RESEARCH ARTICLE

Preparation and Evaluation of Diclofenac Sustained Release Matrix Tablets using Natural Polymer

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ABSTRACT

The present study aimed to develop and evaluate sustained release matrix tablets of diclofenac using natural polymers to prolong drug release and improve patient compliance. Diclofenac matrix tablets (F1–F9) were prepared by the wet granulation method employing cashew nut tree gum as a release-retarding polymer, Psidium guajava mucilage as a swelling agent, and povidone as a binder. Pre-compression parameters such as bulk density, tapped density, Carr's index, and Hausner ratio indicated good flow properties of the granules. Post-compression evaluation revealed acceptable tablet characteristics including uniform weight, adequate hardness, low friability, and uniform drug content. In-vitro dissolution studies demonstrated that drug release was significantly influenced by the concentration of polymeric components. An increase in the concentration of cashew nut tree gum, Psidium guajava mucilage, and povidone resulted in a progressive decrease in the drug release rate. Among all formulations, F9, containing the maximum concentration of all three excipients, exhibited the most controlled and prolonged drug release, with 62.75% drug release at 12 hours and minimal initial burst effect. Stability studies conducted under accelerated conditions for three months confirmed that formulation F9 remained stable with no significant changes in hardness, drug content, or dissolution profile. Thus, the study demonstrates that natural polymers can be effectively used to develop stable and optimized sustained release diclofenac matrix tablets.

Keywords: Diclofenac; Sustained release matrix tablets; Cashew nut tree gum; Psidium guajava mucilage; Natural polymers; In-vitro dissolution; Stability studies.

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INTRODUCTION

Diclofenac is a potent non-steroidal anti-inflammatory drug extensively prescribed for the treatment of rheumatoid arthritis, osteoarthritis, ankylosing spondylitis, and other inflammatory disorders. Despite its therapeutic effectiveness, conventional oral dosage forms of diclofenac exhibit several limitations, including a short plasma half-life of approximately 1–2 hours and the need for multiple daily dosing[1]. Frequent administration not only reduces patient compliance but also increases the risk of gastrointestinal irritation and ulceration associated with NSAIDs[2].

Sustained release drug delivery systems are designed to maintain constant drug levels in systemic circulation for an extended period, thereby minimizing fluctuations in plasma concentration. Matrix tablets represent one of the most simple, cost-effective, and widely used approaches for achieving sustained drug release. In matrix systems, the drug is uniformly dispersed within a polymeric network that controls drug release through diffusion, erosion, or a combination of both mechanisms[3].

Natural polymers have gained increasing attention in sustained release formulations due to their biodegradability, biocompatibility, low toxicity, and economic advantages over synthetic polymers. The use of natural gums as matrix formers can provide controlled drug release while reducing adverse effects and improving formulation safety[4,5].

Therefore, the present investigation focuses on the development of sustained release matrix tablets of diclofenac using suitable polymers, with the objective of prolonging drug release, reducing dosing frequency, and improving patient compliance.

MATERIAL AND METHODOLOGY

Preparation of Granules

Granules of diclofenac matrix tablets were prepared by the wet granulation method using cashew nut tree gum and povidone as release-retarding and binding agents. All ingredients, except magnesium stearate and talc, were passed through sieve No. 80 and blended uniformly. Granulation was carried out by adding ethanol gradually to obtain a coherent mass.

The wet mass was passed through sieve No. 60 and dried at 35°C for 30 minutes. The dried granules were resieved through sieve No. 100, lubricated with magnesium stearate and talc. Table 1 contain the composition of Diclofenac SR tablets.

Evaluation of Granules

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Table 1: Composition of Diclofenac SR tablets

Ingredients (mg)	F1	F2	F3	F4	F5	F6	F7	F8	F9
Diclofenac	100	100	100	100	100	100	100	100	100
Cashew nut tree gum	10	10	10	20	20	20	30	30	30
Psidium guajava	5	10	15	5	10	15	5	10	15
Povidone	5	10	15	5	10	15	5	10	15
Ethanol	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.
Microcrystalline cellulose (MCC)	174	164	154	164	154	144	154	144	134
Magnesium stearate	3	3	3	3	3	3	3	3	3
Talc	3	3	3	3	3	3	3	3	3
Total weight	300	300	300	300	300	300	300	300	300

