STM JOURNALS

Journal of
Polymer & Composites

ISSN: 2321-2810 (Online)
ISSN: 2321-8525 (Print)
Volume 14, Special Issue 2, 2026
DOI (Journal): 10.37591/JoPC

https://journals.stmjournals.com/jopc

Research JoPC

Polymer-Coated Composite Granules of Clarithromycin: Design, Characterization, and Functional Evaluation for Taste Masking and Antibacterial Performance

Mahesh Bhalsing [1,*], Kratika Daniel[2]

Abstract

Background: Masking the unpleasant taste of clarithromycin is essential to improve patient adherence, especially among pediatric and elderly groups. However, enhancing palatability while maintaining its antibacterial effectiveness remains a significant formulation challenge. This study focused on developing polymer-coated clarithromycin granules (B1–B10) using novel non-sugar-based polymers and assessing their antibacterial activity against Staphylococcus aureus Methods: Clarithromycin granules were produced using a fluidized bed coating technique with non-saccharide polymers, specifically Eudragit E-100 and ethyl cellulose. The antibacterial activity of each formulation was assessed by the agar diffusion method, measuring zones of inhibition and comparing them with the uncoated drug and a streptomycin reference. Additionally, FESEM and dissolution studies were conducted to evaluate the granules' morphology and functional performance Results: All granule batches exhibited antibacterial activity, confirming retention of therapeutic action after coating. Batch B9 showed the highest inhibition zone (0.55 cm diameter, 0.24 cm² area), suggesting optimized polymer selection and coating thickness. Streptomycin (2.2 cm diameter, 3.79 cm² area) validated assay sensitivity. FESEM analysis revealed a porous, uniform coating enhancing dissolution. Tablets prepared from B9 showed 98.1% drug release within 30 minutes, with excellent physical properties Conclusion: The optimized batch (B9) achieved effective taste masking without loss of antibacterial efficacy. The polymer coating improved drug diffusion and stability, representing a promising approach for developing patient-compliant clarithromycin formulations.

Keywords: Clarithromycin; polymer composites; drug–polymer interaction; functional coating; controlled permeability; taste masking; antibacterial activity

INTRODUCTION

Oral drug delivery remains the most preferred route for systemic therapy owing to patient compliance and ease of administration. However, the bitterness of many active pharmaceutical ingredients, particularly macrolides such as clarithromycin, limits patient adherence—especially in pediatric and geriatric populations [1–2]. Clarithromycin is a broad-spectrum macrolide antibiotic effective against Gram-positive and Gram-negative bacteria but is intensely bitter. Hence, efficient taste masking is essential to ensure patient acceptability while maintaining its antibacterial potency [3–4].

Taste masking of antibiotics poses a unique challenge because the polymeric coating must prevent drug dissolution in saliva (pH 6.8–7.4) while allowing immediate release in the gastrointestinal tract (pH 1.2–6.8). An excessively thick or insoluble coating may impede dissolution,

***Author for Correspondence**
Mahesh Bhalsing

[1]Research Scholar, Faculty of Pharmacy, Oriental University, Indore, Madhya Pradesh, India
[2]Supervisor, Faculty of Pharmacy, Oriental University, Indore, Madhya Pradesh, India

Received Date: April 09, 2026
Accepted Date: April 21, 2026
Published Date: May 10, 2026

Citation: Mahesh Bhalsing, Kratika Daniel. Polymer-Coated Composite Granules of Clarithromycin: Design, Characterization, and Functional Evaluation for Taste Masking and Antibacterial Performance. Journal of Polymer & Composites. 2026; 14(Special Issue 2): S1042–S1050p.

reducing bioavailability and therapeutic efficacy. Conversely, inadequate coating fails to suppress bitterness. The challenge thus lies in achieving a fine balance between palatability and bioavailability [5].

Bioavailability refers to the proportion of an administered drug that reaches systemic circulation in an active form. In oral formulations, it is influenced by drug solubility, dissolution rate, and permeability across the gastrointestinal membrane. Taste-masking approaches, particularly polymer coatings, can affect bioavailability by altering drug release behavior. Therefore, it is essential to design coating systems that prevent drug release in the oral cavity while ensuring rapid and complete release under gastric conditions [6].

