Comparative analysis of in-vitro dissolution rates for sachet formulations of mesalamine (1g and 2 g) in India.

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Abstract

Objectives: This in-vitro dissolution study evaluated the 5-Amino salicylic acid (5-ASA) dissolution profiles and release patterns of four commercial mesalamine formulations in simulated environment for stomach, intestines and colon.

Methods: The release of mesalamine from 1-gram and 2-gram formulations were evaluated using 12 samples for each formulation. Mesalamine formulations used were Vegaz-OD granules (Dr. Reddy's Laboratories Ltd., India) and three other commonly available Mesalamine formulations in the market, Brand P, Brand M and Brand R. To simulate the gastrointestinal environment, samples were exposed to three stages: Acid Stage-A to mimic gastric conditions, phosphate buffer (Stage-B) to reflect intestinal conditions, and phosphate buffer (Stage-C) to simulate conditions in the colon. Mesalamine estimations were done at 1, 2, 4, 6, 8, 12, 16 and 24 hours, and F2 similarity factors were calculated for pairs. Time required for 100% dissolution and cumulative dissolutions were estimated.

Results: Vegaz-OD exhibited superior release rates over a 12-hour period, while brand M and brand R showed slower release. Vegaz-OD and brand P achieved 100% mesalamine release in 24 hours, but not by Brand R and Brand M. The release rate constant (K1) for Vegaz-OD (0.174) is higher than that of Brand P (0.160), Brand M (0.097) and Brand R (0.093) for 1 gram formulation, whereas for 2-gram formulations, Vegaz-OD, Brand R Brand P, and Brand M had K1 values of 0.183, 0.162, 0.122, and 0.091 respectively. Within 24 hours, Vegaz-OD (1g and 2g) and Brand P (1g and 2g) completely dissolved, whereas Brand M and Brand R attained about 80% dissolution.

Conclusion: The integration of controlled-release mechanisms utilizing Eudragit and ethyl cellulose in the Vegaz-OD formulation enhances the targeted delivery of mesalamine to both the small intestine and colon. This dual-site release profile positions Vegaz-OD as a promising treatment option for managing inflammatory bowel diseases effectively. Thus, it can be concluded that the technology used in Vegaz-OD makes it superior as compare to the other brands (Brand P, Brand M and brand R).

Keywords: 5-ASA, Mesalamine, Bowel disease, Gastrointestinal, dissolution.

Introduction

Inflammatory Bowel Diseases (IBD) are a group of chronic inflammatory conditions primarily affecting the gastrointestinal tract, including Crohn's disease and ulcerative colitis. The pathogenesis of IBD involves a dysregulated immune response to intestinal microbiota in genetically predisposed individuals, leading to persistent inflammation and mucosal damage.[1] Effective management IBD necessitates the use of anti-inflammatory agents to mitigate symptoms of inflammation and avert complications.[2], [3] Mesalamine, or 5-aminosalicylic acid (5-ASA), is a widely used pharmacotherapeutic agent and often the first-line treatment for managing Inflammatory Bowel Disease (IBD).[4] The pharmacodynamic mechanisms of mesalamine involve the inhibition of nuclear factor kappa B (NF-κB) and cyclooxygenase enzymes, resulting in diminished production of pro-inflammatory cytokines and prostaglandins.[5-7]. Although mesalamine can be administered as either an oral or rectal formulation, rectal administration is typically limited to cases where the rectum or distal colon is involved. This is because patients often prefer oral formulations due to the discomfort associated with rectal use, such as local leakage,

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soiling of garments, and abdominal bloating.[8] Mesalamine acts locally at the site of inflammation by inhibiting pro-inflammatory cytokines and pathways, such as the arachidonic acid cascade, thereby reducing inflammation and promoting mucosal healing.

