FORMULATE AND EVALUATE SUSTAINED RELEASE MATRIX TABLETS OF DICLOFENAC SODIUM USING NATURAL GUM EXTRACTED FROM *PRUNUSARMENIACA* L. (APRICOT) AS A MATRIX- FORMING AGENT

Amandeep Kaur and Anjali Negi*
Global Institute of Pharmaceutical Education &Research (GIPER)
Kashipur-244713, Uttarakhand, India

ABSTRACT:

Sustained-release (SR) preparations are formulated to design the active pharmaceutical ingredient (API) gently over an extended duration. This method improves patient compliance, reduces side effects, and provides constant medication action while sustaining therapeutic drug levels in the bloodstream for lengthy stretches of time. This study focuses on the preparation and investigation of sustained-release matrix tablets containing diclofenac sodium, utilizing a natural gum extracted from *Prunus armeniaca* (apricot) and benchmarking its performance against chitosan, a commonly used polymer in drug delivery. Direct compression was employed to formulate the tablets with varying concentrations (5%, 10%, and 15% w/w) of each polymer. Pre-compression parameters such as powder flow and compressibility were analyzed, followed by assessment of tablet properties including hardness, friability, drug content, and uniformity. The release characteristics of the drug were examined using a USP type II dissolution apparatus in phosphate buffer (pH 7.4) over a 12-hour period. Interpretation of the release data was carried out through different kinetic models to determine the release mechanism. Findings revealed that both *Prunus armeniaca* gum and chitosan effectively prolonged the release of diclofenac, with the apricot gum showing a comparable, and in some cases enhanced, sustained release profile at higher polymer concentrations. The observed results point to the fact that *Prunus armeniaca* gum has potential as a natural, eco-friendly, and economical polymer for use in sustained release drug formulations.

Keywords: Sustained release, Diclofenac, Chitosan, *Prunus armeniaca* (apricot) Drug delivery, Biodegradable polymers, Controlled release, NSAIDs.

1. INTRODUCTION

Non-steroidal anti-inflammatory drugs (NSAIDs) are widely utilized for their analgesic, antipyretic, and anti-inflammatory properties. Their primary mechanism involves the inhibition of cyclooxygenase (COX) enzymes, specifically COX-1 and COX-2, which are responsible for the synthesis of prostaglandins—key mediators of pain, inflammation, and fever. This pharmacological mechanism is commonly referred to as the COX inhibition theory, providing a foundational explanation for both the therapeutic effects and potential adverse reactions associated with NSAID use.Diclofenac sodium is a commonly prescribed non-steroidal anti-inflammatory medication (NSAID) that effectively relieves pain and inflammation. Diclofenac's chemical name is 2-(2,6-dichloranilino) phenyl acetic acid. [1-2]. Diclofenac's primary mechanism of action is anti-inflammatory, antipyretic, and analgesic, and it is important to inhibit Cyclooxygenase (COX I, COX II) enzyme, which is responsible for inhibiting prostaglandin synthesis. Diclofenac sodium is widely used to treat pain and inflammation, notably in arthritis, osteoarthritis, and musculoskeletal problems. However, standard dosage forms, such as immediate-release pills, have been associated with fluctuations in plasma drug concentrations, which may lead to suboptimal therapeutic outcomes, an increased incidence of adverse effects, and reduced patient compliance [3-5]. It has a short half-life (1.5-2.5 hours), and traditional immediate-release. DS tablets facilitate the rapid availability of the drug for absorption in the upper gastrointestinal (GI) tract, resulting in local GI toxicity [6]. The short biological half-life and frequent dosing make DS an excellent option for sustained release dosage formulations.

