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Formulation Evaluation and Development of Sustained Release tablet of Aceclofenac using natural polymer

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ABSTRACT

The active study targets on the evaluation and formulation of a sustained-release matrix tablet of Aceclofenac, a non-steroidal anti-inflammatory drug (NSAID) widely used in the disease osteoarthritis, rheumatoid arthritis, and ankylosing spondylitis for treatment. The goal was to prepared a formulation that ensures prolonged therapeutic action, reduced dosing frequency, and improved patient compliance. The total of eight trial batches (F1–F8) were prepared by the wet granulation technique with a composition of synthetic and natural polymers, including HPMC K15M, ethylcellulose, acrypol 934P, and PVP K30, alongside excipients like MCC and magnesium stearate. Preformulation studies confirmed the physicochemical compatibility of the active ingredient (drug) with selected excipients, with Aceclofenac exhibiting optimal UV absorbance at 274 nm and a partition coefficient of 1.8. The flow characteristics of the granules were analyzed, and the resulting tablets were tested for weight variation, hardness, friability, thickness, and drug content uniformity, and In-Vitro dissolution. Among all formulations, Batch F8 demonstrated the most consistent and controlled drug release (99.56% at 24 hours) with superior initial release compared to a marketed product. Stability studies of F8 conducted under accelerated conditions ($40 \pm 2°C/75 \pm 5\%$ RH) for 60 days confirmed the formulation's robustness and retention of drug content and release profile. The findings suggest that the optimized sustained-release tablet of Aceclofenac provides a promising alternative for enhancing therapeutic efficacy and improving patient adherence.

Keywords: Aceclofenac, Matrix Tablet, Natural Polymer,Sustained Release, HPMC K15M, Ethylcellulose, Wet Granulation, Drug Release, In Vitro Dissolution, Stability Studies

INTRODUCTION

Oral administration remains the most preferred and convenient method of drug delivery because of its ease of use, cost-effectiveness, and high patient compliance. However, conventional formulations of rapidly eliminated drugs like Aceclofenac

required frequent dosing, which may lead to change in plasma drug concentration and increased risk of adverse effects. Aceclofenac, a phenylacetic acid derivative belonging to the class of non-steroidal anti-inflammatory drugs (NSAIDs), is commonly prescribed for managing inflammatory and degenerative joint disorders. Despite its potent anti-inflammatory and analgesic properties, its short biological half-life (~4 hours) limits its therapeutic duration, necessitating multiple daily doses to maintain optimal plasma concentrations.

Sustained-release (SR) drug delivery systems are produced to release the API at a predetermined rate, maintaining therapeutic levels for extended periods. Sustained-release offer significant advantages such as improved patient adherence, minimized side effects,reduced dosing frequency, and good management of chronic conditions. In recent years, the use of semi-syntheticandnatural polymers has sick attention for their ability to modulate drug release effectively. Polymers like Hydroxypropyl Methylcellulose (HPMC), ethylcellulose, carbomers, and polyvinylpyrrolidone (PVP) serve as matrix-forming agents that control drug release via erosion and diffusion mechanisms.

The current study aims to produce a Sustained-Release Matrix tablet of Aceclofenacbythe wet granulation method for blend of hydrophobic and hydrophilic polymers. The objective is to achieve a controlled and sustained release profile that matches or exceeds the effectiveness of marketed sustained-release formulations. The study involves comprehensive preformulation characterization, compatibility testing, formulation design, and testing of physicochemical properties, culminating in an optimized formulation. Under accelerated conditionsstability testing was conducted to confirm the robustness of the final product. This formulation approach is intended to enhance the therapeutic efficacy of Aceclofenac while reducing gastrointestinal side effects and improving patient convenience in long-term therapy.