Since the site of action of any drug in IBD is colon, oral formulations which could release adequate mesalamine in the colon would provide greater therapeutic benefit.[9-10]. Recent advancements in the formulation of mesalamine have culminated in the development of different formulations designed to release mesalamine in the colon. These formulations are either extended release, timed release, or pH-dependent release preparations to provide sustained therapeutic concentration over prolonged periods in colon, thereby enhancing patient adherence with less dosing frequency. To overcome the wide range of gastric empty time, time-dependent pellets are used for colon targeting. The gastrointestinal tract's varied pH values under diverse physiological situations necessitate the use of pH-dependent systems. Thus, the time and pH-dependent formulation ensures the novel colon drug delivery system.[11] This controlled drug release is particularly critical in chronic conditions like IBD, where consistent pharmacotherapy is essential to prevent exacerbations and facilitate long-term remission. In-vitro dissolution testing is an indispensable methodology for assessing the release profiles of mesalamine formulations under various gastrointestinal conditions.[12] These tests simulate drug release across distinct segments of the gastrointestinal (GI) tract, capturing the acidic milieu of the stomach and the variable pH levels present in the small intestine and colon. [13] A thorough understanding of these dissolution profiles is crucial for predicting drug release kinetics, which directly correlates with the therapeutic efficacy.

Although drug makers claim their products to be better compared to others, there are published reports of variable dissolution rates with different formulations [14]. This study compares the release profile of mesalamine from four commercial formulations available in India. The formulations of mesalamine for this dissolution experiments were selected based upon their wide use in India. This in-vitro study compared the 5-ASA release at physiologically relevant pH conditions. The formulations used were Vegaz-OD granules (Dr. Reddy's Laboratories Ltd., India), Brand P granules, Brand M granules, and Brand R pellets.

Materials and Methods

Study Design

This was an in-vitro dissolution testing methodology to assess the release rates of mesalamine in the gastrointestinal tract from various commercially available formulations of mesalamine.

Mesalamine formulations

The mesalamine products evaluated in this study include 1-gram and 2-gram sachets formulations of Vegaz-OD® granules from Dr. Reddy's Laboratories, India.

Study procedures

This study evaluates the in-vitro dissolution characteristics of mesalamine formulations in both 1g and 2g strengths using 12 experimental samples. To assess the effect of simulated GI conditions on the release of active 5-ASA, dissolution testing was performed across different physiologically relevant pH levels. Each formulation was individually exposed to different dissolution media to mimic the environments of the stomach, intestines, and colon. The working standard used was 5-amino-2-hydroxybenzoic acid. The dissolution testing was carried out using the USP Type II (Paddle) apparatus, employing FDA-approved methodology, and included the use of the Basket method for comparative analysis. The study was conducted in three structured phases to analyze the dissolution profiles in various media. All testing was performed at an independent site to ensure impartiality and avoid bias Table 1 as below:

Acid Stage-A employs a 100 mM hydrochloric acid solution (750 mL) to mimic gastric conditions, with paddle rotation at 100 RPM and sampling at 1 and 2 hours. Buffer was prepared using 8.5 mL of Hydrochloric acid diluted to 1 liter with water.

Phosphate buffer (Stage-B) uses a phosphate buffer at pH 6.4 (950 mL) to reflect intestinal conditions, with sampling at 1 hour. Buffer was prepared using 21.7 g/L of monobasic potassium phosphate and 0.8 g/L of sodium hydroxide added in water and adjusted with 5N sodium hydroxide or phosphoric acid to a pH of 6.4.

Phosphate buffer (Stage-C) assesses prolonged dissolution in a phosphate buffer at pH 7.2 (960 mL), with sampling at 1, 2, 4, 6, 8, 12, 16 and 24 hours to simulate conditions in the colon. Buffer was prepared by adding 20 ml of 3.3N Sodium hydroxide Solution (136 g/L of sodium hydroxide in water).

The other reagents used were sodium acetate trihydrate, acetonitrile, methanol, triethylamine, acetic acid, potassium dihydrogen phosphate, sodium hydroxide, and Milli-Q water.

Dissolution testing of mesalamine formulations initiated with the preparation of phosphate buffer solutions. Solution A is composed of 21.7 g/L of monobasic potassium phosphate and 0.8 g/L of sodium hydroxide, dissolved in deionized water, and adjusted to pH 6.4 using 5 N sodium hydroxide or phosphoric acid. Solution B consists of 136 g of sodium hydroxide in water to yield a 3.3 N solution.