Sustained delivery systems allow you to manage the bioavailability of therapeutic substances by delivering the medicine in a predetermined and prolonged manner [7]. A diverse array of synthetic and natural polymers has been systematically investigated as drug delivery vehicles, owing to their physicochemical properties that enable controlled release, targeted delivery, and improved stability of pharmaceutical agents [8]. Polymer-based hydrophilic matrix systems are extensively employed in oral sustained-release drug delivery systems due to their versatility in providing a suitable drug release profile, economic benefits, ease of process development, and widespread regulatory acceptability[9-11].In pharmaceutical uses**, chitosan**—a bio-macromolecule originating from crustacean shells—has drawn a lot of interest, especially in modified-release formulations. For sustained-release drug delivery systems, its mucoadhesive qualities, biodegradability, and biocompatibility make it a perfect fit. Chitosan can limit drug release, create gels, and prevent delicate chemicals from degrading. Employment of a pH-sensitive polymeric system in sustained-release distribution appears to be a straightforward strategy that offers the intended release over a

long time [12]. Therefore, an effort was made to create a sustained release dosage form that would eliminate the need for multiple doses by containing beads of diclofenac sodium for controlled release and solid dispersion of diclofenac sodium for immediate release. This approach enhances patient adherence while minimizing the incidence of adverse effects[13-15].

Matrix systems are composed of both active pharmaceutical ingredients (APIs) and excipients, uniformly dispersed throughout the dosage form. They represent one of the most widely employed technologies for oral controlled drug delivery. The widespread adoption of matrix-based systems can be attributed to multiple advantageous factors, which will be elaborated upon in subsequent sections. Drug release from these formulations is primarily governed by Fick's first law of diffusion.

Eq. -

$$J = -D.dC/dX$$

- **J** represents the *diffusive flux*, defined as the amount of substance that passes through a unit area per unit time (e.g., mol/cm²·s).
- **C** denotes the *concentration gradient* (amount of substance per unit volume), which drives the diffusion process.
- **D** is the *diffusion coefficient* (or diffusivity), a proportionality constant that quantifies the rate at which a substance diffuses through a medium, typically expressed in units of cm²/s.

The process used to prepare formulations for compression is contingent upon polymer and drug: polymer ratio. With high drug: polymer ratio, a wet granulation process is required. Low – milligram – potency formulations may be directly compressed or granulated using alcohol if the polymer is not in a form amenable to direct compression [16].

➢ **BENEFITS OF LONG-TERM MEDICATION DELIVERY SYSTEMS [17-19]:**

- Less frequently doses are administered.
- Offer more patient compliance.
- Lessens the likelihood of adverse effects and lessens GIT discomfort.
- Lower drug costs lead to greater patient acceptability.
- Better therapy lowers health care costs.
- By creating sustained release formulations, many medications' bioavailability is increased.

➢ **MODIFIED-RELEASE DRUG DELIVERY SYSTEM DRAWBACKS INCLUDE[17-19]:**

- Drugs with a short halflife need to be administered often, which raises the risk of skipping a dose.

- Unsteady peak plasma concentration results from administering the drug at an arbitrary interval.
- There is a greater likelihood of drug plasma concentration fluctuation.
- Patient compliance is extremely decreased as a consequence of frequent drug administration.

➢ SUSTAINED RELEASE DRUG DELIVERY SYSTEM JUSTIFICATION

- To extend the medication's duration of action.
- To reduce the recurrence of dosage.
- To minimize plasma level variations.
- Better drug use.

➢ PRUNUS ARMENIACA GUM IN DRUG DELIVERY

The gum derived from *Prunus armeniaca*, commonly known as the apricot tree, is an endogenous secretion collected from its bark. This plant-based polymer consists primarily of complex sugars such as arabinose, galactose, rhamnose, and uronic acids. It appears as a light amber or pale-yellow resin and readily dissolves in water, producing a viscous, gel-like solution. These functional characteristics renders it a potential candidate for use in pharmaceuticals, especially in tablet formulation as a binder and for achieving sustained drug release.

Due to its non-toxic nature, biodegradability, and origin from renewable sources, *Prunus armeniaca* gum is gaining interest as a natural substitute for synthetic and semi-synthetic excipients. Its capacity to swell and form gels contributes to the gradual release of drugs, supporting its potential role in precision-controlled therapeutic delivery frameworks. Additionally, its eco-friendly profile aligns well with the current push toward greener pharmaceutical practices.