MATERIALS AND METHODS

Materials

It was used as the model drug for developing a sustained-release oral formulation. Excipients included microcrystalline cellulose (MCC) as a diluent, polyvinylpyrrolidone K30 (PVP K30) as a binder, Hydroxypropyl Methylcellulose K15M (HPMC K15M), ethylcellulose, and Acrypol 934P as matrix-forming agents, and magnesium stearate and aerosil as lubricant and glidant, respectively. Isopropyl alcohol was employed as the granulating solvent. The materials used were of analytical grade and sourced from recognized commercial vendors.

Instrumentation

All analytical proceduresand formulation were performed using calibrated equipment. A digital electronic balance (Contech), tray dryer (Scientech), tablet coating machine (Tanco), and 16-station rotary tablet compression machine (CADMACH) were utilized during formulation. Analytical evaluation was performed by the UV-Visible spectrophotometer (Shimadzu UV-1800), FTIR spectrophotometer (Shimadzu IR Affinity-1S), friability tester (Scientech), Monsanto hardness tester, tap density tester (Tanco), and LOD apparatus (Sartorius). For In-Vitro drug release testing Tancoapparatus was used.

Preformulation Studies

Identification and UV Analysis

Aceclofenac was identified using UV spectrophotometry. A 10 µg/mL solution was formulated in 0.2N NaOH and scanned in the range of 200–400 nm. The maximum absorbance (λmax) was observed at 274 nm, confirming the identity of theAceclofenac drug. Calibration was performed over a concentration range of 5–50 µg/mL to construct the curve.The regression equation was Y = 0.249x + 0.00 with a correlation coefficient (R^2) of 0.999, indicating excellent linearity.

Solubility, Melting Point, and Partition Coefficient

The solubility of Aceclofenac was assessed in various solvents. The drug was highly soluble in ethanol, methanol, chloroform, benzene, and propyl alcohol (+++), slightly soluble in dichloromethane (++), and poorly soluble in water (+), reflecting its hydrophobic nature. The melting point ranged between 149–153°C, and the partition coefficient was determined to be 1.8, indicating moderate lipophilicity.

Drug-Excipient Compatibility

Binary mixtures of Aceclofenac and individual excipients (1:1 ratio) were stored at $30 \pm 2°C/65 \pm 5\%$ RH and $40 \pm 2°C/75 \pm 5\%$ RH for 30 days. Samples were analyzed visually and spectroscopically to evaluate any physical or chemical interactionsNo notable changes were observed, indicating compatibility.

Formulation Development

Wet Granulation Method

Sustained-release tablets were prepared using the wet granulation. The active ingredient and excipients were sieved through a #40 mesh and blended for 5 minutes. The PVP K30 binder solution in isopropyl alcohol was incorporated to obtain a cohesive mass. It was passed through a #12 mesh and dried at 40°C to achieve a loss on drying (LOD) of 2–3%. Uesd #20 mesh sieve for dried granules and lubricated with aerosiland magnesium stearate (passed through #60 mesh), and compressed using 9.6 mm biconvex round punches on a rotary tablet press.

Formulation Design

Eight trial batches (F1–F8) and two optimization batches were formulated, varying the concentrations of HPMC K15M, ethylcellulose, and Acrypol 934P while maintaining a constant dose of 200 mg Aceclofenac per tablet. The overall tablet weight was established as 310 mg.

Table 1 - Development andDesignofAceclofenacSustainedReleaseMatrixTablet

Ingredient	F01	F02	F03	F04	F05	F06	F07	F08
Aceclofenac-200	-	-	-	-	-	-	-	-
MCC	67	63	62	72	72	71	67	49
PVP K-30	10	9	10	8	10	11	10	10
I.P.A.	Q.S.	Q.S.	Q.S.	Q.S.	Q.S.	Q.S.	Q.S.	Q.S.
HPMC K15	–	10	15	10	–	–	10	–
Ethylcellulose	15	20	15	10	10	5	10	23
Acrypol	10	–	–	–	10	15	5	20
Magnesium Stearate	5	5	5	5	5	5	5	5
Aerosil	3	3	3	3	3	3	3	3
Total Weight- 310								

Evaluation of Powder Blends

Flow Properties

The fixed funnel method was employed to measure the angle of repose.Tapped andbulk densities were determined by the standard procedures,Carr's compressibility index and the Hausner ratio were evaluated.All measurements were performed in triplicate

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Loss on Drying

LOD was measured using a digital moisture analyzer at 105°C. The granules were considered acceptable with LOD values between 1.2% and 1.8%.