Sink conditions were maintained. Sampling occurred at 1 and 2 hours for acid Stage-A; at 1 hour for buffer Stage-B, and at 1, 2, 4, 6, 8, 12, 16 and 24 hours for buffer Stage-C. After each sampling, the remaining solution is discarded, and sachet samples are preserved for later analysis.

A standard solution is prepared at 0.016 mg/mL of USP Mesalamine Reference Standard (RS) in the medium and sonicated for dissolution. Sample solutions were filtered through a 0.45 µm filter, discarding initial milliliters, and analyzed using ultraviolet (UV) spectrophotometry at 302 nm. For Buffer Stage-B, solution A is equilibrated to 37 ± 0.5 °C, transferred to dissolution vessels, and sachet samples from the Acid Stage are added. After 1 hour, a 10-mL aliquot is withdrawn for Buffer Stage-C analysis, using a standard

solution of 0.0125 mg/mL USP Mesalamine RS. The samples were similarly filtered and analyzed at 330 nm. In Buffer Stage-C, the pH of 940 mL of Solution A is adjusted to 7.2 with 20 mL of Solution B, and dissolution is initiated. Following specified intervals, 10 mL is withdrawn and replaced with medium. The standard solution for this stage is 0.0315 mg/ mL USP Mesalamine RS, with sample solutions diluted and filtered, analyzed at 332 nm.

Dissolution Study: F2 Similarity Factor

The F2 similarity factor is used to quantify the similarity of dissolution profiles different formulations [15]. It provides values on a scale of 50 to 100, with higher values indicating greater similarity. A value of 85% is the benchmark recommended by regulatory bodies like the FDA and EMA, indicating complete drug release from the dosage form. The F2 factor is calculated using the formula:

$$F_2 = 50 * \log\left(\frac{1}{\left(1 + \frac{1}{N}\sum_{t=1}^{N} |R_t - T_t|\right)} * 100 \right)$$

Where:

NNN = number of time points at which measurements were taken

Rt = percentage dissolved of the reference formulation (Brand P) at time t

Tt = percentage dissolved of the test formulation (Vegaz OD) at time t

For dissolution across the gastrointestinal tract, F2 values were determined for both 1g and 2g formulations based on dissolution profiles, with 12 hours and 10 hours selected as the relevant time points for 1g and 2g formulations, respectively. For dissolution across the intestinal tract, F2 values from 4 hours onwards were selected. This ensures the drug is effectively released primarily in the intestinal tract to maximize therapeutic efficacy.

Results

The cumulative percentage dissolution of mesalamine (1/2 gm) formulations are presented in Figure 1. For 1-gram formulations, for Vegaz OD (1 g), the mean cumulative release was 24% after 2 hours in 0.1 N HCl, 30% after 1 hour at pH 6.8, and 103% after 24 hours at pH 7.2. In contrast, Brand M (1 g) showed a release of 24% after 2 hours, 22% after 1 hour at pH 6.8, and 82% after 24 hours at pH 7.2. Brand R (1 g) had a release of 25% at 2 hours, 27% at 1 hour in pH 6.8, and 79% at 24 hours in pH 7.2. Brand P (1 g) exhibited a similar initial release of 24% after 2 hours but achieved 31% after 1 hour at pH 6.8 and 104% after 24 hours at pH 7.2. Similarly, for 2-gram formulations, Vegaz-OD granules exhibited a mean cumulative release of 25% after 2 hours in 0.1 N HCl, 28% after 1 hour at pH 6.8, and 102% after 24 hours at pH 7.2. Brand M showed similar results, with a release of 25% after 2 hours, 27% after 1 hour at pH 6.8, and 83% after 24 hours at pH 7.2. Brand R granules released 24% after 2 hours, 28% after 1 hour in pH 6.8, and 86% after 24 hours at pH 7.2. Brand P had a release of 26% after 2 hours, 29% after 1 hour at pH 6.8, and 100% after 24 hours at pH 7.2."