From a materials science perspective, polymer coatings act as functional interfaces that govern drug release, diffusion, and surface interaction. These systems can be described as polymer–drug composites, where the physicochemical properties of the polymer matrix—including solubility, permeability, glass transition behavior, and film-forming ability—play a decisive role in formulation performance. Eudragit E-100, a cationic polymethacrylate, exhibits pH-dependent solubility, while Ethyl Cellulose serves as a hydrophobic diffusion barrier. The synergistic combination of these polymers enables the design of a responsive coating system capable of modulating drug release kinetics while maintaining structural integrity [7].

Antibacterial studies following formulation changes are vital to confirm that drug activity remains unaltered post-coating. The agar diffusion assay (Zone of Inhibition test) serves as a direct biological measure correlating formulation performance with pharmacological activity [7]. Non-saccharide polymers like Eudragit E-100, Ethyl Cellulose, and HPMC are increasingly used due to their controlled-release profiles and physicochemical stability [8–9].

Clarithromycin exerts its antibacterial effect by inhibiting bacterial protein synthesis. It binds selectively to the 50S ribosomal subunit of susceptible microorganisms, thereby preventing peptide chain elongation and ultimately blocking bacterial growth. This action is primarily bacteriostatic, although it may exhibit bactericidal effects at higher concentrations against certain organisms. Its broad-spectrum activity against both Gram-positive and Gram-negative bacteria makes it an important therapeutic agent; however, maintaining its bioactivity after formulation modification is essential to ensure clinical effectiveness.

The present study was designed to develop clarithromycin granules coated with innovative non-saccharide polymers for dual functionality—effective taste masking and preserved antibacterial efficacy. The antibacterial performance was evaluated against *Staphylococcus aureus* (ATCC 25923) using the Zone of Inhibition method, followed by physicochemical and morphological analysis to validate formulation performance.

MATERIALS AND METHODS

Materials

Clarithromycin was procured from Taj Pharmaceuticals Ltd., Gujarat. Eudragit E-100 and Ethyl Cellulose were supplied by Evonik India Pvt. Ltd. HP-β-Cyclodextrin, lactose, PVP K30, talc, and magnesium stearate were of analytical grade. *Staphylococcus aureus* (ATCC 25923) was obtained from the Department of Microbiology, SCSSS's Sitabai Thite College of Pharmacy, Shirur.

Preparation of Polymer-Coated Granules

Granules were prepared via bottom-spray fluidized bed coating (MiniQuest F, ACG Pharma) using polymeric solutions of Eudragit E-100 and Ethyl Cellulose dissolved in acetone and IPA. Clarithromycin (100 g) was fluidized, and the polymeric solution was atomized at 3–5 mL/min under an inlet temperature of 40–50°C and atomization pressure of 1.5–2 bar. Ten batches (B1–B10) were developed with varying polymer ratios and plasticizer concentrations. Each granule sample contained 50 mg clarithromycin equivalent for antibacterial testing.

The preparation of polymer-coated composite granules was carried out in a systematic sequence to ensure uniform coating and reproducibility. Initially, clarithromycin was accurately weighed and introduced into the fluidized bed chamber for pre-heating and fluidization. In the next step, a polymeric coating solution containing Eudragit E-100 and Ethyl Cellulose dissolved in a suitable solvent system was prepared under continuous stirring to achieve homogeneity. The coating process was initiated by atomizing the polymer solution onto the fluidized drug particles under controlled temperature and pressure conditions. As the solvent evaporated, a thin polymeric film was formed around each particle, resulting in a core–shell structure. Finally, the coated granules were dried, collected, and stored in airtight conditions for further evaluation.

The efficiency of polymer coating was strongly influenced by key process parameters such as inlet temperature, spray rate, and atomization pressure. A higher inlet temperature facilitated rapid solvent evaporation, leading to uniform film formation, whereas excessively high temperatures could cause surface defects or drug degradation. The spray rate played a critical role in determining coating thickness; an optimized rate ensured uniform deposition, while a higher rate resulted in agglomeration and uneven coating. Similarly, atomization pressure governed droplet size and distribution, directly affecting coating uniformity. Therefore, careful optimization of these parameters was essential to achieve consistent coating efficiency and desired functional performance [10-12].