- **Thickening agent**: It exhibits a significant water uptake capability, making it useful as a gel or thickening agent in drug formulations.
- **Biodegradable and non-toxic**: It is safe for oral and topical applications.
- **Mucoadhesive properties**: Similar to chitosan, Prunus armeniaca gum can also adhere to mucosal surfaces, enhancing drug retention and absorption.
- **Film-forming ability**: It facilitates the formation of films demonstratinguseful for sustained drug release.

➢ COMBINED USE OF CHITOSAN AND PRUNUS ARMENIACA GUM FOR DICLOFENAC DELIVERY

The combination of chitosan and Prunus armeniaca gum has the potential to optimize diclofenac delivery, combining the benefits of both polymers.

- **Synergistic effect**: The combination of the mucoadhesive properties of both chitosan and Prunus armeniaca gum could enhance the residence time of the therapeutic agent at the locus of actionabsorption, leading to improved bioavailability.
- **Sustained release**: Chitosan and Prunus armeniaca gum can form complex networks that control the release rate of diclofenac, providing prolonged therapeutic effects and reducing the need for frequent dosing.
- **Enhanced solubility**: Chitosan can improve the solubility of diclofenac, and Prunus armeniaca gum can aid in forming gel-like structures that dissolve in the gastrointestinal tract, enabling regulated drug deliverymanner.
- **Reduction of side effects**: Utilization of the aforementioned polymerscould help mitigate gastrointestinal irritation by reducing the direct contact of diclofenac with the stomach lining and by controlling its release over time.

➢ APPLICATIONS OF CHITOSAN IN MODIFIED-RELEASE DICLOFENAC FORMULATIONS

1. **Pain Management**: Particularly for long-term ailments like osteoarthritis or rheumatoid arthritis, chitosan-based formulations can offer regulated release of diclofenac, guaranteeing sustained pain treatment with a lower frequency of dosages.
2. **Gastrointestinal Protection**: By offering a sustained-release profile that lowers peak drug concentrations, chitosan may help diclofenac formulations avoid gastric irritation, a frequent NSAID side effect.
3. **Targeted Drug Delivery**: By utilizing its mucoadhesive qualities for localized medication delivery, chitosan can be utilized to create systems that target particular bodily locations, including the colon.
4. **Combination Therapy**: To produce synergistic therapeutic effects, chitosan can also be used in conjunction with other medications or excipients. For instance, diclofenac can be combined with other anti-inflammatory treatments.[20-25].

2. MECHANISM OF ACTION:

During inflammation, pain, and fever, arachidonic acid is released from the phospholipid portion of the cell membrane. This acid is then metabolized through two main pathways: the cyclo-oxygenase (COX-1 and COX-2) pathway, which produces prostaglandins, and the lipoxygenase pathway, which produces leukotrienes. Prostaglandins sensitize blood vessels to mediators like bradykinin, serotonin (5-HT), and histamine, increasing vascular permeability. Specifically, prostaglandins I and E contribute to the heightened pain sensitivity (hyperalgesia) seen in inflammation, and they are also involved in causing headaches, vascular pain, and fever. Leukotrienes play a role in sensitization and contribute to hypersensitivity reactions. Non-steroidal anti-inflammatory drugs (NSAIDs), such as diclofenac, work by inhibiting both the cyclo-oxygenase and lipoxygenase pathways, thereby reducing the synthesis of prostaglandins and leukotrienes. [26-29]