Analysis of Tablets

Physical Characterization

Compressed tablets were examined for weight variation (n=20), thickness and diameter (using digital verniercalipers), hardness (Monsanto tester, n=10), friability was measured using a Roche friabilator at 25 rpm for 4 minutes (n = 20).Weight variation was evaluated as per Indian Pharmacopoeia (IP) guidelines.

Uniformityof Drug Content

From every batch ten tablet were crushed, and an accurately weight of resulting powder was dissolved in 0.2N NaOH. Following suitable dilution, the absorbance was measured at 274 nm, and the drug content was determined using the calibration curve.

In-Vitro Dissolution Study

By using USP Type II apparatus dissolution studies were conducted in 900 ml phosphate buffer (pH 6.8) at $37 \pm 0.5°C$ and 50 rpm for 24 hours. Samples were taken at predetermined intervals, analyzedand filtered at 274 nm by the UV spectrophotometer.To maintain sink conditions fresh dissolution medium was added. Results were compared with a marketed sustained-release formulation.

Stability Studies

The optimized batch (F8) was subjected to accelerated stability testing at $40°C \pm 2°C$ and $75\% \pm 5\%$ RH for 60 days, as per ICH guidelines. Tablets were evaluated at 0 and 60 days for drug content and dissolution profile. No significant deviation in drug content or release profile was observed, confirming the formulation's stability

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RESULTS AND DISCUSSION

Results

UV Spectroscopy and Calibration Curve

Aceclofenac was identified and quantitatively analyzed using a UV-visible spectrophotometric method. The UV scan of the drug in 0.2N NaOH exhibited a maximum absorbance (λmax) at 274 nm, which closely matches the reported standard for Aceclofenac, confirming its identity. Calibration curve constructed using standard solution in the range of 5–50 µg/mL showed a linear relationship between concentration and absorbance at 274 nm, with a regression equation**Y = 0.249x + 0.00**and a correlation coefficient **R^2 = 0.999**, confirming the methods excellent linearity and suitability of the method for drug quantification.