Polymer–Drug Composite Formation and Mechanism

The coating process resulted in the formation of a core–shell composite structure, where clarithromycin particles were encapsulated within a polymeric film. The mechanism involved solvent evaporation and film deposition, producing a continuous polymer layer.

Ethyl Cellulose contributed to hydrophobic resistance, reducing premature drug release in saliva, while Eudragit E-100 facilitated rapid dissolution in acidic conditions. This combination created a pH-responsive composite system with controlled permeability [13].

Antibacterial Activity (Zone of Inhibition Method)

The antibacterial efficacy of clarithromycin granules was evaluated using the agar diffusion method. Mueller–Hinton agar plates were inoculated with *S. aureus* suspension adjusted to 0.5 McFarland standard (1.5×10^8 CFU/mL). Granules equivalent to 50 mg clarithromycin were placed on the agar surface. Streptomycin (10 µg/disc) served as a positive control, and uncoated clarithromycin as reference. Plates were incubated at 37°C for 24 hours. The inhibition zone diameters were measured using a digital caliper, and areas were calculated using Equation (1):

$$Area\ (cm^2) = \pi\left(\frac{d}{2}\right)^2$$

where A = inhibition zone area (cm²), D = zone diameter (cm).

All experiments were conducted in triplicate [14-15].

Morphological and Physical Evaluation

Granules were analyzed for flow properties, bulk density, and compressibility index. Morphology was examined by FESEM (5 kV) to assess coating integrity. The optimized granules (Batch B9) were compressed into orally disintegrating tablets (400 mg each) containing Kollidon CL, Aspartame, Raspberry flavor, and magnesium stearate. Tablets were tested for hardness, friability, disintegration time, and dissolution at pH 1.2 [16-20].

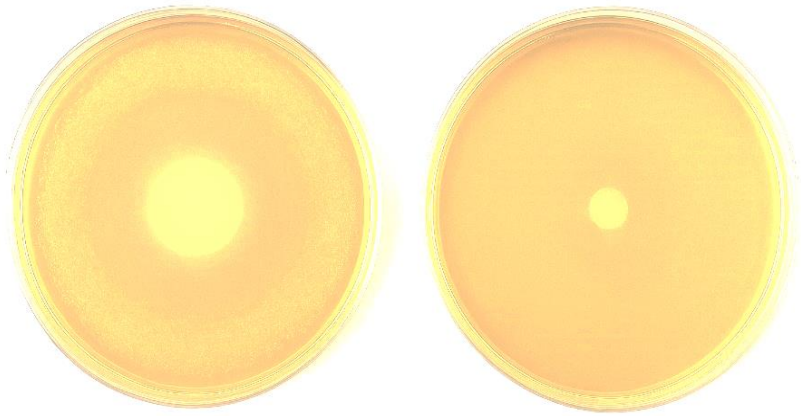
RESULTS

Antibacterial Activity

All polymer-coated batches exhibited antibacterial activity against *S. aureus*, confirming retained drug efficacy post-coating (Table 1). Batch B9 exhibited the highest inhibition zone (0.55 cm diameter; 0.24 cm² area). The Streptomycin control demonstrated a 2.20 cm inhibition zone (3.79 cm²), validating assay sensitivity (Figure 1).

Table 1. Zone of inhibition of clarithromycin granule batches against Staphylococcus aureus.

Batch	Diameter (cm)	Area (cm²)
B1	0.50	0.20
B2	0.51	0.20
B3	0.52	0.21
B4	0.52	0.21
B5	0.50	0.20
B6	0.53	0.22
B7	0.51	0.20
B8	0.52	0.21
B9	0.55	0.24
B10	0.50	0.20
Streptomycin (control)	2.20	3.79



Streptomycin (control) Clarithromycin batch B9

Figure 1. Zone of inhibition of streptomycin (Control) and clarithromycin batch B9 against S. aureus
(The figure shows two distinct clear zones on agar plates, with Streptomycin exhibiting a larger inhibition area and B9 showing a measurable, uniform zone indicating effective diffusion.).

