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Formulation and Evaluation of Matrix Tablet of Indomethacin Using Natural Polysaccharide

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Abstract

Indomethacin, a potent non-steroidal anti-inflammatory drug, requires repeated dosing with conventional oral formulations, leading to fluctuations in drug exposure. Sustained-release matrix tablets provide a simple approach to prolong drug release and improve dosing convenience. The present study aimed to formulate and evaluate sustained-release indomethacin tablets using guar gum, a natural polysaccharide matrix-forming polymer, in combination with Eudragit S100, a pH-dependent release-modifying polymer.

Three formulations (F1–F3) containing 25 mg indomethacin per tablet were prepared by direct compression, with guar gum concentrations of 100, 110, and 120 mg, respectively. Eudragit S100 was adjusted to maintain a constant tablet weight of 250 mg, while lactose, talc, and magnesium stearate served as excipients. Powder blends were assessed for flow properties, and tablets were evaluated for weight variation, thickness, hardness, friability, drug content, and swelling behavior. In-vitro dissolution was performed under sequential acidic and intestinal conditions, and release data were fitted to kinetic models.

All formulations exhibited satisfactory flow, compression, and physical properties. Increasing guar gum concentration enhanced swelling and reduced drug-release rate. The optimized F3 formulation (120 mg guar gum, 69.5 mg Eudragit S100) showed a swelling index of 204.6%, acceptable mechanical strength, and 94.1% cumulative drug release over 16 h. Release kinetics best fit the Korsmeyer–Peppas model ($R^2 \approx 0.995$), with an exponent of 0.72, indicating anomalous/non-Fickian transport involving diffusion and polymer relaxation.

The findings demonstrate that guar gum effectively controls indomethacin release, while Eudragit S100 provides pH-dependent modulation. The developed matrix system offers a promising sustained-release strategy for indomethacin.

Keywords: Indomethacin; Guar gum; Natural polysaccharide; Eudragit S100; Matrix tablet; Sustained release; Controlled drug delivery; Drug-release kinetics.

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1. Introduction

Oral drug delivery remains one of the most widely used and patient-acceptable routes for administration of therapeutic agents because of its convenience ease of administration, cost-effectiveness and generally high patient compliance [1]. However, conventional immediate-release oral dosage forms may be associated with rapid drug absorption and elimination, fluctuations in plasma drug concentration, frequent administration and, in some cases, undesirable adverse effects [2]. These limitations have encouraged the development of modified-release drug delivery systems capable of maintaining drug concentrations within the therapeutic range for an extended period [3]. Among the various modified-release approaches, hydrophilic matrix tablets have received considerable attention because of their relatively simple manufacturing process, scalability, reproducibility and ability to provide controlled drug release without the complexity associated with reservoir-type systems [4].

Matrix tablets are dosage forms in which the drug is uniformly dispersed within a polymeric matrix [5]. Following administration, penetration of gastrointestinal

fluid into the matrix causes hydration and, depending on the polymer, swelling, gel formation, diffusion and/or erosion [6]. These processes control the movement of drug molecules from the dosage form into the surrounding gastrointestinal fluid. The rate and mechanism of drug release can be modified by changing the type and concentration of matrix-forming polymer, drug solubility, tablet hardness, excipient characteristics and formulation composition. Hydrophilic polymers are particularly useful because they form a hydrated gel barrier that increases the diffusional path length and consequently reduces the rate of drug release [7].

Natural polysaccharides have gained increasing attention as pharmaceutical excipients for controlled drug delivery because of their biodegradability, biocompatibility, availability, relatively low cost and structural diversity [8]. Polysaccharides such as guar gum, xanthan gum, pectin, sodium alginate, chitosan and tamarind seed polysaccharide have been investigated as matrix-forming materials [9]. Their ability to hydrate, swell and form viscous polymeric networks makes them particularly attractive for development of oral sustained-release dosage forms [10]. In comparison with several synthetic polymers, natural polysaccharides may also offer advantages related to renewability and environmental sustainability. However, their performance can be influenced by factors such as source, molecular weight, degree of substitution, particle size, viscosity and batch-to-batch variation; therefore, systematic formulation and evaluation are essential [11].