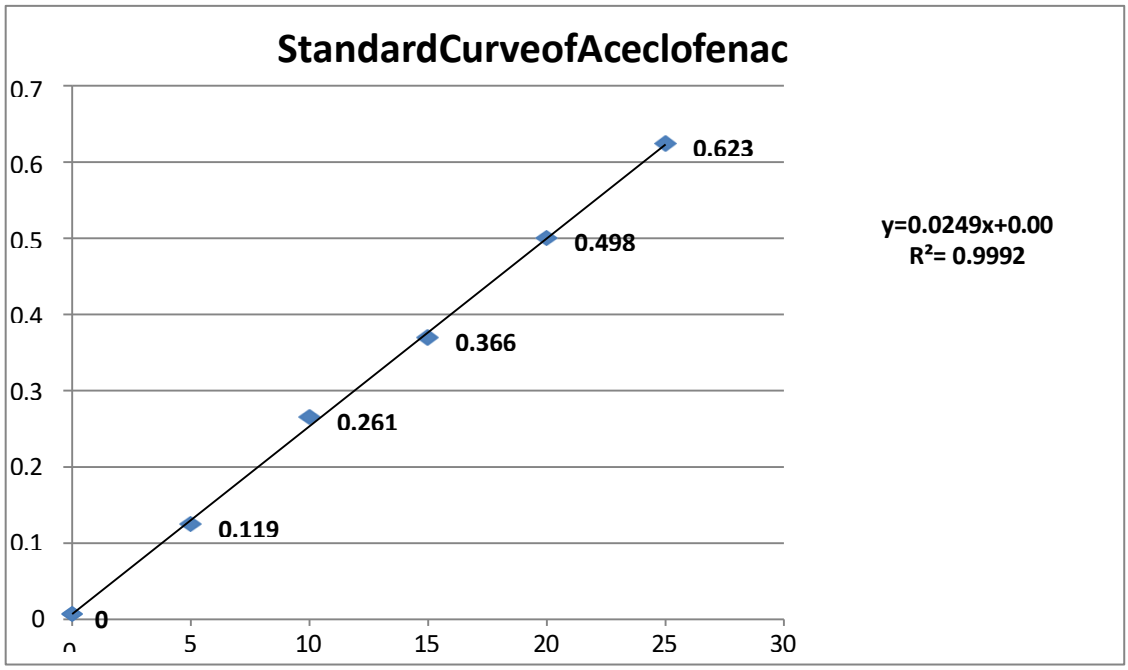

Figure 1.Standard calibration curve of Aceclofenac in 0.2N NaOH showing linearity from 5–50 µg/mL.

Solubility Profile

The solubility of Aceclofenac was evaluated in various solvents to assess its physicochemical behavior, especially for sustained-release formulation development. The drug was found to be highly soluble (+++) in ethanol, methanol, propyl alcohol, chloroform, and benzene, slightly soluble (++) in dichloromethane, and poorly soluble (+) in distilled water. This confirms its hydrophobic nature and supports the selection of both hydrophilic and hydrophobic polymers to regulate its release profile.

Table 2.Solubility of Aceclofenac in Different Solvents

Sr.No.	Solvent	Solubility
i.	Ethanol	+++
ii.	Methanol	+++
iii.	Dichloromethane	++
iv.	PropylAlcohol	+++
v.	Chloroform	+++
vi.	Distilled Water	+
vii.	Benzene	+++

Melting Point and Partition Coefficient

The melting point of Aceclofenac was determined to be in the range of **149–153°C**, consistent with literature values and confirming the purity of the sample. The **partition coefficient (log P)** was determined to be **1.8**, suggesting moderate lipophilicity. This balance between hydrophilic and lipophilic properties is favorable for sustained-release formulations, allowing controlled diffusion through polymer matrices.

Table 3.Melting Point and Partition Coefficient of Aceclofenac

Melting Point	149-153ºC
PartitionCoefficient	1.8

Drug-Excipient Compatibility Studies

This studies were performed by physically mixing Aceclofenac with various excipients in a 1:1 ratio and preserving them under accelerated stability conditions (30°C ± 2°C/65% ± 5% RH and 40°C ± 2°C/75% ± 5% RH) for 30 days. Theblending mixtures were examined visuallyfor any signs of physical changes such as discoloration, clumping, or precipitation. Throughout the observation period, no notable changes were detected, signify that drug remained **compatible** with all selected excipients including **HPMC K15M, ethylcellulose, carbopol 934P, PVP K30, MCC, and magnesium stearate**.

Table 4.Drug-Excipient Compatibility Study of Aceclofenac (1:1 Ratio)

Drugs &Excipients (Ratio1:1)	**Observation**			**Result**
	Initial	**30ºC±2/65%±5 RHafter30 days**	**40ºC±2/75%±5 RHafter30 days**	
Aceclofenac	WhitetoOff White Powder	WhitetoOff White Powder	WhitetoOff White Powder	Compatible
Aceclofenac+ HPMCK15 M	White to Off WhitePowder	White to Off WhitePowder	White to Off WhitePowder	Compatible
Aceclofenac+ Ethyl Cellulose	White to Off WhitePowder	White to Off WhitePowder	White to Off WhitePowder	Compatible
Aceclofenac+ Carbomer 934 P	White to Off WhitePowder	White to Off WhitePowder	White to Off WhitePowder	Compatible
Aceclofenac+ PVP K 30	WhitetoOff White Powder	WhitetoOff White Powder	WhitetoOff White Powder	Compatible
Aceclofenac+ Magnesium Stearate	White to Off WhitePowder	White to Off WhitePowder	White to Off WhitePowder	Compatible
Aceclofenac+ MCC	WhitetoOff White Powder	WhitetoOff White Powder	WhitetoOff White Powder	Compatible