3. MATERIAL & METHOD OF PREPARATION:

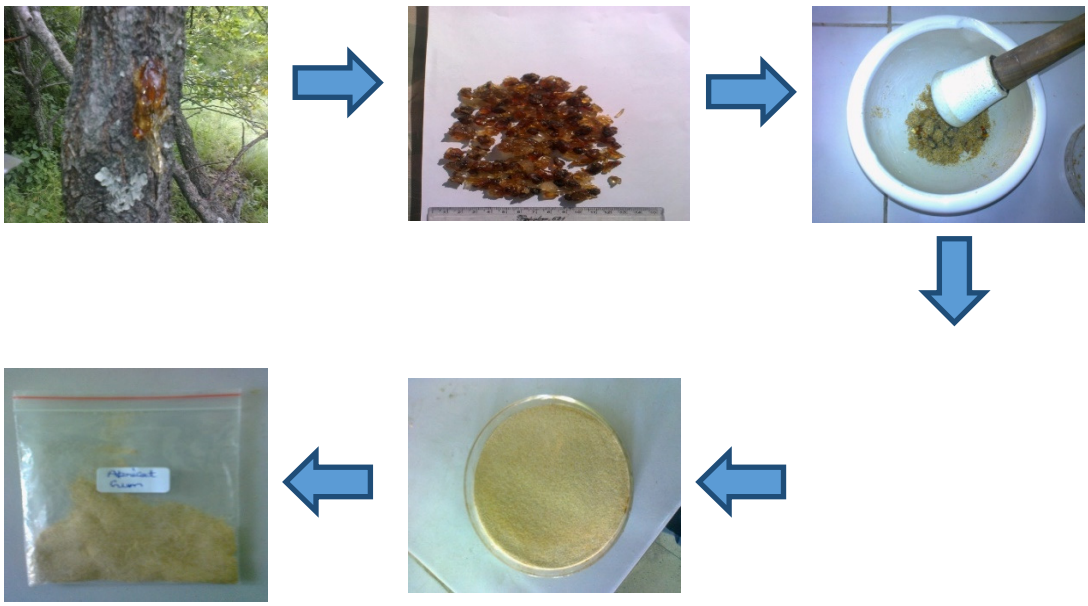
Diclofenac Sodium was a generous gift from Vivimed Labs Ltd. Kundeshwari, Kashipur including the raw materials like MCCPH-102, PVPK-30, Magnesium Stearate, Talcum, and Isopropyl Alcohol. Moreover, the Chitosan was procured from the Agron remedies Kashipur.

3.1 PREPARATION METHOD:

The non-aqueous wet granulation technique was incorporated to formulate the tablets. Diclofenac tablets were prepared in three different consecutive batches with different dose ratio in accordance with the Table 1. Diclofenac sodium and chitosan were weighed properly & this was mixed uniformly with sufficient amount of lactose and MCCPH-102 in a motar pestle for 10 minutes. The mixture was sieved through a 20-mesh sieve to get uniform size particles. After that, polyvinyl pyrollidone K-30 was dissolved with required quantity of isopropyl alcohol, added to the powder, mixed and blended uniformly to form a damp mass. Then the prepared mixture dried at 40°C in oven for 30 minutes, and then passed through a 16-mesh sieve to form the granules. Talcum and magnesium stearate were added to the granules as glidant and lubricant, respectively and mixed properly for 10min. The granulated material was compressed into tablet dosage forms using a 9 mm diameter, standard flat punch on an 8-station double rotary compression machine. After the compression the tablets were evaluated for key quality control parameters, including friability, hardness, thickness, weight variation, dissolution, and assay. [30-31]

➢ EXTRACTION AND PURIFICATION OF GUM

Apricot gum was initially dried and ground using a mortar and pestle, then passed through a #44 mesh sieve. It was subsequently soaked in distilled water for 24 hours with occasional stirring to ensure proper hydration. Any impurities were removed by filtering the mixture through muslin cloth. The gum was then precipitated from the solution by adding absolute acetone. The formed precipitate was harvested and dried at 50°C. Once dried, it was finely powdered using a mortar and pestle, passed through a #72 sieve, and stored in an airtight container. [32]



➢ PHYTOCHEMICAL SCREENING OF *PRUNUS ARMENIACA* L. GUM

A series of phytochemical tests were conducted to identify the presence of various bioactive compounds in *Prunus armeniaca* L. (Apricot) gum:

- **Alkaloids (Dragendorff's Test):**The test solution was exposed with potassium iodide solution. The formation of a reddish-brown precipitate revealed the existence of alkaloids in the sample.