In-Vitro Dissolution Profiles (Cumulative % Dissolution)

Table 2 shows the cumulative percent dissolution for all the formulations, the comparative dissolution analysis of mesalamine formulations revealed that Vegaz OD consistently demonstrated a faster release profile compared to Brand M and Brand R for both 1 g and 2 g dosages. For the 1-gram formulation, Vegaz-OD exhibited superior release rates over a 12-hour period, while Brand M and Brand R showed slower release. Similarly, for the 2 g formulations evaluated over 4 to 27 hours, Vegaz OD maintained its faster release compared to both Brand M and Brand R. Brand P also displayed a relatively quicker release, but both Brand M and Brand R lagged in terms of dissolution rates.

F2 Values for Release Across the Gastrointestinal Tract

The F2 values for the dissolution profiles of mesalamine 1-gram formulations indicate notable similarities in release characteristics within the gastrointestinal tract Table 3. Specifically, Vegaz-OD exhibited a high similarity to Brand P, achieving an F2 value of 96%, while both Brand M and Brand R demonstrated an F2 value of 89%. In the assessment of 2-gram formulations over a 10-hour period, Vegaz-OD and Brand R displayed faster release rates compared to Brand P, with Vegaz maintaining a 94% similarity in its dissolution profile.

F2 Values for Release Across the Intestinal Release

The dissolution profile of Vegaz-OD demonstrates a 96% similarity to Brand P, while Brand M and Brand R exhibit 83% and 81% similarity, respectively Table 3. In the analysis of mesalamine 2-gram formulations over a duration of 4 to 27 hours, Vegaz-OD exhibited a faster release rate compared to both Brand M and Brand R, which showed slower release kinetics. The dissolution profile for Vegaz-OD maintained a 94% similarity to Brand P, whereas Brand M and Brand R demonstrated 83% and 90% similarity, respectively.

Release Kinetics of the Mesalamine

Dissolution kinetics of mesalamine were evaluated using the first-order release rate constant (K1). The release rate constant (K1) for Vegaz-OD is equivalent to that of Brand P across both 1 g and 2 g strengths. In contrast, Brand M and Brand R demonstrate slower and incomplete drug release (<90%) compared to both Brand P and Vegaz-OD. Notably, Brand R exhibits variability in release rate constants between the 1 g and 2 g doses. For 1-gram formulations, the release of Vegaz-OD was faster than Brand M, Brand P and Brand R with 25% release occurring at 1.65, 2.95, 3.10, 1.80 hours respectively for 1-gram formulations Table 4. Similar observations were noted for 2-gram formulations. Time required for 90% dissolution was 13.21 hours with Vegaz-OD 1 gram formulation, whereas Brand M and Brand R formulations required about 24 hours for 90% dissolution. Similar trend was seen with 2-gram formulations. The time required for Vegaz OD to release 25%,

50%, 75%, 80%, and 90% of the drug aligns closely with Brand P, indicating that Vegaz-OD releases mesalamine in a similar pattern Table 4. Overall, based on F2 similarity values and release kinetics, Vegaz-OD shows greater similarity to Brand P than other brands, potentially facilitating enhanced localized drug concentrations in the colon.