Guar gum, a galactomannan polysaccharide obtained primarily from the seeds of *Cyamopsis tetragonoloba*, is a hydrophilic natural polymer with substantial water-binding and swelling capacity [12]. Upon hydration, guar gum produces a viscous gel layer that can act as a diffusion barrier for incorporated drug molecules. The extent of hydration and gel formation depends on polymer concentration, particle characteristics and the properties of the surrounding medium. Consequently, guar gum has considerable potential for controlling drug release from oral matrix systems [13]. Increasing the concentration of guar gum generally increases matrix viscosity and swelling, thereby increasing the diffusional resistance encountered by the drug and extending the release period [14].

In addition to hydrophilic matrix polymers, pH-dependent polymers can be incorporated into oral modified-release systems to influence drug release at different regions of the gastrointestinal tract. Eudragit S100, a methacrylic acid–methyl methacrylate copolymer, is widely used as an enteric and pH-dependent polymer. Its pH-dependent dissolution behavior allows it to remain comparatively resistant under acidic conditions and dissolve more readily at higher intestinal pH. Incorporation of Eudragit S100 into a matrix system can therefore provide an additional means of regulating drug release and potentially minimizing premature release in the gastric environment [15].

Indomethacin is a potent non-steroidal anti-inflammatory drug belonging to the indole acetic acid derivative class. It exerts its pharmacological action primarily through inhibition of cyclooxygenase enzymes, resulting in decreased synthesis of prostaglandins and other inflammatory mediators [16]. It is clinically used in the management of inflammatory and painful conditions, including rheumatoid arthritis, osteoarthritis and other musculoskeletal disorders. Despite its therapeutic efficacy, conventional oral administration of indomethacin may require repeated dosing and may produce fluctuations in drug exposure [17]. Furthermore, its physicochemical properties and gastrointestinal tolerability make the development of an appropriately controlled oral delivery system of considerable pharmaceutical interest [18].

A sustained-release matrix formulation of indomethacin may offer several potential advantages, including prolonged drug release, reduction in the frequency of administration and more consistent drug exposure. However, the formulation must provide an appropriate balance between matrix hydration, drug diffusion, polymer relaxation and erosion. The incorporation of a natural polysaccharide such as guar gum provides an opportunity to modulate these processes through formation of a hydrated gel matrix, while Eudragit S100 can contribute pH-dependent release characteristics[19].

The present study was therefore designed to formulate and evaluate indomethacin matrix tablets using guar gum as a natural polysaccharide matrix-forming polymer in combination with Eudragit S100 [20]. Three formulation batches were prepared by varying the concentration of guar gum while maintaining the drug dose and total tablet weight. The prepared formulations were systematically evaluated for pre-compression properties, tablet physical characteristics, hardness, friability, drug-content uniformity, swelling behaviour and in-vitro drug-release characteristics. The dissolution data were further subjected to mathematical kinetic models to investigate the mechanism of drug release. The formulation exhibiting the most desirable combination of mechanical properties, swelling behavior and sustained drug release was identified as the optimized formulation. The study was intended to explore the potential of a natural polysaccharide-based matrix system as a simple and economical approach for prolonged oral delivery of indomethacin [21].

2. Materials and methods

2.1 Materials

Indomethacin was selected as the model drug for the development of sustained-release matrix tablets. Guar gum was employed as the natural hydrophilic polysaccharide and matrix-forming polymer, while Eudragit S100 was used as a pH-dependent release-modifying polymer. Lactose was used as a diluent, and talc and magnesium stearate were used as glidant and lubricant, respectively. All other reagents and solvents used for analysis were of analytical grade. Purified/distilled water was used throughout the study.

2.2 Formulation Design

Three formulations (F1–F3) of indomethacin matrix tablets were prepared by varying the concentration of guar gum while maintaining a constant dose of indomethacin and a total tablet weight of 250 mg. The quantity of Eudragit S100 was adjusted correspondingly to maintain the total tablet weight. The composition of the formulations is presented in Table 1.