Angle of Repose

The fixed funnel approach was used to estimate the angle of repose. A conical pile of granules was formed when they were free-flowing through a funnel set at a given height and dumped onto a flat surface. The heap's height (h) & radius (r) were measured, and the equation was used to compute the angle of repose (θ).

$$\theta = Tan^{-1}\left(\frac{H}{R}\right)$$

Bulk Density

A 20-gram sample of the Granules was transferred, using a glass funnel, into a graduated cylinder with a 50-milliliter capacity in order to determine their bulk density. The volume of the samples was measured and recorded. The bulk density was calculated as follows.

$$Bulk\ Density = \frac{Granule's\ weight\ (gm)}{Bulk\ volume\ of\ the\ Granule's\ (ml)}$$

Tapped Density

Using a graduated cylinder set on a mechanical tapped apparatus, the sample's tapped density was measured using an Electrolab density instrument. The cylinder was filled with a well-balanced powdered sample using a funnel. People often tap the samples 50 times till the volume doesn't drop any more or the percentage change is less than 2% from the initial volume[5,6].

$$Tapped\ Density = \frac{Mass\ of\ sample\ (gm)}{Tapped\ volume\ of\ \ the\ sample\ (ml)}$$

Hausner's Ratio

Hausner's ratio was calculated from bulk and tapped density values using the following equation:

$$Hausner's\ ratio = \frac{Tapped\ density\ of\ Granule's}{Bulk\ density\ of\ Granule's}$$

Compressibility Index (Carr's Index)

Compressibility index was calculated to assess flow properties of granules using bulk and tapped density values according to the formula[7]:

$$Compressibility\ index = \frac{Tapped\ density\ of Granule's - Bulk\ density\ of Granule's}{Tapped\ density\ of\ Granule's}\ x\ 100$$

Compression of Granules into Matrix Tablets

Sustained release matrix tablets of diclofenac were prepared by direct compression of the dried granules. The required quantities of diclofenac and excipients, as specified in formulations F1–F9, were accurately weighed and blended uniformly. Magnesium stearate and talc were then added as lubricant and glidant, respectively, and mixed gently to ensure uniform distribution. The lubricated granule blend was finally compressed into matrix tablets using a tablet compression machine to obtain tablets of 300 mg weight.

Table 2: Pre-compression Evaluation of Diclofenac Matrix Tablets

Formulation Code	Bulk Density (g/cm^3)	Tapped Density (g/cm^3)	Carr's Index (%)	Hausner Ratio
F1	0.72	0.78	7.69	1.08
F2	0.7	0.77	9.09	1.1
F3	0.75	0.82	8.54	1.09
F4	0.73	0.8	8.75	1.1
F5	0.74	0.79	6.33	1.07
F6	0.71	0.76	6.58	1.07
F7	0.72	0.77	6.49	1.07
F8	0.68	0.74	8.11	1.09
F9	0.73	0.8	8.75	1.1

Evaluation of Prepared Matrix Tablets

After formulation of tablets, they are evaluated for various parameters. Prepared matrix tablets were evaluated for following parameters:

Appearance, Shape and Size

Visual inspection of the produced tablets was performed.

Dimension (Thickness and Diameter)

A vernier calliper was used to measure the tablet's thickness and diameter. Ten tablets were taken from each formulation type and the average values were determined.

Weight Variation

Since the amount of medicine in a tablet is proportional to its weight, this test ensures that the manufactured tablets are uniform in weight. Twenty tablets were weighed separately during this procedure. By calculating the average mean, the average weight of a single tablet was determined.

Hardness

A tablet's hardness is defined by the amount of pressure required to break it. To find out how hard the created tablets were, a Monsanto-style hardness tester was employed. kg/cm2 is the unit of hardness measurement. Each formulation was tested by taking three tablets and then calculating the average[8].

Friability

The prepared tablets' friability was measured using the Roche friabilator. The friabilator chamber was filled with twenty tablets that had been measured for weight. A friabilator was spun at 25 revolutions per minute for four minutes. The tablets were reweighed after 100 rotations to determine the percentage of weight loss, which is indicative of friability.

$$\%\ Friability = \frac{Initial\ weight - Final\ weight}{Initial\ weight} \times 100$$

Drug Content

To determine the dosage, 10 tablets were crushed into a fine powder using a mortar and pestle. Distilled water was used to dissolve powder that was equal to the weight of one tablet. Use a UV-Visible Spectrophotometer to measure the absorbance of Diclofenac at λmax, following dilution if necessary. A standard calibration curve was used to determine the drug content[9].