Morphological Characterization

FESEM images revealed that uncoated clarithromycin showed a crystalline, irregular surface, while coated granules (B9) exhibited a uniform, porous, and smooth morphology. This surface modification indicates successful polymer deposition and improved wettability, which likely contributed to enhanced diffusion and antibacterial performance (Figure 2).

Pure clarithromycin exhibits plate-like, highly crystalline particles with sharp edges and layered morphology. Partial coating results in fragmented particles with non-uniform polymer coverage. Progressive polymer deposition produces smoother, aggregated granules with reduced crystallinity. The optimized batch (B9) displays a continuous, uniform polymer film with controlled surface porosity, indicating effective coating integrity conducive to taste masking and rapid drug release under acidic conditions (Figure 3).

Tablet Evaluation

The optimized batch (B9) tablets exhibited satisfactory pharmaceutical properties: Weight = 400.32 ± 1.25 mg; Hardness = 3.52 ± 0.18 kg/cm²; Friability = 0.16 ± 0.02%; Disintegration = 40.12 ± 0.28 s.

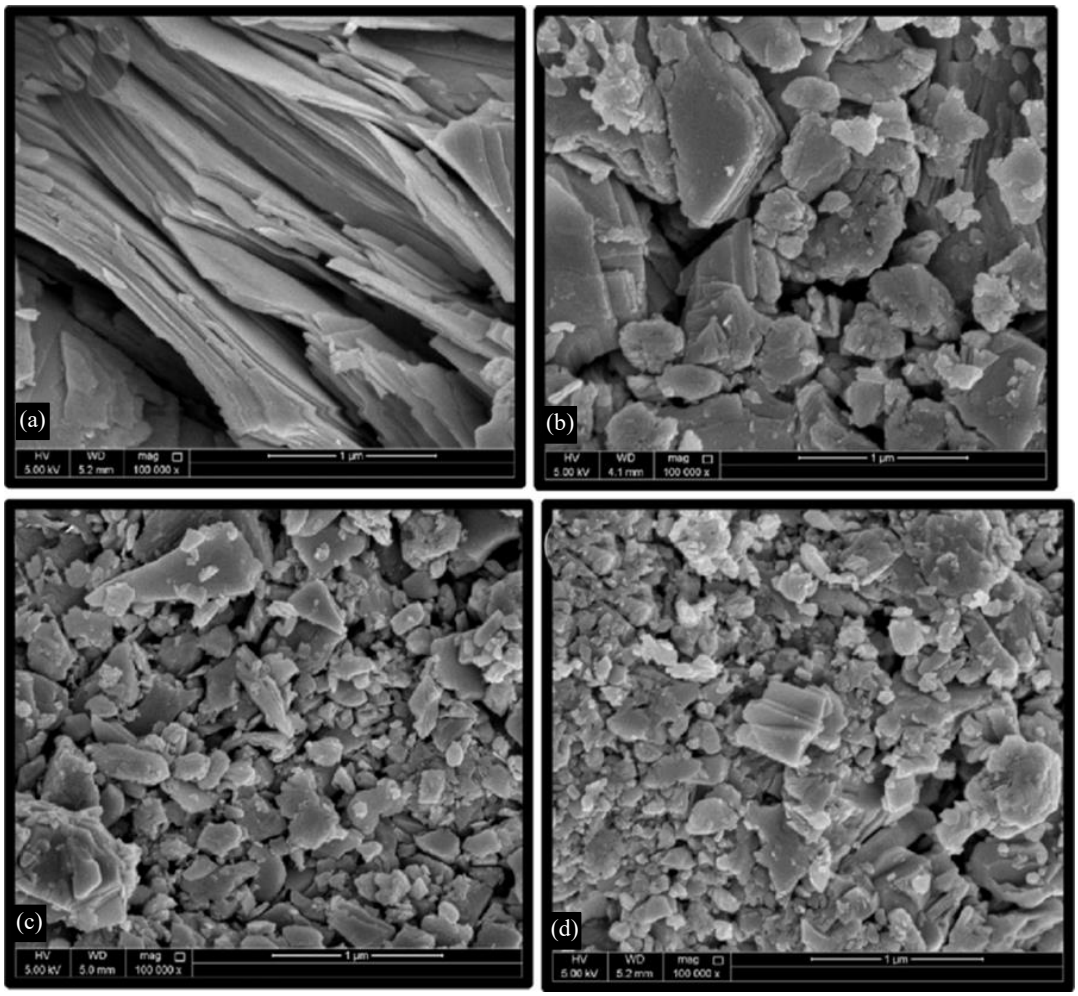


Figure 2. FESEM analysis of clarithromycin and polymer-coated granules.
Field-emission scanning electron microscopy (FESEM) micrographs showing surface morphology of (a) pure clarithromycin, (b) partially coated granules, (c) polymer-coated granules from intermediate batches, and (d) optimized polymer-coated granules (Batch B9), recorded at 100,000× magnification (scale bar = 1 µm).