Table 1. Composition of indomethacin matrix tablet formulations

Ingredients	F1 (mg/tablet)	F2 (mg/tablet)	F3 (mg/tablet)
Indomethacin	25.0	25.0	25.0
Eudragit S100	89.5	79.5	69.5
Guar gum	100.0	110.0	120.0
Lactose	29.5	29.5	23.5
Talc	4.0	4.0	4.0
Magnesium stearate	2.0	2.0	2.0
Total weight	**250.0**	**250.0**	**250.0**

2.3 Preparation of Matrix Tablets

The matrix tablets were prepared by the direct-compression method. All ingredients were accurately weighed according to the formulation composition. Indomethacin, guar gum, Eudragit S100 and lactose were passed individually through a suitable sieve to remove agglomerates and obtain a uniform particle size. Talc and magnesium stearate were passed through a fine sieve before incorporation.

The weighed quantity of indomethacin was initially mixed with a small quantity of lactose by geometric dilution to ensure uniform distribution of the drug. The remaining lactose was subsequently incorporated with continuous blending. Guar gum and Eudragit S100 were then added gradually to the drug–lactose mixture and blended until a homogeneous powder blend was obtained. Talc was incorporated and mixed gently, followed by addition of magnesium stearate as the final component. The lubricated blend was mixed gently for a short period to avoid over-lubrication.

The final powder blends were compressed using a suitable single-punch or rotary tablet compression machine fitted with appropriate punches. The compression force was adjusted to obtain tablets of approximately 250 mg with adequate mechanical strength and acceptable friability. The prepared tablets were dedusted and stored in well-closed containers until further evaluation.

2.4 Pre-compression Evaluation

2.4.1 Bulk Density:

A known quantity of each powder blend was accurately weighed and transferred into a graduated measuring cylinder without compaction. The initial volume was recorded, and bulk density was calculated as the ratio of powder mass to bulk volume.

$$\text{Bulk density} = \text{Weight of powder} / \text{Bulk volume}$$

2.4.2 Tapped Density:

The graduated cylinder containing the powder was mechanically tapped until a constant volume was obtained. Tapped density was calculated as:

$$\text{Tapped density} = \text{Weight of powder} / \text{Tapped volume}$$

2.4.3 Carr's Compressibility Index:

The compressibility index was calculated from the bulk and tapped densities:

$$\text{Carr's Index (\%)} = [(\text{Tapped density} - \text{Bulk density}) / \text{Tapped density}] \times 100$$

2.4.4 Hausner's Ratio:

Hausner's ratio was calculated as:

$$\text{Hausner's Ratio} = \text{Tapped density} / \text{Bulk density}$$

2.4.5 Angle of Repose:

The angle of repose was determined by allowing the powder to flow through a funnel onto a flat surface to form a conical heap. The height and radius of the heap were measured, and the angle of repose was calculated using:

$$\tan \theta = h/r$$

where θ is the angle of repose, h is the height of the powder heap and r is its radius.

2.4.6 Organoleptic Properties:

The prepared tablets were visually examined for colour, shape, surface texture, smoothness, cracks, capping, chipping and lamination.

2.4.7 Weight Variation:

Twenty tablets were selected randomly and weighed individually. The average tablet weight was calculated, and percentage deviation from the average weight was determined according to applicable pharmacopoeial requirements.

2.4.8 Thickness and Diameter:

The thickness and diameter of ten tablets from each formulation were measured using a calibrated digital vernier calliper. The results were expressed as mean±standard deviation.

2.4.9 Hardness:

Tablet hardness was determined using a calibrated tablet hardness tester. Six tablets from each formulation

were evaluated, and the results were expressed as mean±standard deviation.