***In-vitro* Dissolution Studies**

We conduct dissolution experiments of matrix tablets to make sure the medicine (Diclofenac) is released slowly over a longer period of time. There were two stages to the dissolution testing of the matrix tablets that were made. For the first two hours, the dissolving media was an acid buffer with a pH of 1.2, which is similar to the stomach's acidic environment. Subsequently, over the subsequent ten hours, the dissolving fluid was substituted with phosphate buffer pH 6.8, which corresponds to the intestinal environment. Dissolution investigations were conducted using a paddle device set at 50 RPM and $37^0 \pm 0.5^0C$[10].

Stability Study

This study aimed to determine the impact of ageing on hardness, drug content, and in vitro drug release by conducting stability testing under an accelerated setting (400 C ± 20 C at 75% RH ± 5% RH) for the chosen formulation F9 for a duration of three months.

For the optimised formulation F9, stability investigations were conducted under accelerated conditions (400 C ± 20 C at 75% RH ± 5% RH). Over the course of three months, the matrix tablets were kept in a temperature-accelerated environment (400 C ± 20 C, 75% RH ± 5% RH) in tightly sealed containers with aluminium foil. After the first, second, and third months, the samples were taken out. Testing for hardness, drug content, and in vitro drug release were performed on the samples[11].

RESULTS AND DISCUSSION

The outcomes of pre-compression evaluation of diclofenac matrix tablets are displayed in table 2.

Table 3: Shape and size of prepared matrix tablets

Formulation	Shape	Diameter	Thickness
F1	Round	8.1 mm	3.7 mm
F2	Round	8.0 mm	3.8 mm
F3	Round	8.2 mm	3.9 mm
F4	Round	7.9 mm	3.8 mm
F5	Round	8.1 mm	3.9 mm
F6	Round	8.0 mm	3.9 mm
F7	Round	8.1 mm	3.8 mm
F8	Round	8.2 mm	4.0 mm
F9	Round	8.0 mm	3.9 mm

The precompression parameters of diclofenac matrix tablet formulations (F1–F9) were evaluated by measuring bulk density, tapped density, Carr's index, and Hausner ratio to assess the flow characteristics of the granules. The bulk density values ranged from 0.68 to 0.75 g/cm³, while tapped density values were found between 0.74 and 0.82 g/cm³, indicating satisfactory packing ability of the granules. Carr's index values for all formulations were in the range of 6.33–9.09%, which falls within the good flow property category, suggesting acceptable compressibility of the granules. The Hausner ratio values were observed between 1.07 and 1.10, further confirming good flow behavior of the powder blends. Overall, the results indicate that all formulations possessed adequate flow and packing characteristics, making them suitable for compression into sustained release matrix tablets without any processing difficulties.

The physical characteristics of the prepared diclofenac matrix tablets were evaluated in terms of shape, diameter, and thickness and are given in table 3. All formulations (F1–F9) were found to be round in shape, indicating uniform die filling and proper compression during tablet manufacture. The tablet diameter ranged from 7.9 to 8.2 mm, which corresponds to the use of an 8-mm round punch and demonstrates minimal variation among formulations. Tablet thickness values were observed between 3.7 and 4.0 mm, reflecting uniform compression force and consistent tablet

