Content available at: https://www.ipinnovative.com/open-access-journals

IP International Journal of Comprehensive and Advanced Pharmacology

Journal homepage: https://www.ijcap.in/

Original Research Article

Improvement of pharmacokinetic properties and release of aceclofenac swellable matrix tablets utilizing okra (Abelmoschus Esculentus) and Hibiscus Leaf (Hibiscus Rosa-Sinensis) natural polymer mucilage

Rajdip Goswami[1], Saikat Santra, Bhaskar Pal[2], Biswajit Basu[3], Bhupendra Prajapati[4]*

[1]*Dept. of Pharmaceutical Technology, School of Health and Medical Sciences, Adamas University, Barasat, Kolkata, West bengal, India*
[2]*Dept. of Pharmacology, Charaktala College of Pharmacy, Charaktala, Mothabari, Malda, West Bengal, India*
[3]*Dept. of Pharmaceutical Technology, School of Health and Medical Sciences, Adamas University, Barasat, Kolkata, West Bengal, India*
[4]*Dept. of Pharmaceutics, Shree S.K. Patel College of Pharmaceutical Education and Research, Ganpat University, Gujarat, India*

ARTICLE INFO

Article history:
Received 17-04-2024
Accepted 06-06-2024
Available online 12-06-2024

Keywords:
Okra Gum
Hibiscus Leaf Mucilage
Matrix-tablets
Direct compression
Natural polymers
Sustained release

ABSTRACT

Aim: To Development and Evaluation of Aceclofenac Swellable Matrix Tablets Utilizing Okra (Abelmoschus Esculentus) and Hibiscus Leaf (Hibiscus Rosa-Sinensis) Natural Polymer Mucilage as Release Modifier.

Background: This study investigates the development of sustained-release Aceclofenac tablets using natural polymers, Okra Gum and Hibiscus Leaf Mucilage, to enhance drug efficacy, reduce dosing frequency, and minimize adverse effects in the treatment of inflammation and pain.

Objective: Sustained-release NSAID formulations using natural polymers like Okra Gum and Hibiscus Leaf Mucilage enhance drug efficacy, patient adherence, and safety by reducing dosing frequency and adverse effects.

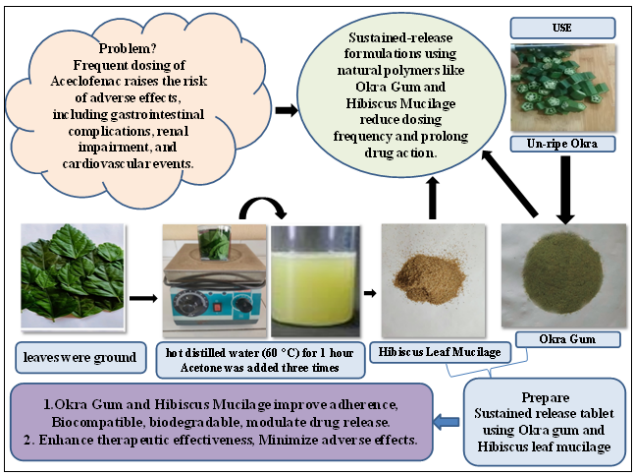
Materials and Methods: Non-steroidal anti-inflammatory drugs (NSAIDs), like Aceclofenac, are commonly prescribed for managing inflammation and pain associated with various conditions such as arthritis, musculoskeletal disorders, and post-operative recovery. Despite their effectiveness, traditional NSAIDs often exhibit rapid-release kinetics, necessitating frequent dosing intervals to maintain therapeutic efficacy. However, frequent dosing increases the risk of adverse effects such as gastrointestinal complications, renal impairment, and cardiovascular events. To address these challenges, sustained-release formulations have been developed to prolong drug action and reduce dosing frequency. Natural polymers, such as Okra Gum and Hibiscus Leaf Mucilage, have emerged as promising excipients for sustained drug delivery systems. These natural polymers offer several advantages, including biocompatibility, biodegradability, and the ability to modulate drug release kinetics. By incorporating Okra Gum and Hibiscus Leaf Mucilage into pharmaceutical formulations can improve patient adherence and therapeutic effectiveness while minimizing adverse effects.

Results: Fourier Transform Infrared analysis conducted as part of this study demonstrated no chemical interaction between Aceclofenac and the natural polymers, confirming their compatibility for formulation purposes. The formulated tablets met pharmacopoeial specifications for physicochemical properties, ensuring quality and consistency in manufacturing. The optimized formulation exhibited prolonged drug release lasting up to 12 hours, with release kinetics inversely proportional to polymer concentration. Stability studies conducted over a specified period indicated no significant changes in tablet attributes, affirming the robustness of the formulation.