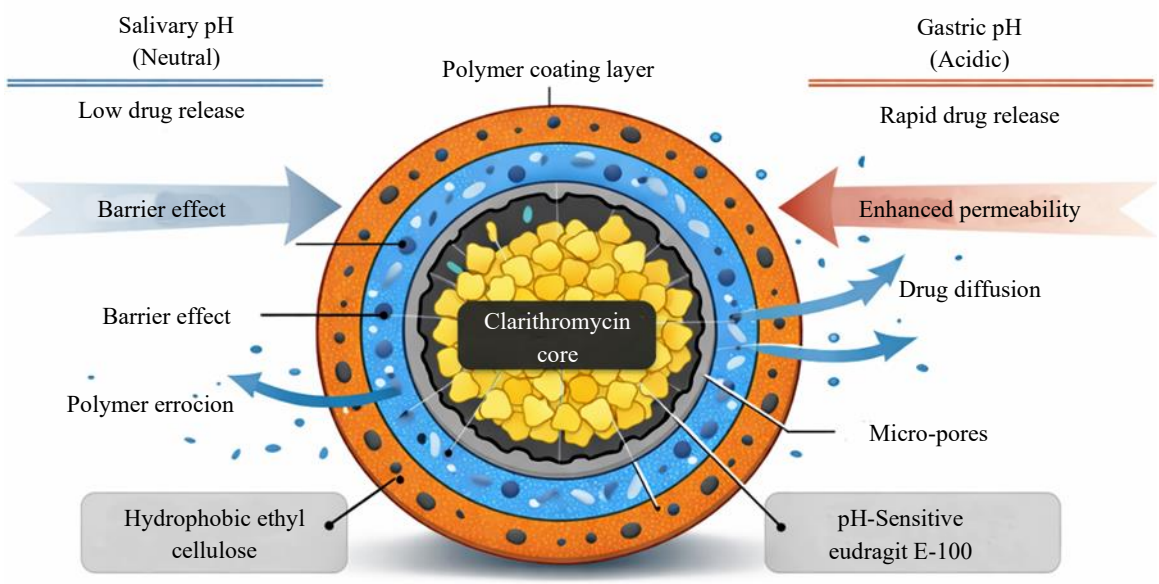


Figure 3. Schematic representation of polymer-coated composite granule showing core–shell structure.

Table 2. Evaluation of final tablet formulation (Batch B9).

Parameter	Result (Mean ± SD)	Pharmacopoeial limit
Weight Variation(mg)	400.32 ± 1.25	±5% (380-420 mg)
Hardness (kg/cm²)	3.52 ± 0.18	3 – 4 kg/cm²
Friability (%)	0.16 ± 0.02	≤1%
Disintegration Time (sec)	40.12 ± 0.28	≤60 sec
% Drug Release (30 min, pH 1.2)	98.1% ± 1.2%	≥85%

Table 3. Dissolution profile of batch B9 vs. marketed product.

Time (minutes)	% Clarithromycin released (batch B9)	% Clarithromycin released (marketed RDT)
5	40.2% ± 1.1%	62.5% ± 1.4%
10	68.1% ± 1.0%	84.2% ± 1.2%
15	82.4% ± 0.8%	92.3% ± 1.1%
20	91.5% ± 1.0%	97.4% ± 0.9%
30	98.1% ± 1.2%	99.5% ± 0.8%