Evaluation of Granule Blends

Granule blends from batches F1–F8 were tested for their pre-compression properties including bulk and tapped density, compressibility index (Carr's Index), Hausner ratio, loss on drying (LOD), angle of repose. The angle of repose ranged in

the **26° to 35°**, indicating acceptable to excellent flow characteristics. Compressibility index values were between **8.02% (F6)** and **12.65% (F1)**, and Hausner ratios ranged from **1.09 to 1.14**, all within pharmacopeial limits, indicating good flowability and compressibility of the blends.

Table 5.Pre-Compression Parameters of Granule Blends (F1–F8)

(*Values are presented as mean ± SD, n = 3*)

Batch	Bulk Density (g/cm³)	Tapped Density (g/cm³)	LOD (%)	Compressibility Index (%)	Hausner Ratio	Angle of Repose (°)
F1	0.442 ± 0.025	0.506 ± 0.015	1.70 ± 0.012	12.65 ± 0.016	1.14 ± 0.015	34.0 ± 2
F2	0.486 ± 0.017	0.556 ± 0.025	1.20 ± 0.015	12.59 ± 0.023	1.14 ± 0.017	31.0 ± 3
F3	0.529 ± 0.018	0.593 ± 0.023	1.50 ± 0.014	10.79 ± 0.023	1.12 ± 0.014	31.0 ± 2
F4	0.512 ± 0.016	0.574 ± 0.026	1.40 ± 0.017	10.80 ± 0.016	1.12 ± 0.019	28.0 ± 3
F5	0.544 ± 0.022	0.601 ± 0.023	1.40 ± 0.011	9.48 ± 0.014	1.10 ± 0.019	28.0 ± 2
F6	0.539 ± 0.018	0.586 ± 0.023	1.30 ± 0.016	8.02 ± 0.015	1.09 ± 0.021	26.0 ± 3
F7	0.499 ± 0.018	0.564 ± 0.016	1.80 ± 0.016	11.52 ± 0.025	1.13 ± 0.023	32.0 ± 2
F8	0.527 ± 0.018	0.587 ± 0.025	1.20 ± 0.016	11.59 ± 0.016	1.13 ± 0.019	35.0 ± 2

Evaluation of Tablets

All prepared batches were assessedfor post-compression parameters for example thickness,weight variation, friability, hardness and drug content. All tablets conformed to pharmacopeial specifications. Average weights were within ±5% of 310 mg, confirming content uniformity. Hardness values ranged from **4 to 6 kg/cm²**, while friability remained under **1%**, indicating beneficial mechanical strength. The drug content varied from **96.43% (T7)** to **103.98% (T3)**, ensuring accurate dosing.

Table 6.Post-Compression Parameters of Tablets (Batches T1–T8)

Batch No.	Weight Variation (mg)	Thickness (mm)	Hardness (kg/cm²)	Friability (%)	Drug Content (%)
T1	310 ± 1.98	4.66 ± 0.2	6	0.62 ± 0.02	101.65
T2	310 ± 1.69	4.65 ± 0.0	4	0.63 ± 0.03	98.23
T3	310 ± 3.06	4.37 ± 0.3	4	0.42 ± 0.02	103.98
T4	310 ± 3.02	4.62 ± 0.2	5	0.49 ± 0.04	100.84
T5	310 ± 1.85	4.68 ± 0.2	6	0.66 ± 0.02	96.99
T6	310 ± 2.36	4.65 ± 0.2	6	0.59 ± 0.04	96.88
T7	310 ± 3.15	4.59 ± 0.4	4	0.69 ± 0.02	96.43
T8	310 ± 2.16	4.72 ± 0.3	6	0.54 ± 0.05	99.26