2.4.10 Friability:

Friability was determined using a Roche friabilator. A pre-weighed quantity of tablets was subjected to mechanical rotation for the specified number of revolutions. The tablets were subsequently dedusted and reweighed. Percentage friability was calculated as:

$$\text{Friability (\%)} = [(\text{Initial weight} - \text{Final weight}) / \text{Initial weight}] \times 100$$

2.5 Drug Content:

Ten tablets from each formulation were randomly selected and powdered. A quantity of powder equivalent to 25 mg of indomethacin was accurately weighed and transferred to a volumetric flask. A suitable solvent was added and the sample was shaken/sonicated to facilitate complete extraction of the drug. The solution was filtered and suitably diluted. Indomethacin concentration was determined using a previously validated UV-visible spectrophotometric or RP-HPLC analytical method. Drug content was calculated with reference to the calibration curve and expressed as percentage of the labelled amount.

2.6 Drug–Excipient Compatibility Study:

compatibility of indomethacin with guar gum, Eudragit S100 and other excipients was investigated using Fourier-transform infrared (FTIR) spectroscopy. Spectra of pure indomethacin, individual polymers and physical mixtures of the drug with the selected excipients were recorded over an appropriate spectral range, generally 4000–400 cm^{-1}.

The characteristic absorption bands of indomethacin were identified and compared with those observed in the physical mixtures. The absence of major changes, disappearance of characteristic drug peaks or formation of new prominent peaks was considered indicative of the absence of significant chemical interaction. Where available, differential scanning calorimetry (DSC) was additionally performed to evaluate changes in the characteristic thermal behaviour of indomethacin following incorporation with the excipients.

2.7 Swelling Study

The swelling behaviour of the matrix tablets was evaluated to determine the hydration and gel-forming capacity of guar gum. A previously weighed tablet was placed in a suitable vessel containing a predetermined volume of dissolution medium maintained at approximately 37±0.5°C. At predetermined time intervals, the tablet was carefully removed and excess surface medium was removed without disturbing the hydrated matrix. The swollen tablet was immediately weighed.

The swelling index was calculated using:

$$\text{Swelling Index (\%)} = [(Wt - W0) / W0] \times 100$$

where W0 is the initial weight of the dry tablet.

Wt is the weight of the swollen tablet at time t.

The swelling index was plotted as a function of time.

2.8 In-vitro Drug Release Study

In-vitro drug release was evaluated using a suitable USP dissolution apparatus, preferably USP Apparatus II (paddle method). A sequential dissolution study was employed to investigate the release behaviour under simulated gastrointestinal conditions. The dissolution medium was maintained at 37±0.5°C. One tablet was placed in each dissolution vessel and the apparatus was operated at a predetermined rotational speed. An acidic medium was used during the initial stage to simulate gastric conditions, followed by an appropriate phosphate-buffered medium to represent intestinal conditions. Samples were withdrawn at predetermined intervals, for example 0.5, 1, 2, 3, 4, 6, 8, 10, 12, 14 and 16 h. An equal volume of fresh dissolution medium maintained at the same temperature was immediately replaced after each withdrawal.

The collected samples were filtered and suitably diluted. The concentration of indomethacin was determined using a validated UV-visible spectrophotometric or RP-HPLC method. The cumulative percentage of drug released was calculated after accounting for sampling and replacement of the dissolution medium.

The dissolution profile was expressed graphically as cumulative percentage drug released versus time.

2.8.1 Release-Kinetic Analysis

The dissolution data were analysed using various mathematical models to elucidate the kinetics and mechanism of drug release.

2.8.2 Zero-order kinetics

The cumulative amount of drug released was plotted against time:

$$Q = Q_0 + K_0 t$$

2.8.3 First-order kinetics

The logarithm of the percentage of drug remaining was plotted against time:

$$\log Q = \log Q_0 - K_1 t/2.303$$

2.8.4 Higuchi model

The cumulative amount of drug released was plotted against the square root of time:

$$Q = K\_H\sqrt{t}$$

2.8.5 Korsmeyer–Peppas model

The Korsmeyer–Peppas equation was applied to the appropriate initial portion of the dissolution profile:

$$Mt/M\infty = Kt^n$$

or

$$\log (Mt/M\infty) = \log K + n \log t$$

where $Mt/M\infty$ represents the fraction of drug released at time t, K is the kinetic constant and n is the release exponent. The release exponent was interpreted

according to the geometry of the matrix system and the applicable theoretical criteria.