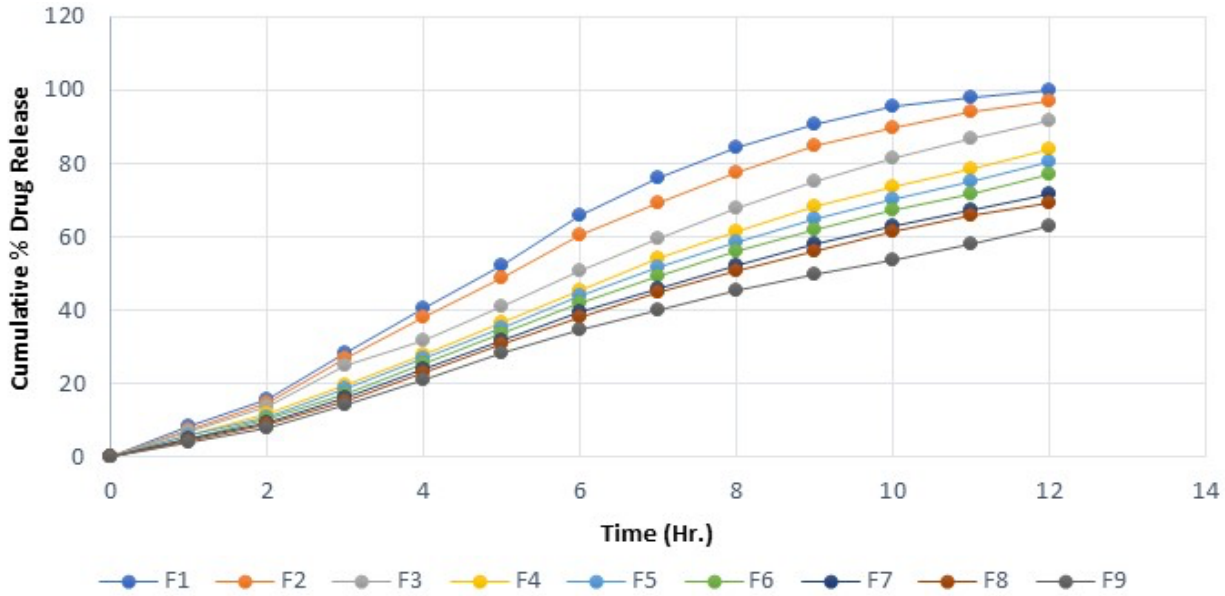

Figure 1: *In-vitro* Cumulative % Drug Release of Diclofenac Matrix Tablets

Table 4: Post-compression Evaluation of Diclofenac Matrix Tablets

Formulation	Average Weight (mg) *(Mean ± S.D.)*	Average Hardness (kg/cm²) *(Mean ± S.D.)*	Friability (%)	Drug Content (% w/w)
F1	300.15 ± 0.72	5.8 ± 0.25	0.66 ± 0.15	98.12 ± 0.10
F2	299.64 ± 0.60	6.0 ± 0.30	0.64 ± 0.12	97.88 ± 0.14
F3	301.84 ± 0.69	6.3 ± 0.20	0.62 ± 0.10	98.46 ± 0.18
F4	300.06 ± 0.55	5.7 ± 0.25	0.60 ± 0.18	97.15 ± 0.20
F5	301.32 ± 0.52	6.0 ± 0.20	0.59 ± 0.15	98.74 ± 0.12
F6	299.92 ± 0.63	6.2 ± 0.20	0.57 ± 0.12	97.96 ± 0.16
F7	300.28 ± 0.80	6.4 ± 0.25	0.56 ± 0.18	98.95 ± 0.21
F8	301.58 ± 0.70	6.6 ± 0.30	0.54 ± 0.10	98.63 ± 0.11
F9	300.74 ± 0.55	6.8 ± 0.20	0.52 ± 0.10	99.28 ± 0.15

Table 5: *In-vitro* Cumulative % Drug Release of Diclofenac Matrix Tablets

Time (h)	F1	F2	F3	F4	F5	F6	F7	F8	F9
0	0	0	0	0	0	0	0	0	0
1	8.25	7.6	6.95	6.2	5.85	5.3	4.85	4.35	3.9
2	15.9	14.72	13.65	11.84	11.12	10.28	9.35	8.72	7.98
3	28.45	26.88	24.92	19.75	18.64	17.3	16.25	15.42	14.1
4	40.62	38.1	31.75	27.96	26.85	25.3	23.84	22.96	21.05
5	52.48	48.96	41.2	36.84	35.42	33.78	31.95	30.88	28.6
6	65.85	60.4	50.76	45.28	43.95	41.82	39.64	37.95	34.72
7	75.92	69.35	59.64	54.3	51.68	49.25	46.12	44.8	40.15
8	84.6	77.82	67.95	61.48	58.62	55.96	52.14	50.72	45.3
9	90.85	84.76	75.38	68.1	64.95	61.78	57.95	56.4	49.85
10	95.4	89.92	81.26	73.65	70.48	67.3	62.98	61.45	53.9
11	98.1	94.35	86.72	78.4	74.95	71.88	67.2	65.84	58.2
12	99.85	97.1	91.65	83.92	80.48	76.9	71.85	69.4	62.75

weight across all batches. The slight variations in diameter and thickness were within acceptable limits and are attributed to differences in polymer concentration and granule packing behavior. Overall, the dimensional uniformity of the tablets indicates good mechanical integrity and reproducibility of the compression process, confirming the suitability of the prepared blends for sustained release matrix tablet formulation.