Stability Studies of Optimized Batch (F8)

Based on controlled drug release and excellent physicochemical characteristics, Batch F8 was identified as the optimized formulation. The formulation was exposed to accelerated stability conditions of 40 °C ± 2 °C and 75% ± 5% RH for a period of 60 days.. The drug content showed negligible change from **99.25% (Day 0)** to **99.24% (Day 60)**, indicating chemical stability. The In-Vitro drug release profile remained nearly unchanged, confirming formulation robustness under stress conditions.

Table 7. Drug Content of F8 During Stability Study

Time	Drug Content(%)
ZeroDay	99.25
60Days	99.24

TableNo.8 Drugcontentof batchF-8kept for stability

Dissolution Medium	Timein hours	Initial	60 Days
6.8pH Buffer	0	0	0
	2	15.54	14.13
	4	25.65	23.68
	8	69.86	69.13
	12	82.45	81.79
	16	92.06	91.24
	24	99.56	99.32

Dissolution Study

The in vitro dissolution of the formulations was evaluatedto assess the drug excretion profiles of Aceclofenac sustained-release tablets (F1–F8) over a 24-hour period in phosphate buffer 6.8pH using USP Dissolution Apparatus II.The absorbance was recorded at 274 nm, and cumulative drug release (%) was determined. Among the eight trial formulations, **Batch F8** exhibited the most desirable controlled-release profile.

Dissolution Results of F1–F8 and Marketed Product

Batch F1, F5, and F7 showed higher initial drug release and reached more than 100% within 24 hours, indicating burst release. In contrast, Batch F8 displayed a more sustained release, delivering **15.57% at 2 hours**, **69.86% at 8 hours**, and **99.56% at 24 hours**, which aligns well with the therapeutic objective of a once-daily formulation.

Table 9(Previously Shown): Dissolution Profile of Batches F1–F8 and Marketed Product in 6.8pH buffer

Time (hr)	F1	F2	F3	F4	F5	F6	F7	F8	Marketed
0	1.37	-1.32	-0.98	-1.18	-0.75	0.85	0.28	1.05	0.15
2	24.66	22.92	20.21	20.76	27.65	24.25	27.11	16.9	10.83
4	49.76	39.68	40.71	40.23	48.73	41.96	44.18	24.39	21.8
8	78.61	73.57	64.53	72.31	76.94	71.4	75.99	69.24	70.46
12	92.32	89.36	89.52	92.86	94.21	85.88	89.83	83.04	77.73
16	100.6	96.42	98.88	100.02	100.27	91.61	99.58	93.47	88.01
24	102.05	99.92	100.05	103.17	101.09	100.31	102.45	98.15	100.2