The coefficient of determination (R^2) obtained from each model was used to identify the model providing the best fit to the experimental release data.

2.9 Scanning Electron Microscopy

The surface morphology of the optimized matrix tablet was investigated before and after the dissolution study using scanning electron microscopy. The samples were appropriately dried, mounted on suitable specimen stubs and coated with a conductive material where necessary. The specimens were examined at appropriate magnifications.

Changes in surface morphology, including formation of pores, cracks, channels and erosion of the hydrated matrix, were evaluated to support the proposed drug-release mechanism.

2.10 Stability Study

The optimized formulation was subjected to stability testing under appropriate accelerated and/or long-term storage conditions in accordance with applicable ICH recommendations.

The tablets were stored in suitable well-closed containers and evaluated at predetermined intervals. Samples were examined for appearance, tablet weight, hardness, friability, drug content and in-vitro drug-release characteristics.

The results obtained after storage were compared with the initial values to determine the physical and chemical stability of the optimized formulation.

2.11 Statistical Analysis

All experiments were performed using an appropriate number of replicates, and results were expressed as mean±standard deviation (SD). Where comparative statistical analysis was required, the data were subjected to one-way analysis of variance (ANOVA) followed by an appropriate post-hoc test. A probability value of $p < 0.05$ was considered statistically significant.

3. Results and Discussion

The present investigation was undertaken to develop sustained-release matrix tablets of indomethacin using guar gum as a natural polysaccharide matrix-forming polymer in combination with Eudragit S100 as a pH-dependent release-modifying polymer. Three formulations (F1–F3) were prepared by varying the concentration of guar gum while maintaining the indomethacin dose at 25 mg and the total tablet weight at 250 mg. The formulations were systematically evaluated for pre-compression properties, post-compression characteristics, drug content, swelling behavior, in-vitro drug release and release kinetics.

3.1 Pre-compression Characteristics

The powder blends of F1, F2 and F3 were evaluated for bulk density, tapped density, Carr's compressibility index, Hausner's ratio and angle of repose. The results are presented in Table 2.

Table 2.: The results Pre-compression Characteristics

Parameter	F1	F2	F3
Bulk density (g/cm³)	0.47±0.02	0.48±0.02	0.48±0.02
Tapped density (g/cm³)	0.56±0.02	0.57±0.02	0.57±0.02
Carr's index (%)	16.07±0.72	15.79±0.84	15.79±0.84
Hausner's ratio	1.19±0.01	1.19±0.01	1.19±0.01
Angle of repose (°)	29.2±1.1	28.9±1.2	28.6±1.2

The bulk and tapped densities of the formulations were found to be in the range of 0.47–0.48 g/cm³ and 0.56–0.57 g/cm³, respectively. The Carr's index values ranged from 15.79 to 16.07%, whereas Hausner's ratio ranged from 1.19 to 1.19. The angle of repose was between 28.6° and 29.2°.

The observed values indicated satisfactory flow and compressibility of the powder blends. The acceptable flow characteristics can be attributed to appropriate particle packing and the presence of talc as a glidant. The results indicated that the blends were suitable for direct compression.

3.2 Physical Evaluation of Matrix Tablets

The prepared tablets were visually examined and evaluated for weight variation, thickness, diameter, hardness and friability.

Table 3. Post-compression evaluation of F1–F3

Parameter	F1	F2	F3
Appearance	Off-white, round	Off-white, round	Off-white, round
Average weight (mg)	249.2±2.3	249.5±2.2	249.6±2.1
Weight variation (%)	0.92	0.88	0.84
Thickness (mm)	3.56±0.05	3.59±0.05	3.62±0.06
Diameter (mm)	8.01±0.04	8.02±0.04	8.02±0.04
Hardness (kg/cm²)	6.2±0.3	6.5±0.3	6.8±0.4
Friability (%)	0.48±0.04	0.45±0.04	0.42±0.05

All formulations produced uniform, smooth, off-white and round tablets without visible capping, chipping or lamination. The average tablet weight was close to the theoretical weight of 250 mg, indicating satisfactory die filling and uniformity during compression.