Conclusion: The findings of this study confirm the suitability of Okra Gum and Hibiscus Leaf Mucilage as effective release modifiers for Aceclofenac, offering potential benefits for sustained drug delivery in inflammation therapy. By providing valuable insights into the development of improved drug delivery systems using natural polymers, this research contributes to enhanced patient care and treatment outcomes in inflammatory conditions. Further exploration and optimization of natural polymer-based formulations hold promise for advancing drug delivery technologies and improving patient outcomes in clinical practice.

https://doi.org/10.18231/j.ijcaap.2024.019

1. Introduction



The most common practical method of medicine's routes of administration is oral administration.[1] Due too many reasons, such as high solubility and hence drug dosage dumping, it is difficult to manage The liberation of water-soluble medications from the matrix setup.[2] Drug poisoning or drug toxicity might occur from this.[3] The release behavior of matrix tablets can be predicted by performing the in-vitro evaluation study, and these dosage forms are inexpensive and simple to make.[4] Optimizing pharmacological characteristics and delivery methods will help the pharmaceutical industry overcome a significant difficulty in drug development, producing safe and effective medications.[5,6] A formulation with controlled release that maintains a blood level that is almost constant or uniform is required since the traditional drug delivery method is marked by rapid release and frequent dosing of the medication, potentially elevating the risk of dosage inconsistency. Maintaining a nearly constant or uniform blood level of a medication frequently results in greater patient compliance and increased clinical effectiveness of the medication for its intended usage.[7] Systems for delayed medication release over an extended duration of time are referred to as sustained release systems. The technique is referred to as a controlled-release system if it achieves success in upholding consistent medication concentrations in the bloodstream or specific tissue targets.[8] If it falls short in achieving this, it's termed as an extended-release system, yet it extends the duration of action beyond conventional delivery methods.[9] For sustained release, matrix methods are frequently employed. Howard Press in New Jersey created the first sustained-release tablets in the early 1950s. The first pills developed using his technique patent were known as "Nitroglyn" and were produced by Key Corp.[10] In Florida under license, Aceclofenac is a kind of NSAID, or non-steroidal anti-inflammatory medicine,[11–13] Aceclofenac is used to treat osteoarthritis, rheumatoid arthritis, and ankylosing spondylitis-related pain and inflammation. This medication works by preventing the cyclooxygenase (COX) enzymes from producing the chemical prostaglandins that cause pain, edema, and inflammation when an injury occurs. Nephrotoxicity, vomiting, diarrhea, flatulence, constipation, dyspepsia, somnolence, disorientation, etc. are all possible side effects of this medication.[14]

* *Corresponding author*.
E-mail address: bhupen27@gmail.com (B. Prajapati).

2. Materials and Methods

2.1. Raw materials

Aceclofenac was procured from Yarrow Chem Products in Mumbai. Local Markets were visited to purchase fresh okra, and a neighborhood garden was visited to procure hibiscus leaves.[11] We bought Ethylcellulose, talc, lactose, and magnesium stearate from Loba Chemicals in Mumbai.[10] All are LR grades.

2.2. Removal or isolation okra gum

The local market provided 1 kilogram of unripe and delicate Okra fruits (Pods). The seeds were eliminated because they lacked mucilage. After washing, the fruits were thinly cut using a knife.[15]

To remove the mucilage, the cut mass was immersed in distilled water overnight After soaking, the viscous gum extract (mucilage) was filtered out using a white muslin cloth.[15]

To induce gum precipitation, acetone was added in a proportion of 3-1 part gum extract. The gum extract underwent drying at 60°C for 72 hours, and was store in a desiccator to maintain its reduced size.[15]

2.3. Isolation of Hibiscus Leaf Mucilage

The dried leaves were ground into a powder and sent through screen number 10.[15] The powdered leaves were steeped in hot distilled water (60 °C) for 1 hour and mixed vigorously for 30 minutes, followed by a resting period of 1 hour. Permit the mucilage to completely discharge into the water. A multi-layered muslin cloth bag was employed to extract the mucilage while simultaneously eliminating the marc from the dispersion. To precipitate the mucilage, acetone was added in amounts three times as large as the filtrate's. In a laboratory oven set at 40 °C for 6 hours, precipitated mucilage was dried on stainless steel trays.[15]

2.4. Quality control of pre-compression parameters

2.4.1. Micromeritic properties

BD was determined by dividing the mass (M) of the powder by its BV. This allows us to quantify the density (D) of the powder based on its mass and volume (V).[14]

2.4.2. Tapped density (TD)

TD was determined by splitting the mass of the powder by its TV. This formula helps in determining the tap density (Dt) of the powder based on its mass (M) and volume after tapping (Vt).[14]

2.4.3. Hausner's ratio (HR)

HR is obtained by dividing the TD by the BD. This calculation provides a measure of the powder's flow properties relative to its packing characteristics.[14]

Carr' s index (%)= TD-BD / TDx100[14]

AOR: (θ) =$\tan^{-1}$h/r

Where, θ = AOR, h = height, r = radius[2]

3. Preparation of Aceclofenac Tablet

The direct compression procedure was used to produces the various tablet (Table 1) batch formulations (F1-F9). In a motor and pestle, the polymers (okra, hibiscus leaf, and ethyl cellulose) and API were well mixed for 10 minutes.[11] This mixture had lactose, talc, and magnesium Stearate added, and it underwent mixing for 20 minutes.[4] The formulation utilizes Aceclofenac as the API, a combination of okra, hibiscus leaf, and ethyl cellulose as polymers, lactose as a diluent, Magnesium Stearate as a lubricant, and talc as a glidant.