Discussion

This study evaluated the 5-ASA dissolution profiles of four commercial mesalamine formulations in simulated environment for intestines and colon. For inflammatory bowel disorders like Crohn's disease, which primarily affects the intestines, it's crucial for the drug to be released predominantly in the intestinal tract to maximize therapeutic efficacy. To prevent release of mesalamine in stomach and delay the release of 5-ASA until the drug reaches the colonic mucosa, many mesalamine formulations use pH-dependent release mechanisms that limit the drug release in acidic environments.[16] The comparative analysis of in-vitro dissolution profiles for mesalamine formulations at both 1 gram and 2 gram formulations reveal significant insights into their release kinetics and overall therapeutic potential. We observed that Vegaz-OD consistently exhibited superior release rates (100%) compared to its counterparts, Brand M and Brand R, across both dosage strengths. The dissolution profiles also illustrated the better performance of Vegaz-OD and Brand P over Brand M and Brand R. This enhanced release profile underscores Vegaz-OD's efficacy in delivering mesalamine, crucial for optimizing treatment regimens for inflammatory bowel disease (IBD) patients. The consistent findings with Vegaz-OD imply the importance of the specific matrix composition and the formulation strategy employed for Vegaz-OD, especially the impact of coating agents like Eudragit and ethyl cellulose. Ethyl cellulose functions as a coating agent that enables controlled release of mesalamine, prolonging its therapeutic effect. Eudragit is a polymer widely used in drug formulations to design pH-triggered delivery systems, and different grades of Eudragit have been used for designing and delivery of therapeutics at a specific site via the oral route. Notably, most commercially available sachet formulations rely on either pH or time-dependent technology; however, Vegaz-OD combines both. This dual approach ensures that the therapeutic effect of mesalamine is sustained across nearly the entire gastrointestinal tract, optimizing drug release from the stomach to the colon.[17] The optimal coating with Eudragit and Ethyl cellulose is critical for delayed release of mesalamine.[18] The duration of action varies by formulation and is designed to provide extended release, typically lasting several hours, influenced by composition and patient-specific pharmacokinetics. Our study shows that mesalamine release are consistent with previous observations of 5-ASA release from multimatrix mesalamine in similar conditions. [19,20]

When comparing the similarity of different formulations, the F2 (similarity factor) is particularly important for assessing how similar the drug release profiles are during the time the drug is expected to be released in the intestine. The calculated F2 similarity values provide further insights into the dissolution kinetics of the formulations, revealing a high degree of similarity between Vegaz-OD and Brand P (96% for 1 g and 94% for 2 g formulations), suggesting a comparable therapeutic efficacy within the gastrointestinal tract. In contrast, Brand M and Brand R exhibited lower F2 values, indicating less similarity in their release profiles, which could impact their clinical effectiveness in localized treatment scenarios (**Table 1, 2,3,4) and Figure 1**.

Dissolution kinetics assessed through first-order release rate constants (K1) elucidated that Vegaz-OD demonstrated a dissolution time of approximately 13.21 hours for the 1 g formulation, considerably shorter than the 23.62 hours required by Brand M. This delineation of release profiles is vital as it informs clinicians regarding the expected time frames for therapeutic action and the potential need for dosage adjustments in clinical practice. The role of ethyl cellulose as a controlled release agent is particularly noteworthy. Its influence in prolonging mesalamine's therapeutic effect cannot be overstated, as the formulation is designed to provide sustained release lasting several hours. This controlled release is particularly beneficial for IBD patients, where achieving consistent drug levels can significantly enhance therapeutic outcomes.

Table 1. *Dissolution media details.*

Stages	***Acid Stage A***	***Buffer Stage B***	***Buffer Stage C***
Dissolution Media	**0.1 N hydrochloric acid**	**Phosphate buffer**	**Phosphate buffer**
pH	< 1 pH	6.4 pH	7.2 pH
Volume (mL)	750 mL	950 mL	940 mL + 20 mL Solution B
Sampling time (h) point	1Hr, 2Hrs	1Hr	1Hr, 2Hrs, 4Hrs,6Hrs, 8Hrs, 12Hrs,16Hrs and 24Hrs
Rotation Speed (rpm)	100 rpm	100 rpm	100 rpm
Acid Stage Procedures	Withdraw solution samples after 1 and 2 h, preserving sachet samples for further analysis.	Use equilibrated Solution A at 37 ± 0.5°C and Transfer to dissolution vessels, add sachet samples and After 1 hour, withdraw 10 mL aliquot for Buffer Stage B	Adjust pH of 940 mL Solution A to 7.2 with 20 mL Solution B. and withdraw 10 mL at specified intervals, replacing with Medium.
Apparatus	USP Type I (Basket)	USP Type I (Basket)	USP Type I (Basket)
Standard Solution	0.016 mg/mL USP Mesalamine RS in Medium, sonicated.	0.0125 mL USP Mesalamine RS, sonicated.	0.0315 mg/mL USP Mesalamine RS, sonicated.
Sample Solution	Filter through a 0.45-µm filter, discarding initial millilitres.	Filter, discarding initial millilitres.	Dilute 2.5 mL to 100 mL and filter.
Instrumental Conditions	UV mode at 302 nm; blank as Medium.	UV mode at 330 nm.	UV mode at 332 nm.