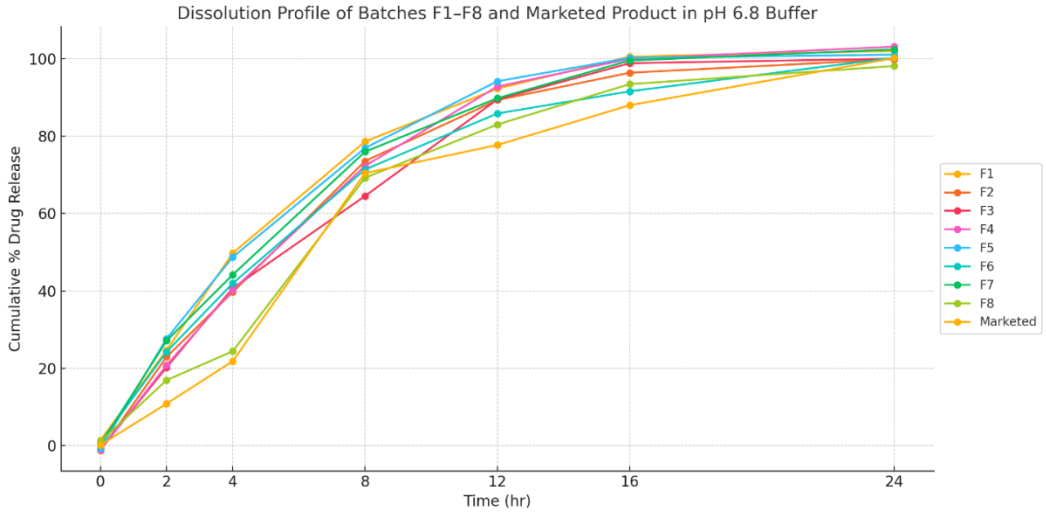

Fig.2.*Dissolution Profile of Batches F1–F8 and Marketed Product in 6.8pH Phosphate Buffer*

The figure illustrates cumulative percentage drug release over 24 hours, comparing all formulated batches with the marketed Aceclofenac sustained-release tablet.

Comparative Dissolution Study: Batch F8 vs. Marketed Product

A direct comparison between the optimized batch (F8) and a commercially distributedsustained-release Aceclofenac tablet revealed that both produced near-complete drug releaseat 24 hours. However, Batch F8 showed slightly faster initial release (15.57% vs. 11.42% at 2 hours), Which might promote fasteronset of action while maintaining sustained release.

Table 10.Comparative Dissolution Profile of Batch F8 and Marketed Product

Time (hr)	Marketed Product (%)	Batch F8 (%)
0	0	0
2	11.42	15.57
4	21.65	25.65
8	71.65	69.86
12	78.45	82.45

16	89.25	92.06
24	100.25	99.56

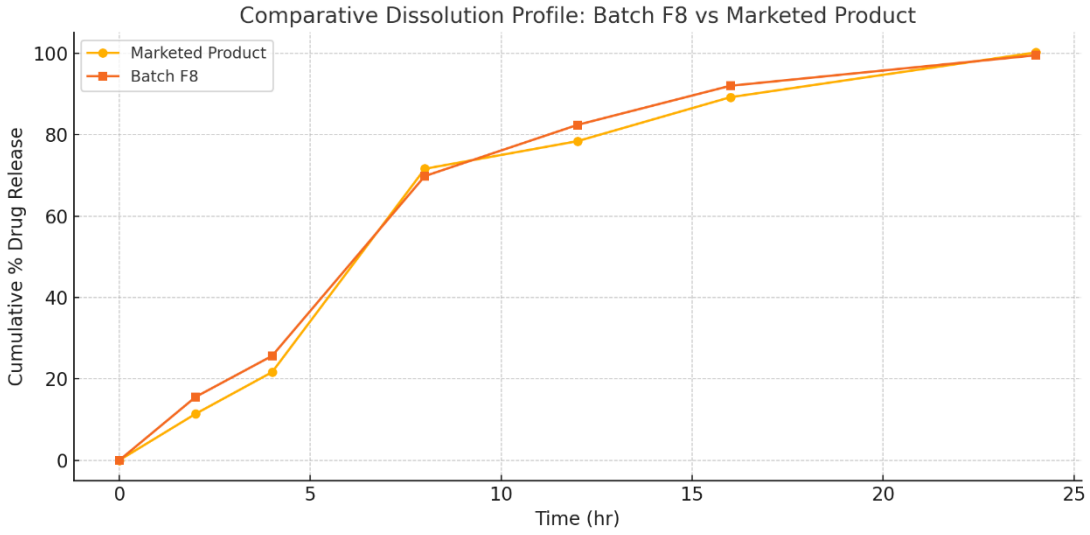

Figure 3. Comparative Dissolution Profile of Batch F8 vs. Marketed Product

Discussion

The primary goal of the study was the formulation of a sustained-release (SR) Aceclofenac matrix tablet using a combination of hydrophilic and hydrophobic polymers, with the goal of maintaining prolonged therapeutic levels and reducing dosing frequency. Eight trial batches (F1–F8) were formulated via the wet granulation technique and evaluated for pre-compression, post-compression, and in vitro dissolution parameters. The findings reveal that formulation composition, especially the concentrationand type of polymer, had a significant impact on drug release kinetics, mechanical strength, and overall performance of the tablets.