4. Quality control of Post Compression parameters

4.1. Weight variation test

To analyze weight variation, 20 tablets from every formulation were weighed utilizing a digital balance, adhering to the prescribed official procedure.[10]

4.2. Thickness

The thickness of each tablet was assessed using Vernier calipers. Five tablets were randomly selected from each batch, and the average measurements were computed.[11]

4.3. Hardness

The durability of tablets against shipping, breakage, and storage conditions before usage relies on their hardness. Hardness measurements of the tablets were conducted using MHT.[11]

4.4. Friability

Friability serves as an indicator of tablet strength, assessed using the Roche friabilator. It was determined by the formula: [(Primary weight - Final weight) / Primary weight] * 100.[11]

4.5. Drug content study

The mean weight of the three tablets was ascertained by weighing each one separately. All of the tablets were then crushed, and a quantity of powder equal to 50 mg of the medication was weighed. The powder was dissolved in PBS (pH 6.8), and the stock solution was created by adding more buffer to get the volume down to 50 milliliters. Using PBS (pH 6.8), 1 milliliter of this stock solution was suitably diluted, and the drug content was assessed spectrophotometrically at 275 nm.[11]

4.6. Swelling index

The swelling process of tablet excipient particles involves absorbing liquid, leading to increased weight and volume. This liquid absorption may stem from capillary saturation or macromolecule hydration. As liquid infiltrates the particles through pores, it binds to large molecules, disrupting hydrogen bonds and causing swelling. Swelling is measured by the tablet's weight gain. Tablets from all formulations were first weighed, and then left to soak in 100ml of water for 12 hours. Afterward, the tablets were removed, blotted dry, and reweighed. SI was determined using: % SI = [(W2 - W1)/W1] $\times$ 100, where W1 is the primary weight and W2 is the final weight.[7]

4.7. In-vitro release-kinetics

The dissolution studies for all formulated tablets were conducted using a USP type-II apparatus (Electro lab, paddle method) with 900 ml of PBS (pH 7.8) as the dissolution vehicle. The vehicle was allowed to reach a temperature of 37°C ± 0.5°C. Tablets were placed in the vessel, which was covered, and the apparatus was running for 12 hours in PBS (pH 7.8) at 50 rpm. At specific time intervals, 5 ml aliquots of the sample were withdrawn accordingly, and the volume was restored with an exact volume of fresh dissolution vehicle. The samples were then assessed spectrophotometrically at UV. Following dissolution data collection, we delved deeper into pharmacokinetic parameters and kinetics. Our analysis included Hixson-Crowell Rate Kinetic Model, Higuchi plot, Korsmeyer-Peppas model, zero-order, and first-order kinetics. This comprehensive study unveils the intricate dynamics of our formulations, paving the way for precision-driven pharmaceutical advancements.[7]

4.8. Stability studies

The chosen formulations, including the optimized batch F6, underwent a three-month stability study by ICH guidelines. The tablets were placed in their final packaging and exposed to a temperature of 40 ± 0.2°C and a relative humidity of 75 ± 5% in a stability chamber.[6] After one month, the tablets were assessed for alterations in appearance,

physical properties, drug content, and in vitro dissolution performance.

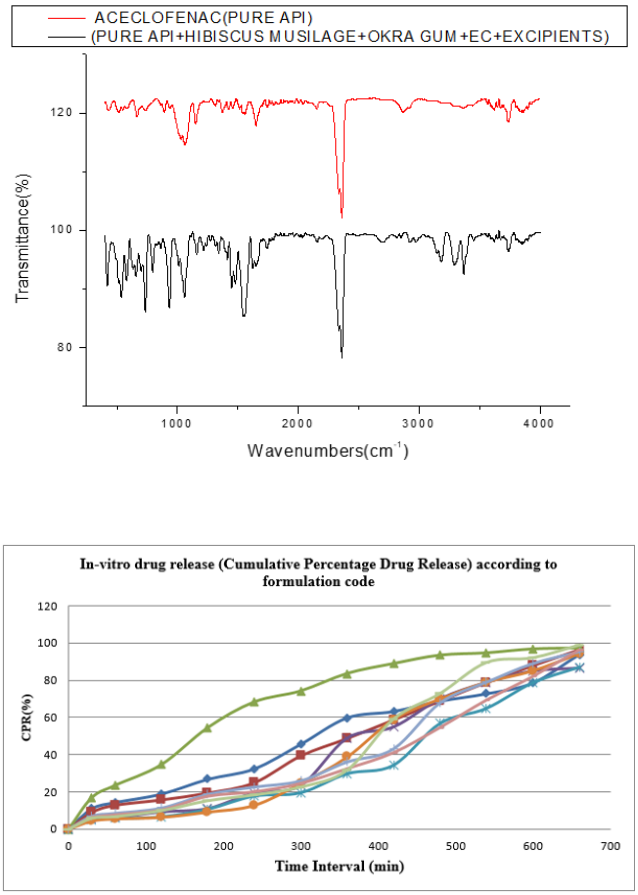


Figure 1: In-Vitro drug release profile of formulated tablets

Tablets F3 and F9 emerged as optimal formulations post in-vitro dissolution studies, meeting study criteria. Optimization selects formulations achieving desired release profiles,ensuring efficacy and safety. F6 and F9's selection signifies their ability to meet target release profiles, promising controlled drug delivery for enhanced therapeutic outcomes and reduced risks.

