tract and ensured its release in the colon by employing the principles of osmotic pressure to demonstrate controlled and site-specific medication release. By improving local drug availability and reducing systemic adverse effects, this focused method offers considerable therapeutic advantages, especially for the treatment of inflammatory bowel illnesses like Crohn's disease and ulcerative colitis**.**

Because of its once-daily dosage and long-lasting therapeutic effects, the formulation demonstrated encouraging physicochemical properties, predictable drug release patterns, and the potential to increase patient compliance. All things considered, the osmotic drug delivery method created in this work is a practical and efficient way to deliver budesonide to a specific colon and may be further refined for use in clinical settings to treat chronic colonic illnesses.

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REFERENCES:

1. Philip, A. K. and B. Philip (2010). "Colon targeted drug delivery systems: a review on primary and novel approaches." Oman medical journal 25(2): 79.
2. Akala, E.O., et.al. (2003). “Organic redox-initiated polymerization process for the fabrication of hydrogels for colon-specific drug delivery.”Drug development and industrial pharmacy 29(4):375-386
3. Friend, D. R. (1991). "Colon-specific drug delivery." Advanced drug delivery reviews 7(1): 149-199.
4. K. V. Vinay, Sivakumar, T. Tamizh. Int J pharm Biomed Sc. i., 2011,2,1,11-19 5 Wasnik , S. and P. Parmar (2011). “The design of colon – specific drug delivery system and differednt approaches to treat colon disease.” Int J Pharm Sci Rev Res 6(2):167-177
5. Nasra, M., et al. (2007). "Development of metronidazole colon-specific delivery systems." Asian J Pharm Sci 2(1): 18-28.
6. Srikanth, S., et al. "Research Journal of Pharmaceutical, Biological and Chemical Sciences." 2011,02,01,469-481
7. Patel, P., et al. (2011). "Formulation and evaluation of colon targeted tablets of Ornidazole for the treatment of amoebiasis." International Journal of Drug Development and Research 3(1): 52-61.
8. S. C. Chetan, S. N. Pushpendra, S. R. Rajendrapal, B. Viralkumar. Journal of Chemical and Pharmaceutical Research., 2010, 2, 4, 993-998.
9. Rao, K. P., et al. (2003). "Formulation and roentgenographic studies of naproxen-pectin-based matrix tablets for colon drug delivery." The Yale journal of biology and medicine 76(4-6): 149.
10. Jenita, J. J. L., et al. (2010). "Formulation and evaluation of compression coated tablets of mesalazine for colon delivery." International Journal of PharmTech Research 2(1): 535-541.
11. G.L.Simon, S.L. Gorbach.Dig.Dis.Sci.319 Suppl,1986, 147S-162S.
12. Gorbach, S. L. (1971). "Intestinal microflora." Gastroenterology 60(6): 1110-1129.
13. Rubinstein, A. (1990). "Microbially controlled drug delivery to the colon." Biopharmaceutics & drug disposition 11(6): 465-475
14. Sinha, V. R. and R. Kumria (2001). "Polysaccharides in colon-specific drug delivery." International journal of pharmaceutics 224(1-2): 19-38.
15. Sinha, V. and R. Kumria (2003). "Microbially triggered drug delivery to the colon." European journal of pharmaceutical sciences 18(1): 3-18.