- **Carbohydrates (Molisch's Test):** To the test solution, alcoholic α-naphthol was added followed by a few drops of concentrated sulfuric acid. The emergence of a purple to violet ring at the interface validated thepresence of carbohydrates.
- **Proteins (Biuret Test):** Upon addition of Biuret reagent to the test solution, the manifestation of a violet color indicated the presence of proteins.
- **Mucilage (Ruthenium Red Test):** The test solution was processed with Ruthenium red solution. A pink coloration confirmed the presence of mucilage.
- **Tannins (Ferric Chloride Test):**Following the introduction of ferric chloride solution into the test sample, a blue color indicated the identification ofhydrolysable tannins, while a green color suggested the presence of condensed tannins.
- **Starch (Iodine Test):**The test solution was conditioned with iodine solution. The appearance of a blue color indicated the occurrence ofstarch.
- **Glycosides (Salkowski's Test):**Upon incorporation of concentrated sulfuric acid into the test sample. The formation of a red layer at the lower interface indicated the presence of steroids, while a yellow coloration at the lower layer suggested the presence of triterpenoids.

➢ SWELLING INDEX OF GUMS:

A 1.0 g sample of gum was placed in a 15 mL graduated test tube, and the initial volume it occupied ($\mathbf{V_1}$) was recorded. Subsequently, 10.0 mL of distilled water was added, and the mixture was stirred gently to ensure uniform dispersion. The tube was subsequently allowed to stand undisturbed for24 hours to allow complete hydration. After this period, the ultimate volume occupied by the swollen gum ($\mathbf{V_2}$) was measured. The swelling index (**S**) was determined by applying the following equation:

$$\mathbf{S=V_2/V_1}$$

Where:

- **S** = Swelling Index
- $\mathbf{V_1}$ = Initial volume of gum before hydration
- $\mathbf{V_2}$ = Final volume of gum after hydration[32]

4. EXPERIMENTAL WORK:

A: PRE-FORMULATION STUDIES:

The majority of orally active drugs are available in the form of tablets, capsules, or a composite of both elements. Before formulating a dosage form for a new drug candidate, it is crucial to assess the drug's basic physical and chemical characteristics, along with key properties of its powdered form. These foundational insights play a significant role in guiding formulation strategies and determining the most suitable development pathway.

1. ANGLE OF REPOSE:

The **angle of repose (θ)** is the steepest angle at which a pile of unconsolidated powder or granules remains stable without slumping. It is determined by using fixed funnel method. When formulating diclofenac with chitosan for sustained-release purposes, the angle of repose elucidates the extent to which the powder mix will flow, which affects tablet uniformity, die filling, and compression.

It's a key preformulation parameter in pharmaceuticals used to evaluate flow properties of powders or granules -crucial for processes like tablet compression**,** capsule filling**,** and granulation**.** [33-34]

Formula:

Angle of Repose: $\theta = \tan^{-1} (h/r)$

Where:

- **θ** = angle of repose (degrees)
- **h** = height of the cone (cm or mm)
- **r** = radius of the cone base (cm or mm)

Flowability Interpretation Table:

Angle of Repose (°)	**Flow Property**
< 25	Excellent
25–30	Good
31–35	Fair
36–40	Passable

41–45	Poor
> 45	Very Poor

2. BULK DENSITY:

Bulk density refers to the mass of a powdered or granular pharmaceutical material per unit volume, including the interparticulate voids (spaces between particles). It is a critical parameter in preformulation and formulation stages, influencing:

- Powder flow
- Tablet compression
- Encapsulation
- Packaging design

Procedure: Weigh a specific amount of powder (usually 10–100 grams depending on the powder's density) from formulation A1. Pour the powder into a graduated measuring cylinder (usually 100 mL) without compacting or tapping. Record the volume the powder occupies (bulk volume). Calculate bulk density using the formula.

Bulk density= Mass of powder (g) / Bulk of Volume (ml)

3. TAPPED BULK DENSITY (TBD):

Tapped density is the density of a powder after it has been compacted by tapping or vibration. It is calculated by dividing the mass of the powder by the volume it occupies after being mechanically tapped until a minimum volume is reached.

Procedure: Use the same sample and cylinder from Bulk density. Place it on a tap density tester or manually tap the base 100 times (initially). Record the volume after 100 taps (V_1)**.** Repeat tapping until the volume change between 2 sets of 25 taps is <2% or until 1250 taps (whichever comes first). Record the final volume (VF)**.** [35-37]

Calculate: **TBD = Mass of powder (g) / Final tapped volume (mL)**

4. CARR'S INDEX (COMPRESSIBILITY INDEX)

Carr's Index is a measure of the powder's **compressibility**, i.e., how much it can be compacted. The value is computed based on the difference between a powder's **bulk density** and **tapped density**. It helps predict flow characteristics.