The results for the kinetic study were plotted by Hixson Crowell Rate Kinetic Model, Higuchi plot, Korsmeyer-Peppas, zero-order and first-order kinetics.

5. Results

5.1. Micromeritic properties

Quality control of pre-compression parameters for the Swellable Matrix Tablets was conducted through hands-on experiments, following the procedure outlined in the methodology section above. Subsequently, the findings of the quality control assessment for pre-compression parameters, including BD, TD, HR, CI, and AOR were documented in a tabular format.[16,17]

5.2. Result of quality control of post compression parameters

Quality control of Post Compression parameters of the Swellable Matrix Tablets was determined by the hands-on experiments by following the above procedure written at the methodology section.[18] Then the result of Quality control of Post Compression parameters like Weight Variation test, Thickness, Hardness, Friability, and Drug content study reported in a tabular manner.[14]

5.3. Optimization of matrix tablet

After determining the CPR through the In- Vitro dissolution study F3 & F9 were optimized due to their drug release property was up to the mark that was required for the study.[2,19,20]

6. Discussion

In contemporary pharmaceutical research, concerns over the adverse effects of synthetic polymers and excipients have prompted a shift towards exploring natural alternatives. In the current study, we focused on harnessing the potentiality of two natural excipients: okra gum and hibiscus leaf mucilages, for formulating sustainable or extended-release tablets. Before formulation, extensive pre-formulation studies including micro-politics property analysis, IR spectroscopy, and organoleptic assessments were conducted. These studies yielded consistent and reliable results, affirming the compatibility and suitability of the selected natural excipients. Subsequently, formulation studies were initiated, involving the evaluation of various ratios of okra gum and hibiscus leaf mucilages using the dry granulation process. Post-formulation studies were then performed to assess crucial parameters like hardness, friability, DT, and dissolution characteristics.[21] Notably, formulations utilizing 75 mg per tablet of okra gum and 75 mg per tablet of hibiscus leaf mucilage demonstrated superior performance across all evaluated parameters. Specifically, formulations designated as F6 and F9 emerged as the optimal formulations, exhibiting optimal hardness, minimal friability, rapid disintegration times, and desirable dissolution profiles. These findings underscore the efficacy of the selected natural excipients in facilitating the development of robust and effective extended-release tablets.[22] Overall, the successful formulation of sustainable tablets using okra gum and hibiscus leaf mucilagesp[23,24] highlights the potential of natural alternatives in pharmaceutical research and underscores the importance of prioritizing safety and sustainability in drug formulation practices[25,26]. Okra gum and hibiscus leaf mucilage both are intrinsic natural semicrystalline polysaccharide, which serves as an efficient retarding polymer to formulate sustained-release pharmaceutical preparations. Okra gum from Hibiscus esculentus is a