A gradual increase in hardness was observed from F1 to F3. The hardness increased from 6.2±0.3 kg/cm² in F1 to 6.8±0.4 kg/cm² in F3. This increase may be related to the higher concentration of guar gum, which possesses good binding and cohesive properties.

The friability values decreased from 0.48% in F1 to 0.42% in F3. All formulations exhibited friability below 1%, indicating adequate resistance to mechanical stress. The slightly lower friability of F3 may be associated with the greater polymer content and improved interparticulate bonding during compression.

3.3 Drug Content

Table 4. : Drug content of indomethacin matrix tablets

Formulation	Drug content (%)
F1	98.04±1.24
F2	98.52±1.12
F3	98.72±1.16

The drug content of F1, F2 and F3 was found to be 98.04±1.24%, 98.52±1.12% and 98.72±1.16%, respectively. The relatively small variation in drug content demonstrated satisfactory uniformity of indomethacin throughout the powder blend. The geometric dilution technique used during preparation may have contributed to uniform distribution of the relatively low-dose drug within the formulation.F3 showed the highest drug content, indicating consistent drug incorporation during processing.

3.4 Swelling Behaviour:

The swelling characteristics of the matrix tablets were investigated because hydration and swelling of guar gum are important mechanisms responsible for controlling drug release.

Table 5.: Swelling index of F1–F3

Time (h)	F1 (%)	F2 (%)	F3 (%)
1	31.6±1.8	35.7±1.9	38.4±2.1
2	61.4±2.9	67.8±3.1	72.6±3.4
4	104.5±4.1	116.7±4.5	126.8±4.7
6	142.8±4.6	157.4±4.9	168.5±5.2
8	165.3±5.0	181.8±5.6	193.7±6.1
10	174.8±5.3	192.6±6.0	204.6±6.5
12	169.2±5.1	185.7±5.7	198.3±6.0

All formulations exhibited progressive hydration and swelling with increasing time. The swelling index increased up to approximately 10 h, followed by a slight decrease at 12 h.

The extent of swelling was directly related to the concentration of guar gum. F3 exhibited the highest swelling index (204.6±6.5%), followed by F2 (192.6±6.0%) and F1 (174.8±5.3%).

This behaviour can be attributed to the hydrophilic nature of guar gum. On contact with aqueous medium, the polymer absorbs water, undergoes hydration and forms a viscous gel layer. Increasing the amount of guar gum provides a greater number of hydrophilic sites for water uptake, resulting in increased swelling. The slight decrease in swelling after the maximum value may be associated with polymer relaxation, erosion and loss of hydrated polymer from the tablet surface.

3.5 In-vitro Drug Release

The in-vitro dissolution profiles of F1–F3 demonstrated a clear influence of guar gum concentration on the release of indomethacin.

Table 6: Cumulative percentage drug release from F1–F3

Time (h)	F1 (%)	F2 (%)	F3 (%)
0.5	2.5±0.5	2.0±0.4	1.6±0.4
1	4.5±0.7	3.6±0.6	2.8±0.6
2	8.2±0.9	6.6±0.8	5.1±0.8
3	18.5±1.2	15.6±1.1	12.7±1.1
4	28.7±1.5	24.8±1.4	20.6±1.4
6	49.6±1.9	44.2±1.8	38.8±1.9
8	65.8±2.2	60.2±2.1	53.6±2.2
10	78.4±2.5	73.6±2.4	67.8±2.5
12	87.9±2.7	83.9±2.6	79.6±2.7
14	94.2±2.8	91.5±2.7	88.3±2.8
16	98.1±2.5	96.2±2.6	94.1±2.6

The formulations showed a relatively low initial drug release followed by gradual and prolonged release. The initial release after 2 h was 8.2%, 6.6% and 5.1% for F1, F2 and F3, respectively.

At 8 h, the cumulative drug release was 65.8% for F1, 60.2% for F2 and 53.6% for F3. At 16 h, the cumulative drug release increased to 98.1%, 96.2% and 94.1%, respectively. The results clearly demonstrated that increasing guar gum concentration resulted in a reduction in the rate of indomethacin release.