The pre-compression evaluation demonstrated that all granule batches had acceptable flow properties. The compressibility index (8.02–12.65%) and Hausner ratio (1.09–1.14) were within pharmacopeial limits, indicating good blend uniformity and suitability for compression. Batch F6 exhibited the best flow characteristics; however, flow alone is not the determinant of optimal formulation performance. Granules with consistent particle size and moisture content (LOD: 1.2–1.8%) ensured minimal tablet weight variability and uniform compression.

Post-compression evaluation indicated that all batches conformed to Indian Pharmacopoeia specifications for physical attributes. The tablet hardness ranged between 4–6 kg/cm², with friability below 1% in all cases, confirming adequate mechanical strength for handling and transportation. Drug content ranged from 96.43% to 103.98%, showing uniform drug distribution.

Significant variations in drug release among batches were observed during in vitro dissolution studies.Batches F1, F5, and F7 exhibited rapid initial release with over 100% release within 24 hours, likely due to the dominance of hydrophilic excipients in the matrix which facilitated faster water ingress and matrix erosion. While these formulations

achieved complete drug release, they failed to control the release rate effectively over the desired 24-hour period.

In contrast, Batch F8, formulated with a balanced combination of **HPMC K15M**, **ethylcellulose**, and **acrypol 934P**, exhibited a more controlled and consistent release. This batch released **15.57% of the drug at 2 hours**, with **99.56% release at 24 hours**, closely matching the release pattern of the marketed sustained-release

Stability testing of Batch F8 under accelerated conditions ($40 \pm 2°C$ / $75 \pm 5\%$ RH) for 60 days further confirmed the robustness of the formulation. There were no observed changes in drug content

The comparison with the marketed product showed that Batch F8 provided comparable, if not superior, performance in terms of both initial drug release and sustained delivery over 24 hours. These results validate the use ofartificial and

CONCLUSION

In this study, a sustained-release Aceclofenac matrix tablet was successfully formulated and optimized using natural and synthetic polymers. Systematic developmentformulation and comprehensive evaluation confirmed that

The dissolution profile of Batch F8 showed a controlled release pattern comparable to a marketed sustained-release formulation, with improved initial drug release that may contribute to faster onset of therapeutic action. Furthermore, The results suggest that the optimized Aceclofenac matrix tablet is a promising sustained-release system that may improve patient compliance, decrease dosing frequency, and enhance therapeutic

product (100.25% at 24 hours). The higher initial release compared to the marketed product may offer a faster onset of action, while the prolonged release ensures sustained therapeutic effect. The blend of hydrophilic polymers and hydrophobic polymers likely contributed to both diffusion-controlled and erosion-controlled mechanisms of the drug release, producing a biphasic profile ideal for chronic inflammatory conditions like osteoarthritis and rheumatoid arthritis.

(99.25% at 0 days vs. 99.24% at 60 days) or dissolution profile, indicating that the matrix system successfully protected the active drug from environmental degradation.

natural polymersblends in creating effective sustained-release drug delivery systems, while also highlighting the importance of formulation optimization using rational excipient selection and systematic process control.

polymer composition plays a pivotal role in controlling drug release. Among all the trial formulations, Batch F8, containing HPMC K15M, ethylcellulose, and Acrypol 934P, Showed superior performance with respect to tablet mechanical strength, consistent drug content, and extended in vitro drug release over a 24-hour period.

stability studies confirmed the robustness and reliability of the optimized batch under accelerated storage conditions, with negligible changes in drug content and release behavior.

efficacy in chronic inflammatory disorders.. Future work may focus on in vivo pharmacokinetic studies and scale-up validation for commercial production.

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