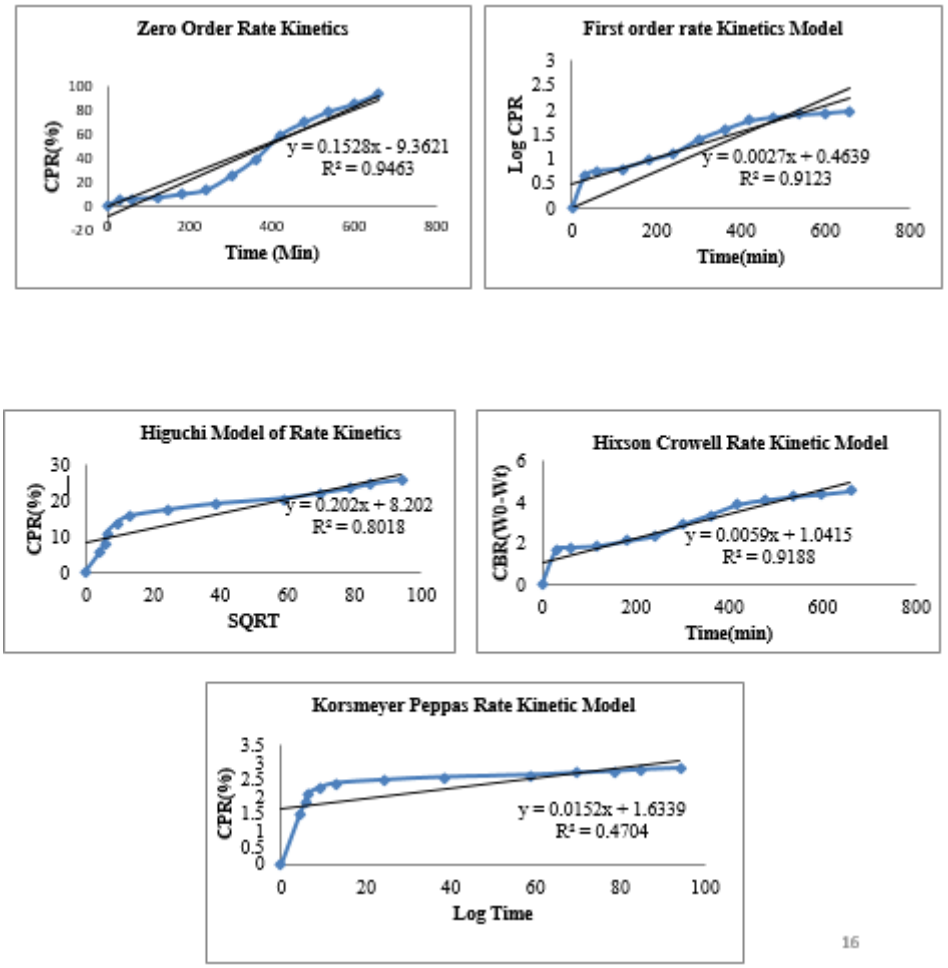


Figure 2: Kinetic Study of Optimized Matrix Tablet.

Table 1: Formulation table of tablets

Ingredients(mg)	F1	F2	F3	F4	F5	F6	F7	F8	F9
Aceclofenac	100	100	100	100	100	100	100	100	100
Okra Gum	x	x	x	x	x	x	25	50	75
Hibiscus Leaf extract	x	x	x	25	50	75	x	x	x
Ethyl Cellulose	25	50	75	x	x	x	x	x	x
Magnesium Stearate	5	5	5	5	5	5	5	5	5
Lactose	65	40	15	65	40	15	15	40	65
Talc	5	5	5	5	5	5	5	5	5
Total Wt.	200	200	200	200	200	200	200	200	200

Table 2: Micromeritic properties

Formulation Code	CI	HR	FP
F1	12.54±0.15	1.15±0.10	Good
F2	7.18±0.12	1.13±0.14	Good
F3	12.42±0.34	1.12±0.39	Good
F4	14.27±0.25	1.14±0.28	Good
F5	11.25±0.12	1.15±0.44	Good
F6	8.538±0.27	1.14±0.87	Good
F7	12.03±0.19	1.12±0.58	Good
F8	14.51±0.14	1.13±0.98	Good
F9	13.7±0.18	1.15±0.31	Good

*All data are mean + SD (n=3) here, CI= Carr's index, HR= Hausner's ratio, FP= Flow Property

Table 3: Result of Quality Control of Post Compression Parameters

Formulation Code	Weight Variation (% Deviation)	Thickness (mm)	Hardness (Kg/cm^2)	Friability (% Loss)	Swelling index	Drug content (%)
F1	198.8±0.76	4.66±0.71	7.8±0.53	0.54±0.56	45±0.8	98.67±0.27
F2	193.8±0.42	4.13±0.65	6.9±0.27	0.67±0.86	63±0.76	99.84±0.76
F3	199.8±0.13	4.76±0.34	6.5±0.45	0.26±0.53	45±0.65	98.43±0.65
F4	198.6±0.58	4.87±0.75	7.1±0.65	0.29±0.73	36±0.73	96.56±0.76
F5	198.8±0.16	3.83±0.87	6.3±0.75	0.65±0.28	38±0.69	98.19±0.56
F6	198.5±0.38	3.97±0.62	6.8±0.56	0.79±0.65	34±0.87	95.47±0.88
F7	196.8±0.47	4.22±0.71	5.9±0.94	0.71±0.94	45±0.46	97.16±0.64
F8	196.8±0.35	4.16±0.59	5.4±0.78	0.45±0.86	29±0.66	96.97±0.83
F9	191.8±0.69	4.86±0.48	5.8±0.23	0.34±0.19	45±0.45	97.55±0.67

*All data are mean + SD (n=3)

Table 4: In-Vitro release profile of formulated tablets

Time Interval (min)	In-vitro drug release (Cumulative Percentage Drug Release) according to formulation code								
	F1	F2	F3	F4	F5	F6	F7	F8	F9
0	0	0	0	0	0	0	0	0	0
30	10.97	8.97	16.93	5.67	5.19	4.37	6.98	6.17	5.89
60	14.32	12.84	23.54	6.18	5.84	5.54	8.56	7.76	6.79
120	18.90	15.76	34.67	9.34	6.71	6.38	11.34	10.39	9.96
180	26.85	19.44	54.56	11.09	10.78	9.17	18.76	17.78	15.32
240	32.43	24.97	68.32	19.56	17.88	12.77	22.65	20.15	18.45
300	45.65	39.35	74.21	23.45	19.64	24.51	25.96	24.66	22.65
360	59.87	48.76	83.60	48.87	29.87	38.64	36.09	32.60	31.67
420	63.32	58.73	88.91	54.87	34.43	58.89	43.12	41.19	59.15
480	68.87	68.84	93.43	69.89	56.89	69.83	67.78	54.74	72.78
540	72.83	78.86	94.65	78.75	64.98	78.87	78.94	69.47	89.47
600	78.64	87.89	96.76	84.92	78.76	84.98	88.96	82.23	92.03
660	93.93	96.43	97.23	86.41	87.19	94.19	95.34	96.53	98.83

Table 5: Stability studies of F9 formulation at 40 °C±2 °C/75% Relative Humidity ±5%