The post-compression evaluation of diclofenac matrix tablets (F1–F9) demonstrated in table 4 has satisfactory physical and mechanical properties. The average tablet weight for all formulations was found to be close to the theoretical value of 300 mg, with minimal standard deviation, indicating uniform die filling and good flow properties of the granules. Tablet hardness values ranged from 5.7 to 6.8 kg/cm², suggesting adequate mechanical strength to withstand handling while maintaining appropriate matrix integrity for sustained drug release.

Friability values for all formulations were below 1%, confirming good resistance to abrasion and compliance with pharmacopeial limits. The drug content of the tablets was observed in the range of 97.15–99.28% w/w, indicating uniform distribution of diclofenac throughout the matrix and reproducibility of the formulation process. Overall, the results confirm that the prepared diclofenac matrix tablets possessed acceptable post-compression characteristics and were suitable for further in-vitro dissolution and sustained release evaluation.

The release behavior of diclofenac from the prepared sustained-release matrix tablets was strongly influenced by the combined concentration of cashew nut tree gum, Psidium guajava mucilage, and povidone. These three excipients play complementary roles in matrix formation: cashew nut tree gum acts as the primary release-retarding polymer, Psidium guajava mucilage contributes to swelling and gel formation, and povidone functions as a binder that enhances matrix integrity.

Table 6: Stability Study of Optimized Formulation (F9)

Characteristic	Initial	1st Month	2nd Month	3rd Month
Hardness (kg/cm²)	7.6	7.55	7.45	7.35
Drug content (%)	99.28	99.05	98.72	98.4
In-vitro drug release (% at 12 h)	62.75	62.3	61.85	61.4

As shown in the formulation composition table, formulations F7–F9 contained the maximum concentration of all three components, with cashew nut tree gum at 30 mg, Psidium guajava at 15 mg, and povidone at 15 mg. To maintain a constant tablet weight, the proportion of microcrystalline cellulose (MCC) was correspondingly reduced. This compositional adjustment resulted in the formation of a denser and more cohesive polymeric matrix. The in-vitro drug release data clearly demonstrated that formulation F9, which incorporated the highest levels of cashew nut tree gum, Psidium guajava, and povidone, exhibited the most pronounced sustained-release behavior among all formulations. F9 showed the lowest cumulative drug release of 62.75% at 12 hours, compared with F7 (71.85%) and F8 (69.40%). Additionally, F9 displayed minimal initial burst release and a gradual, uniform release

profile throughout the dissolution period, indicating effective control over drug diffusion and matrix erosion.

The comparative analysis of formulation composition and dissolution profiles confirms that the combined use of cashew nut tree gum, Psidium guajava, and povidone at their maximum concentrations resulted in optimal sustained-release performance. Therefore, formulation F9 was identified as the best and optimized formulation and was selected for further evaluation and stability studies.

These results displayed in table 6 indicate no significant change in hardness, drug content, or drug release profile during the stability period, confirming that formulation F9 remains stable under the tested conditions.

CONCLUSION

The present investigation successfully demonstrated the formulation and evaluation of sustained release matrix tablets of diclofenac using natural polymers. Cashew nut tree gum, Psidium guajava mucilage, and povidone played a crucial role in controlling drug release by forming a cohesive and swellable polymeric matrix. All formulations exhibited satisfactory pre-compression and post-compression characteristics, confirming their suitability for tablet manufacturing. In-vitro dissolution studies revealed a clear relationship between polymer concentration and drug release behavior. Increasing the concentration of cashew nut tree gum, Psidium guajava, and povidone resulted in a significant reduction in drug release rate due to enhanced matrix integrity and diffusion resistance. Among all formulations, F9 showed the most desirable sustained release profile with minimal burst release and controlled drug delivery over 12 hours. Furthermore, stability studies confirmed that F9 remained stable under accelerated storage conditions, indicating good formulation robustness. Overall, the results conclude that the combined use of cashew nut tree gum, Psidium guajava mucilage, and povidone at optimized concentrations is an effective strategy for developing sustained release matrix tablets of diclofenac. Formulation F9 was identified as the optimized formulation and holds promise for improving therapeutic efficacy and patient compliance in the management of chronic inflammatory conditions.

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