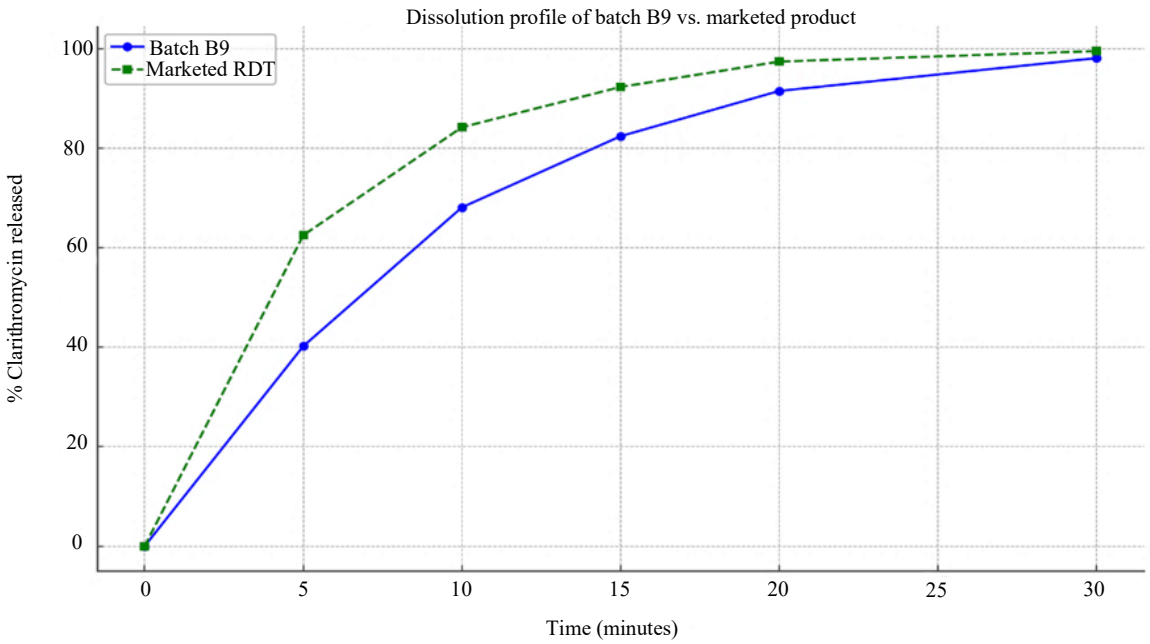


Figure 4. Comparison of dissolution profiles of clarithromycin: batch B9 vs. marketed RDT.

Dissolution testing in 0.1N HCl (pH 1.2) showed 98.1 ± 1.2% drug release in 30 min, confirming rapid release and complete availability.

Tablets were assessed for weight variation, hardness, friability, disintegration time, and in vitro drug release to confirm conformance with pharmacopoeial standards (Table 2).

Each parameter plays a crucial role in ensuring tablet uniformity, mechanical stability, patient compliance, and effective drug delivery.

In-Vitro Dissolution Study

Dissolution testing evaluates the drug release profile of the tablet formulation, ensuring optimal drug release (Table 3). The dissolution profile of Batch B9 was compared with a marketed clarithromycin rapidly disintegrating tablet (RDT) under identical conditions as depicted in Figure 4.

A one-way ANOVA was applied to compare the dissolution profiles of batches B1–B10, confirming that Batch B9 had a significantly higher drug release ($p < 0.05$). Further, similarity factor (f2) analysis between Batch B9 and the marketed formulation yielded a value of 71.6, indicating comparable release profiles.

Stability Studies

Accelerated stability (40°C/75% RH, 3 months) showed negligible changes in hardness, color, or drug release (maintained >95%). The formulation demonstrated excellent physical and chemical stability suitable for commercial scale-up.

DISCUSSION

The present study can be interpreted through the framework of polymer composite science, where the coated granules function as multi-component systems integrating drug and polymer phases. The performance of such systems is strongly dependent on polymer composition, film uniformity, and interfacial characteristics. The dual-polymer approach employed in this work enabled the development of a controlled permeability barrier, demonstrating how polymer engineering can be utilized to tailor drug release and sensory properties simultaneously.