Parameter	Days			
	15	30	60	90
In vitro API release (%)	63.6 ± 0.65	63.4 ± 0.45	63 ± 0.18	62.6 ± 0.78
Hardness (kg/cm^2)	6.0±0.15	6.2±0.18	6.0±0.31	6.3±0.91
Disintegration time (min)	31±0.01	32.3±0.11	31±0.25	30±0.06
Drug content	98.7±0.21	97.2±0.03	98.2±0.11	98.3±0.22

*All data are mean + SD (n=3)

Table 6: Drug Release kinetics

Formulations	Zero Order Kinetics (R^2)	First Order Kinetics (R^2)	Higuchi Plot (R^2)	Korsmeyer-Peppas (R^2)	Hixson Crowell (R^2)
F1	0.9772	0.9537	0.9008	0.9853	0.801
F2	0.9842	0.8957	0.8223	0.9898	0.7302
F3	0.7791	0.9901	0.9726	0.9739	0.7122
F4	0.9433	0.8507	0.7427	0.9698	0.6543
F5	0.9058	0.8079	0.6780	0.9858	0.9008
F6	0.946	0.912	0.801	0.470	0.918
F7	0.9360	0.8255	0.7302	0.9784	0.9726
F8	0.9261	0.8203	0.7122	0.9858	0.7427
F9	0.9119	0.7875	0.6940	0.9675	0.6780

polysaccharide recently being studied in pharmaceutical research as a hydrophilic polymer in different dosage forms, and also exists as binding material for tablets and shows adequate hardness, friability, and drug release kinetics, In the present study we were using okra gum (F7, F8 & F9) and hibiscus leaf mucilage (F4, F5 & F6) as the release modifier and both of these were showing optimized drug release as compare to ethylcellulose (F1, F2& F3). The tablets with these polymers show greater bioavailability for sustained release and steady-state concentration for a prolonged duration of time. In the rate kinetic study, it was found that among all these formulations (F4 to F9) F6 and F9 follows zero-order kinetics and exhibits greater R^2value. Furthermore, the dissolution study and kinetic study suggests the formulation with these natural polymer shows less frequency and less adverse toxic effects as compared to conventional Tablets.[27,28]

7. Conclusion

The formulation development and evaluation of swellable matrix tablets were successfully conducted with a NSAID entrapped to block the COX pathway. The polymeric coating was achieved using two natural polymers: okra gum and hibiscus leaf mucilage, aiding extended-release properties. Aceclofenac was the chosen drug, along with excipients like lab-made okra gum and hibiscus leaf mucilage. Preformulation studies ensured parameters were acceptable before formulation. Quality control tests included weight variations, hardness, friability, drug contents, and in-vitro API release kinetics. Stability studies were also conducted. Dissolution studies for formulations F1-F9 were performed, with absorbance values collected to calculate the percentage of drug release. Formulations F3, F6, and F9 showed promising results, with cumulative percentage drug release values of 97.23%, 94.19%, and 98.83% respectively. The study concluded that replacing Ethyl Cellulose with natural polymers like okra gum and hibiscus leaf mucilage was beneficial due to lower toxicity and higher biodegradability. Our sustained release formulation adheres to the matrix type of drug release kinetics, ensuring controlled release characteristics. Specifically, controlled release formulations are ideally designed to exhibit zero-order drug release kinetics. Through meticulous optimization, formulations F6 and F9 have demonstrated impeccable adherence to this principle. The outstanding R^2 values approaching 1 indicate that our tablets, F6 and F9, achieve zero-order rate kinetics with utmost precision. In our cutting-edge research on matrix tablets, Okra Gum and Hibiscus Mucilage shine as star ingredients in formulations F6 and F9, boasting the highest concentrations. These dynamic duos have propelled F6 and F9 to the forefront, showcasing remarkable results. Our groundbreaking study confirms that both F6 and F9 embrace the coveted zero-order rate kinetics, rendering them concentration-independent powerhouses. Furthermore, F6 and F9 go beyond conventional release mechanisms, orchestrating a controlled and sustained release profile that stands the test of time. Their unparalleled ability to maintain steady-state concentrations over prolonged periods sets a new standard in formulation excellence. In essence, F6 and F9 emerge as the pinnacle of optimization, offering not just efficacy but a promise of sustained therapeutic impact. Step into the future of pharmaceuticals with F6 and F9. Formulations F6 and F9 were identified as the best formulations for natural matrix-based coated tablets.

8. Limitation

8.1. Limited generalizability

The study's findings, based on specific laboratory conditions and the use of a particular drug and excipients (Aceclofenac), may not directly apply to other drugs or formulations without further validation.

8.2. Biological evaluation

While the study extensively assesses physicochemical assets and in-vitro API release kinetics, the absence of biological evaluation, including pharmacokinetic and pharmacodynamic studies, limits understanding of

the formulation's performance in living organisms and predicting clinical efficacy.

8.3. Scale-up considerations

Conducted on a small scale, the study raises concerns about transition costs and the availability of natural polymers, particularly those from botanical sources, which may hinder large-scale production and commercialization. Economic feasibility studies and exploration of alternative sources are warranted to address these challenges.