Table 2. *Cumulative percent dissolution of all the formulations.*

Cumulative % Drug dissolution												
Sample no.		Acid		Buffer	Buffer							
		Stage		Stage-1	Stage-2							
		1hr	2hr	1hr	1hr	2hr	4hr	6hr	8hr	12hr	16hr	24hr
1 gm Mesalamine												
Vegaz-OD	*Mean*	25	24	30	54	66	80	83	88	90	99	103
	*%RSD**	6.58	3.9	3.38	5.28	5.55	3.12	2.9	2.06	1.64	2.46	1.25
Brand M	*Mean*	25	24	30	54	66	80	83	88	90	99	103
	*%RSD**	6.58	3.9	3.38	5.28	5.55	3.12	2.9	2.06	1.64	2.46	1.25
Brand R	*Mean*	25	25	27	39	48	54	61	67	70	76	79
	*%RSD**	6.28	5.6	4.34	3.06	4.88	4.49	3.74	3.95	3.43	2.76	1.52
Brand P	*Mean*	24	24	31	46	55	77	81	89	96	100	104
	*%RSD**	6.57	4.4	3.53	4.23	5.24	4.21	2.32	1.97	1.91	1.41	1.46
2 gm Mesalamine												
Vegaz-OD	*Mean*	26	25	28	57	68	81	86	90	94	97	102
	*%RSD**	4.31	2.69	3.4	7.36	4.6	2.66	1.94	2.23	1.85	1.46	1.13
Brand M	*Mean*	25	25	27	28	38	48	62	72	76	80	83
	*%RSD**	4.49	3.96	3.87	5.28	6.74	4.7	4.95	3.31	2.21	1.87	1.46
Brand R	*Mean*	24	24	28	68	71	74	76	79	81	83	86
	*%RSD**	4.18	4.54	4.35	2.57	2.44	2.18	1.84	1.75	1.2	0.85	0.72
Brand P	*Mean*	25	26	29	49	61	69	77	85	89	96	100
	*%RSD**	6.28	5.6	4.34	3.07	4.91	4.52	3.76	3.97	3.44	2.77	1.53

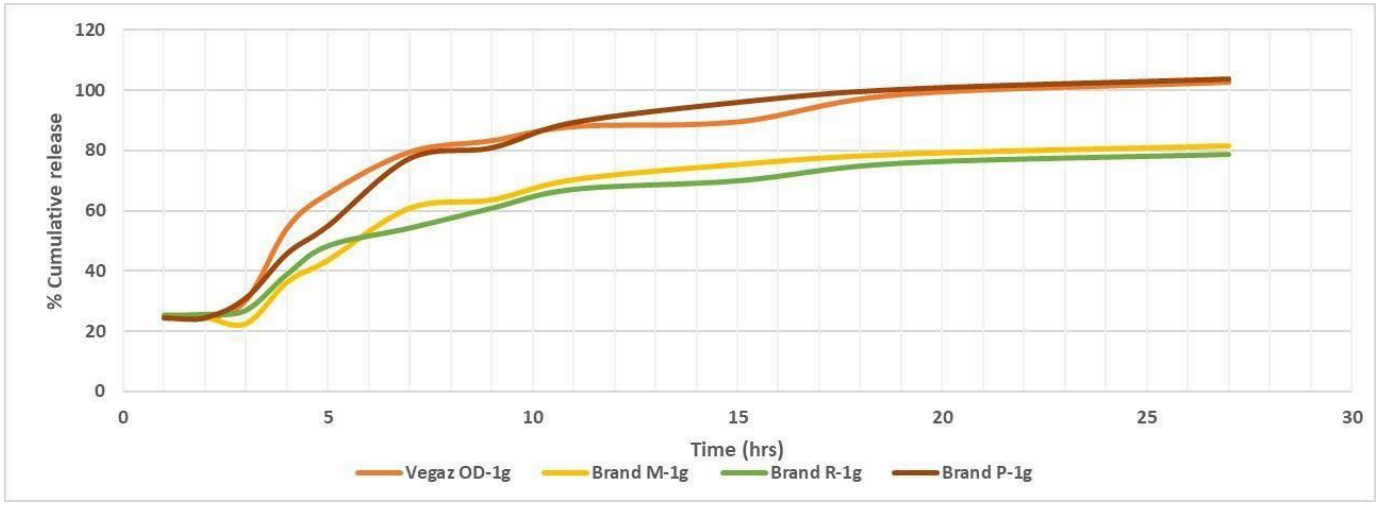
Table 3. *F2 (similarity factor) values for mesalamine formulations.*