The antibacterial evaluation clearly demonstrated that polymer coating of clarithromycin granules did not compromise the intrinsic antimicrobial activity of the drug. All formulated batches (B1–B10) produced measurable zones of inhibition against *Staphylococcus aureus*, confirming that the coating system permitted effective drug diffusion from the granules into the agar medium. This observation is critical because polymer-based taste-masking approaches can sometimes hinder drug release if the coating is excessively dense or impermeable. The presence of inhibition zones across all batches indicates that the selected non-saccharide polymers were appropriately balanced to mask bitterness in the oral cavity while allowing rapid drug availability under test conditions.

Among all formulations, Batch B9 exhibited the largest zone of inhibition (0.55 cm diameter; 0.24 cm^2 area), highlighting its superior antibacterial performance relative to other coated batches. The incremental increase in inhibition zone from B1 to B9 suggests a formulation-dependent enhancement in drug diffusion, likely arising from optimized polymer ratio, coating thickness, and surface characteristics. Although the inhibition zone produced by clarithromycin formulations was smaller than that of the streptomycin control, this outcome is expected due to differences in aqueous solubility, molecular diffusion rates, and mechanisms of antibacterial action. Importantly, the consistent antibacterial response of Batch B9 confirms that the optimized coating neither chemically interacted with nor inactivated clarithromycin, thereby preserving its therapeutic efficacy.

Morphological characterization using FESEM provided crucial insight into the structural basis underlying the observed antibacterial and dissolution behavior. Pure clarithromycin displayed irregular, plate-like crystalline particles with sharp edges, a morphology typically associated with poor wettability and rapid exposure of the drug in the oral cavity, contributing to bitterness. In contrast, the optimized polymer-coated granules (Batch B9) exhibited a smooth, uniform, and porous surface with reduced crystallinity. The formation of a continuous polymeric film around the drug particles confirms successful deposition of Eudragit E-100 and Ethyl Cellulose, effectively shielding the drug from immediate salivary contact while maintaining permeability under acidic conditions. The controlled surface porosity observed in Batch B9 likely facilitated efficient penetration of dissolution media, thereby supporting enhanced drug diffusion during antibacterial testing.

The tablet evaluation results further validated the robustness of the optimized formulation. Batch B9 tablets complied with pharmacopoeial requirements for weight variation, hardness, friability, and disintegration time, indicating uniformity, mechanical integrity, and patient-friendly performance. Rapid disintegration within approximately 40 seconds ensured prompt exposure of the coated granules to gastric fluid, while the high drug release (98.1% within 30 minutes) confirmed that the polymer

coating did not impose a diffusion barrier in acidic environments. These findings underscore the dual functionality of the coating system—effective taste masking in the oral cavity and rapid drug release post-swallowing.

In vitro dissolution studies revealed a controlled yet efficient release profile for Batch B9 when compared with a marketed rapidly disintegrating tablet. Although the marketed product showed slightly faster initial release, Batch B9 achieved nearly complete drug release within 30 minutes, closely matching the reference product. The statistically significant improvement in drug release among batches, as confirmed by one-way ANOVA, emphasizes the role of optimized polymer composition in governing release kinetics. Furthermore, the similarity factor ($f_2 = 71.6$) indicates that the dissolution behavior of Batch B9 is comparable to that of the marketed formulation, supporting its potential for therapeutic equivalence.

The observed dissolution behavior of the optimized formulation indicates that the polymer coating did not compromise drug bioavailability. The rapid release of clarithromycin in acidic conditions suggests that the coating system successfully maintained drug availability for absorption. This confirms that the formulation achieved a balance between effective taste masking and preservation of pharmacokinetic performance.

The improved performance of Batch B9 can be attributed to an optimal balance between hydrophilic and hydrophobic polymer fractions, resulting in a semi-permeable composite structure. This structure facilitated selective diffusion of the drug under physiological conditions, highlighting the importance of polymer ratio optimization in composite coating systems.

Accelerated stability studies demonstrated that the optimized formulation retained its physical appearance, mechanical strength, and drug release profile over three months under stressed conditions. The maintenance of drug release above 95% suggests that the polymer coating provided adequate protection against environmental factors such as temperature and humidity, contributing to formulation stability. Collectively, these results establish a strong correlation between surface morphology, dissolution behavior, antibacterial efficacy, and stability, confirming that Batch B9 represents a well-balanced formulation capable of improving patient compliance without sacrificing therapeutic performance.