9. Future Prospective

9.1. Exploration of other natural polymers

While okra gum and hibiscus leaf mucilage show promise, future research should investigate additional natural polymers for drug delivery purposes. The vast array of polysaccharides and proteins from botanical sources offer diverse properties that could be explored for drug delivery, including swelling, mucoadhesion, and controlled release.

9.2. Optimization of formulation parameters

Subsequent studies should concentrate on refining formulation parameters like polymer concentration, drug loading, coating thickness, and excipient composition to improve formulation performance and consistency. The utilization of Design of Experiments (DOE) methodologies can systematically assess and refine these parameters.

9.3. Biocompatibility and toxicity studies

Thorough evaluations of biocompatibility and toxicity for natural polymer-based formulations are crucial to ensure their safety and effectiveness in clinical settings. Future investigations should encompass comprehensive studies on cytotoxicity, genotoxicity, immunogenicity, and tissue compatibility to meet regulatory requirements and address safety concerns.

9.4. Incorporation of therapeutic agents

Beyond NSAIDs, exploration of natural polymer-coated matrix tablets for delivering various therapeutic agents such as antimicrobials, antioxidants, anti-cancer drugs, and peptides could enhance therapeutic outcomes and minimize adverse effects. Developing combination therapies or targeted delivery systems holds promise for improving treatment efficacy.

9.5. Advanced drug delivery strategies

Future research avenues may involve exploring advanced drug delivery strategies like stimuli-responsive systems, nanotechnology-based carriers, and personalized medicine approaches. Integration of stimuli-responsive polymers or nanocarriers could facilitate triggered drug release in response to specific physiological signals or external triggers, enhancing drug targeting and efficacy.

9.6. Clinical translation and validation

Further preclinical and clinical studies are necessary to validate the efficacy, safety, and pharmacokinetic profiles of natural polymer-coated matrix tablets in human subjects. Clinical trials can offer valuable insights into real-world performance and support regulatory approval for commercialization.

10. Abbreviations

1. BD: Bulk density
2. BV: Bulk volume
3. TD: Tapped density
4. TV: Tapped volume
5. AOR: Angle of repose
6. HR: Hausner's Ratio
7. MHT: Monsanto Hardness tester
8. SI: Swelling index
9. FP: Flow property
10. DT: Disintegration time
11. PBS: Phosphate Buffer Solution

11. Author Contributions

Study conception and design: *Bhupendra Prajapati, Biswajit Basu, Rajdip Goswami*; data collection: *Rajdip Goswami, Saikat Santa, Bhaskar* Pal; analysis and interpretation of results: Biswajit Basu, Bhupendra Prajapati, Saikat Santra, Bhaskar Pal; draft manuscript preparation: Rajdip Goswami, Saikat Santa, Bhaskar Pal. All authors reviewed the results and approved the final version of the manuscript.

11.1. Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

11.2. Consent for publication

We all authors are declared that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. It is also declared that no data from animal and human studies are there in the manuscript and no individuals' data are present in the manuscript.

12. Source of Funding

None.

13. Conflict of Interest

None.

14. Acknowledgements

The authors acknowledged the facility provided by the institutional authority and the contribution by the corresponding authors.