Across gastrointestinal tract Across intestinal tract						
	Time	*F2*	*Similarity (%)*	*Time*	*F2*	*Similarity (%)*
1 gm Mesalamine						
Brand P - Vegaz-OD	12 hrs.	65	96%	4 hrs. to 24 hrs.	63	96%
Brand P - Brand M	12 hrs.	45	89%	4 hrs. to 24 hrs.	37	83%
Brand P - Brand R	12 hrs.	43	89%	4 hrs. to 24 hrs.	34	81%
Vegaz-OD - Brand M	12 hrs.	40	87%	4 hrs. to 24 hrs.	36	81%
Vegaz-OD - Brand R	12 hrs.	39	87%	4 hrs. to 24 hrs.	33	79%
2 gm Mesalamine						
Brand P - Vegaz-OD	10 hrs.	58	94%	4 hrs. to 24 hrs.	57	94%
Brand P - Brand M	10 hrs.	41	88%	4 hrs. to 24 hrs.	38	83%
Brand P - Brand R	10 hrs.	54	94%	4 hrs. to 24 hrs.	48	90%
Vegaz-OD - Brand M	10 hrs.	33	83%	4 hrs. to 24 hrs.	31	76%
Vegaz-OD - Brand R	10 hrs.	60	95%	4 hrs. to 24 hrs.	47	89%

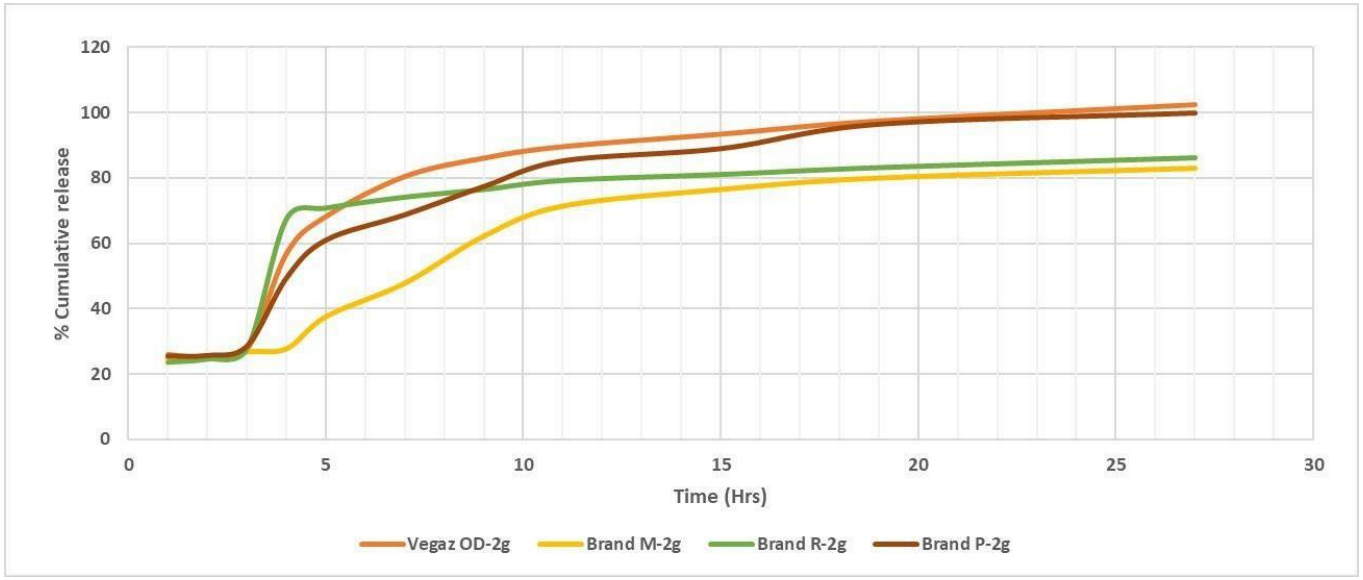
Table 4: *Release kinetics of the mesalamine formulations.*