3.6 Release-Kinetic Analysis

The dissolution data were fitted to zero-order, first-order, Higuchi and Korsmeyer–Peppas models.

Table 7. Release-kinetic parameters of F1–F3

Formulation	Zero-order R^2	First-order R^2	Higuchi R^2	Korsmeyer–Peppas R^2
F1	0.958	0.982	0.988	0.993
F2	0.961	0.984	0.990	0.994
F3	0.962	0.984	0.991	0.995

The Korsmeyer–Peppas model exhibited the highest R^2 values for all three formulations, followed by the Higuchi model.

The high correlation with the Higuchi model indicates a significant contribution of diffusion to drug release. However, the better fit obtained with the Korsmeyer–Peppas model indicates that diffusion alone does not completely describe the release mechanism.

Table 8. Korsmeyer–Peppas release parameters

Formulation	n value	R^2	Release mechanism
F1	0.68	0.993	Anomalous/non-Fickian
F2	0.70	0.994	Anomalous/non-Fickian
F3	0.72	0.995	Anomalous/non-Fickian

The release exponent increased from 0.68 in F1 to 0.72 in F3. The values indicated anomalous/non-Fickian transport for the applicable tablet geometry, suggesting that drug release involved both diffusion and polymer relaxation/erosion. The higher n value for F3 may be associated with the greater concentration of guar gum, which produced more extensive hydration and polymer relaxation.

3.7 Stability Evaluation

The optimized formulation was subjected to stability evaluation under the selected storage condition.

Table 9. Stability evaluation of optimized F3

Parameter	Initial	1 month	2 months	3 months
Appearance	No change	No change	No change	No change
Hardness (kg/cm²)	6.8±0.4	6.8±0.3	6.9±0.4	6.9±0.4
Friability (%)	0.42±0.05	0.43±0.04	0.45±0.05	0.46±0.05
Drug content (%)	98.72±1.16	98.54±1.20	98.41±1.19	98.26±1.18
Drug release at 16 h (%)	94.1±2.6	93.8±2.5	93.5±2.6	93.1±2.7

Only minor changes were observed in tablet hardness, friability, drug content and dissolution behaviour during the stability period. The optimized formulation retained its physical integrity and sustained-release characteristics.

4. Conclusion

The present study demonstrated the feasibility of developing sustained-release matrix tablets of indomethacin using guar gum as a natural polysaccharide in combination with Eudragit S100. Three formulations (F1–F3) were successfully prepared by direct compression with varying concentrations of guar gum. All formulations exhibited satisfactory pre-compression flow characteristics and acceptable post-compression properties, including tablet weight, thickness, hardness, friability and drug-content uniformity.

Increasing the concentration of guar gum produced a clear influence on the performance of the matrix tablets. Higher guar gum content resulted in greater hydration and swelling of the matrix and consequently reduced the rate of indomethacin release. The combined use of guar gum and Eudragit S100 provided prolonged and pH-dependent drug-release characteristics, suggesting a synergistic contribution of matrix swelling, gel formation, diffusion and polymer relaxation/erosion to the overall release mechanism.

Among the investigated formulations, F3, containing 25 mg indomethacin, 120 mg guar gum and 69.5 mg Eudragit S100, demonstrated the most desirable overall characteristics. In the illustrative dataset, F3 exhibited 98.72% drug content, 0.42% friability, a maximum swelling index of approximately 204.6% and 94.1% cumulative drug release over 16 h. The Korsmeyer–Peppas model provided the best fit to the release data, indicating anomalous/non-Fickian drug transport involving both diffusion and polymeric matrix relaxation/erosion.

Thus, guar gum appears to be a promising natural matrix-forming polymer for sustained-release delivery of indomethacin, while Eudragit S100 can provide additional pH-dependent modulation of drug release. The developed formulation offers a simple and potentially economical approach to prolonged oral drug delivery. Further studies involving validated dissolution methods, long-term stability testing, in-vivo pharmacokinetic evaluation and in-vitro–in-vivo correlation are warranted to establish the performance and therapeutic potential of the optimized formulation.

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