CONCLUSION

This study establishes the successful development of a polymer-based composite coating system for clarithromycin, demonstrating the critical role of polymer engineering in pharmaceutical formulation design. The combination of Eudragit E-100 and Ethyl Cellulose enabled the formation of a functional coating that effectively masked bitterness while preserving antibacterial activity. The optimized formulation exhibited desirable morphological characteristics, controlled permeability, and rapid drug release under acidic conditions, confirming the efficiency of the polymer composite approach. The findings highlight that polymer selection, composition, and structural properties are key determinants of formulation performance. This work contributes to the growing field of polymer-assisted drug delivery and provides a scalable framework for designing advanced composite systems with improved patient compliance and therapeutic efficiency.

REFERENCES

1. Gupta R, Patel P, Shah D. Recent advances in taste masking of bitter drugs for oral pharmaceutical formulations. J Drug Deliv Ther. 2020;10(3):234–242.
2. Felton LA. Film coating of oral solid dosage forms: A review of process and formulation variables. Drug Dev Ind Pharm. 2020;46(6):855–870.
3. Porter SC, Kaushik D, Kaur S. Polymer-based strategies for taste masking of bitter drugs: Current perspectives. Int J Pharm Sci Rev Res. 2020;62(1):1–10.

4. Reddy BV, Navaneetha K, Reddy YS. Development of taste-masked clarithromycin granules for improved patient compliance. Asian J Pharm Sci. 2020;15(5):612–620.
5. Costa P, Sousa Lobo JM. Evaluation of dissolution profiles using model-independent methods: Recent trends. Eur J Pharm Sci. 2020;147:105298.
6. Qiu Y, Zhang GGZ. Recent advances in polymeric coatings for modified and immediate-release dosage forms. Int J Pharm. 2021;592:120041.
7. Prinderre P, Sauzet C, Fuxen C. Progress in taste masking technologies: Pharmaceutical applications. Pharm Dev Technol. 2021;26(4):423–434.
8. Dürig T, Fassihi R. Polymeric coating systems and their impact on drug release mechanisms. Eur J Pharm Biopharm. 2021;165:35–45.
9. Kaur M, Singh S, Bala R. Taste masking of macrolide antibiotics using polymeric carriers: A formulation approach. J Pharm Innov. 2021;16(3):409–419.
10. ICH Harmonised Guideline. Stability testing of new drug substances and products Q1A(R2): current considerations. Drug Inf J. 2021;55(4):547–556.
11. Allen LV. Advances in orally disintegrating tablet technologies for bitter drugs. Drug Dev Ind Pharm. 2022;48(2):193–204.
12. Kumar S, Rao M, Patel K. Formulation and evaluation of taste-masked antibiotic granules using fluidized bed coating. Powder Technol. 2022;395:707–715.
13. Felton LA, McGinity JW. Influence of polymer type and coating thickness on drug release from film-coated systems. Int J Pharm. 2022;623:121943.
14. Kothawade SN, Chaudhari PD. Development of biodegradable porous starch foam for improving oral delivery of eprosartan mesylate. J Adv Sci Res. 2021;12(3):120–126.
15. Desai S, Bolton S. Modern dissolution testing and its relevance to oral solid dosage forms. Pharm Res. 2022;39(9):1917–1928.
16. Kothawade SN, Pande VV. Formulation optimization of solid dispersion of candesartan cilexetil. Asian J Pharm Res Health Care. 2023;15(1):59–63.
17. Sharma P, Verma S, Singh I. Correlation of surface morphology with dissolution behavior of polymer-coated granules. Adv Powder Technol. 2023;34(6):103799.
18. Patel H, Shah N, Amin A. Recent developments in FESEM characterization of pharmaceutical solid dosage forms. J Pharm Anal. 2024;14(1):12–23.
19. Arane PM, Ghanwat DA, Boyane V, Kothawade SN, Doshi P. Preparation and in vitro characterization of eprosartan mesylate solid dispersions using skimmed milk powder as carrier. Int J Adv Pharm Res. 2011;2(12):658–665.
20. Ghazi N, Liu Z, Bhatt C, Kiang S, Cuitino A. Investigating the effect of APAP crystals on tablet behavior manufactured by direct compression. AAPS PharmSciTech. 2019;20:1–4.