Product K1 (1st order release Rate constant)		Time required for specific release (h)				
		25%	50%	75%	80%	90%
1 gm formulation						
Vegaz-OD	0.174	1.65	3.98	7.95	9.23	13.21
Brand M	0.097	2.95	7.11	14.22	16.51	23.62
Brand R	0.093	3.1	7.46	14.92	17.32	24.78
Brand P	0.16	1.8	4.33	8.65	10.05	14.37
2 gm formulation						
Vegaz-OD	0.183	1.57	3.79	7.58	8.8	12.59
Brand M	0.091	3.17	7.64	15.29	17.75	25.39
Brand R	0.162	1.77	4.27	8.54	9.91	14.18
Brand P	0.152	1.89	4.56	9.13	10.6	15.16

In summary, the present study demonstrates that Vegaz-OD exhibits superior in vitro dissolution profiles compared to Brand M and Brand R. Its performance, characterized by faster and more complete release of mesalamine, positions it as a promising formulation for the management of IBD. Although physiologically relevant pH conditions were used in our study, the phosphate buffer used may not be physiologically relevant, limiting the ability to correlate results with in-vivo performance.[21] Future clinical investigations are needed to validate these findings and explore their implications for



(A)



(B)

Figure 1: *Cumulative percentage dissolution of mesalamine (1/2 gm) formulations.*

A): Mesalamine 1 gm formulations; B): Mesalamine 2 gm formulations

patient treatment regimens, ensuring optimal therapeutic efficacy. The integration of controlled release mechanisms through innovative formulation strategies is pivotal in enhancing the localized delivery of mesalamine, ultimately aiming to improve the quality of life for individuals affected by inflammatory bowel disease.

Conclusion

This study offers critical insights into the dissolution characteristics of mesalamine formulations, particularly emphasizing the roles of Eudragit and ethyl cellulose in achieving controlled release. The results indicate that Vegaz-OD (1/2 gram) and Brand P (1/2 gram) attain complete dissolution within 24 hours, whereas Brand M and Brand R reach approximately 80% dissolution. All formulations display similar dissolution profiles under gastric and duodenal conditions. Notably, Vegaz-OD's Eudragit coating effectively inhibits drug release at lower pH levels, while ethyl cellulose ensures sustained release over 16 hours, enhancing bioavailability. Comparative analysis reveals that Vegaz-OD closely resembles Brand P in release rates, supporting its potential as an effective treatment for inflammatory bowel disease.

Conflicts of interest

The authors declare no conflicts of interest regarding the publication of this study. All financial support and sponsorship have been acknowledged, and there are no personal or professional relationships that could influence the outcomes or interpretations presented in this work.

Author contributions

DY: Conceptualization, Data collection, formal analysis, Manuscript- review and editing; **VC:** Conceptualization, Data collection, formal analysis, Manuscript- review and editing; **RB:** Investigation, Formal analysis, Manuscript- writing original draft, Manuscript- review and editing; **SY:** Resources, Manuscript- review and editing; **KP:** Formal

analysis, Manuscript- review and editing, supervision; **PK:** Manuscript- writing original draft, Manuscript- review and editing; **AS:** Conceptualization, Manuscript- review and editing; **SK:** Manuscript- writing original draft, Manuscript- review and editing.

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Ethical standards statement

This manuscript does not contain clinical studies or patient data.

Data availability

The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request. Access to the raw data will be provided to qualified researchers for purposes of replicating or extending the research findings. All relevant data supporting the conclusions of this study are included in the manuscript and its supplementary materials.

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