References

1. Smitharaj RS, Deepu S, Kuriachan PMA. Formulation and Evaluation of Swellable Matrix Tablet Using Emerging Excipient Hibiscus Esculentus. *Int J Res Rev*. 2018;5(8):65–77.
2. Ganesh GNK, Sureshkumar R, Jawahar N, Senthil V, Venkatesh DN, Srinivas MS. Preparation and evaluation of sustained release matrix tablet of diclofenac sodium using natural polymer. *J Pharm Sci Res*. 2010;2(6):360–8.
3. Basavaraja K, Navade BS, Rao SV. Formulation and evaluation of sustained release matrix tablets of flurbiprofen by using natural and synthetic polymers. *J Pharm Sci Res*. 2015;7(6):274–81.
4. Guntaka PR. Formulation And Evaluation Of Sustained Release Matrix Tablets Of Glimipride Using Natural Polymers Tamarind Seed Mucilage And Guar Gum. *J Pharm Negat Results*. 2022;13(9):5256–67.
5. Pranati S, Rishabha M, Sumedha G, Sharma PK. Preparation and evaluation of matrix based tablet using natural polymers as release modifiers. *Int J Pharm Sci*. 2010;2(1 A):411–7.
6. Laxmi MV, Vijaya M. Formulation and Evaluation of Aceclofenac Matrix Tablets Using Ethyl Cellulose And Cellulose Acetate Phthalate. *Turk J Pharm Sci*. 2014;5(3):1804–10.
7. Bansal D, Choudhary M, Dubey N, Ganeshpurkar A, Pandey V, Salukhe T. Formulation and evaluation of sustained release matrix tablets of pioglitazone hydrochloride using processed Aloe vera mucilage as release modifier. *Drug Dev Ther*. 2015;6(1):1–5.
8. Madaan R, Bala R, Vasisht T, Sharma R, Garg S. Formulation and Characterization of Matrix Tablets Using Mucilage of Tinospora Cordifolia As Natural Binder. *Int J Pharm Pharm Sci*. 2018;10(7):22. doi:10.22159/ijpps.2018v10i7.25447.
9. Jayaswal SR, Joe VF, Viswanath BA. Formulation and evaluation of sustained release matrix tablets of glibenclamide. *Int J Pharm Technol*. 2014;6(2):6572–86.
10. Chaturvedi H, Garg A, Rathore US. Post-Compression Evaluation Parameters for Tablets-an. *Euro J Pharma Med Res*. 2022;4:526–30.
11. Chowdary K, Enturi V, Rani AS. Formulation Development of Aceclofenac Tablets Employing Starch Phosphate-A New Modified Starch. *Int J Pharma Sci Res*. 2011;2(3):124–9.
12. Kumar RS, Pratibhanusha CH. Isolation and Characterization of Aegle marmelos Gum-A Novel Controlled Release Polymer. *J Drug Deliv Ther*. 2019;9(3):479–83.
13. Gayathri R, Jose B, Ramkanth C, Mohan S, Mohan P, Swetha S. Preliminary Characterization and Comparison of Mucilage from Leaves of Hibiscus Sabdariffa L. as A Tablet Binder. *Int J Res Pharm Sci*. 2021;12(1):487–96.
14. Êkansson IH, Lipiec J. A review of the usefulness of relative bulk density values in studies of soil structure and compaction. *Soil Tillage Res*. 2000;53(2):71–85.
15. Ameena K, Dilip C, Saraswathi R, Krishnan PN, Sankar C, Simi SP. Isolation of the mucilages from Hibiscus rosasinensis linn. and Okra (Abelmoschus esculentus linn.) and studies of the binding effects of the mucilages. *Asian Pac J Trop Med*. 2010;3(7):60130–7.
16. Verstraete G. Hydrophilic thermoplastic polyurethanes for the manufacturing of highly dosed oral sustained release matrices via hot melt extrusion and injection molding. *Int J Pharm*. 2016;506(1-2):214–21.
17. Berhe HE, Mezgebo D, Abrha S, Haile T, Molla F. Extraction, Characterization, and Evaluation of Lepidium sativum Linn. Mucilage as a Mucoadhesive Polymer. *Adv Pharmacol Pharm Sci*. 2023;14:5535344.
18. Patel J, Maji B, Moorthy N, Maiti S. Xanthan gum derivatives: Review of synthesis, properties and diverse applications. *RSC Adv*. 2020;10(45):27103–36.
19. Butani SB. Development and Optimization of Venlafaxine Hydrochloride Sustained Release Triple Layer Tablets Adopting Quality by Design Approach. *Pharmacol Pharm*. 2013;4(3):9–16.
20. Zhang Y. DDSolver: An add-in program for modeling and comparison of drug dissolution profiles. *AAPS J*. 2010;12(3):263–71.
21. Nokhodchi A, Raja S, Patel P, AAddo K. The role of oral controlled release matrix tablets in drug delivery systems. *BioImpacts*. 2012;2(4):175–87.
22. Amiri MS, Mohammadzadeh V, Ehsan M, Yazdi T. Plant-Based Gums and Mucilages Applications in. *Molecules*. 2021;26(1770):1–23.
23. Shende MA, Marathe DRP. Extraction of Mucilages and Its Comparative Mucoadhesive Studies From Hibiscus Plant Species. *World J Pharm Pharm Sci*. 2015;4(3):900–24.
24. Sharma V, Pathak K. Modified xanthan gum as hydrophilic disintegrating excipient for rapidly disintegrating tablets of roxithromycin. *Indian J Pharm Educ Res*. 2013;47(4):79–87.
25. Chandran S, Asghar L, Mantha N. Design and evaluation of ethyl cellulose based matrix tablets of ibuprofen with pH modulated release kinetics. *Indian J Pharm Sci*. 2008;70(5):596–602.
26. Ward A, Brown B, Walton K, Timmins P, Conway BR, Addo KA. Application of focus variation microscopy and dissolution imaging in understanding the behaviour of hydrophilic matrices. *Pharmaceutics*. 2020;12(12):1–16.
27. Okoye EI, Onyekweli AO, Kunle OO. Okra gum-an economic choice for the amelioration of capping and lamination in tablets. *Ann Biol Res*. 2011;2(2):30–42.
28. Yahaya NA, Anuar NK, Saidin NM. Hibiscus rosa-sinensis mucilage as a functional polymer in pharmaceutical applications: a review. *Int J App Pharm*. 2023;15(1):44–53.

Author biography

Rajdip Goswami, Assistant Professor https://orcid.org/0000-0003-3296-8799

Saikat Santra, Assistant Professor https://orcid.org/0000-0002-9398-7945

Bhaskar Pal, Assistant Professor https://orcid.org/0009-0007-6299-4871

Biswajit Basu, Professor

Bhupendra Prajapati, Professor https://orcid.org/0000-0001-8242-4541

Cite this article: Goswami R, Santra S, Pal B, Basu B, Prajapati B. Improvement of pharmacokinetic properties and release of aceclofenac swellable matrix tablets utilizing okra (Abelmoschus Esculentus) and Hibiscus Leaf (Hibiscus Rosa-Sinensis) natural polymer mucilage. *IP Int J Comprehensive Adv Pharmacol* 2024;9(2):130-138.