Carr's Index (%) = (Tapped Density−Bulk Density) ×100

Tapped Density

Interpretation:

Carr's Index (%)	Flowability
5 – 15	Excellent
12 – 16	Good
18 – 21	Fair
23 – 28	Poor
>28	Very Poor

5. HAUSNER'S RATIO:

Hausner's Ratio is another measure of powder flowability. Defined as the quotient of tapped density over bulk density**.** A higher ratio reflects that the powder displays more cohesive and resists flow. A low Hausner's Ratio means better flow properties.[38-39]

Hausner's Ratio = Tapped Density
Bulk Density

Interpretation:

Hausner's Ratio	Flowability

1.00 – 1.11	Excellent
1.12 – 1.18	Good
1.19 – 1.25	Fair
1.26 – 1.34	Poor
>1.34	Very Poor

6. PARTICLE SIZE DISTRIBUTION (PSD):

Particle Size Distribution (PSD) refers to the measurement of the range and proportion of various particle sizes within a powder or granular substance. It plays a critical role in pharmaceutical development, as it directly affects the flowability, compressibility, dissolution rate, and uniformity of the drug product. A limited particle size range usually ensures better content uniformity and faster dissolution, especially for poorly water-soluble drugs. PSD is commonly reported using statistical measures such as d10, d50, and d90, which represent the particle diameters below which 10%, 50%, and 90% of the sample volume lie, respectively. Techniques such as sieve analysis, laser diffraction, and dynamic light scattering are employed to determine PSD in pharmaceutical materials [40].

7. MOISTURE CONTENT (% LOD -LOSS ON DRYING):

Moisture content, typically expressed as Loss on Drying (LOD), is an expression of moisture content. LOD was calculated by placing 2 gm of drug powder in a Petri dish for drying in an oven at 105^0C for 1 hr. Then weighed after drying and LOD was calculated.[41]

8. DRUG-EXCIPIENT COMPATIBILITY:

Drug-excipient compatibility refers to the assessment of potential physical or chemical interactions between a pharmaceutical active component and the excipients used in its formulation. Compatibility studies are essential in the preformulation phase to ensure the selection of excipients that do not adversely affect the API. Analytical techniques such as Differential Scanning Calorimetry (DSC), Fourier-Transform Infrared Spectroscopy (FTIR), and High-Performance Liquid Chromatography (HPLC) are commonly used to detect incompatibilities. Identifying and addressing these interactions early in development is crucial for the formulation of safe and effective pharmaceutical products.[42]

9. DRUG SOLUBILITY STUDY

Drug solubility studies investigate the interactions between a drug and various solvents that may occur during drug delivery. This study evaluated the solubility of the compound by adding an excess amount of Diclofenac, both alone and as a physical mixture, to 10 ml of different solvents listed in Table 9.1. The prepared solutions were placed in a shaking water bath at room temperature for 24 hours, agitated at 100 rpm. After incubation, filtration of the solutions was performed using Whatman filter paper, and the dissolved drug content was analyzed spectrophotometrically following appropriate dilutions.

Table no. 9.1- Solubility of Diclofenac, in different solution media -

Drug	**Medium**
Diclofenac	Ethanol
Diclofenac	0.1 N HCl
Diclofenac	Phosphate buffer pH 6.8
Diclofenac	Phosphate buffer pH 7.4
Diclofenac	Distilled Water

10. ANALYTICAL TECHNIQUE:

1. **Fourier Transform Infrared Spectroscopy (FTIR)**

   FTIR spectra were obtained using ATR mode (Shimadzu FTIR-8400S). Samples were scanned from 4000–400 cm^{-1}. The spectra of pure diclofenac sodium, excipients, and binary mixtures were compared for significant shifts or disappearance of characteristic peaks, particularly those related to the carboxylic acid group (C=O stretch at ~1720 cm^{-1}) and aromatic rings (C=C stretch ~1600 cm^{-1}).

2. **Infrared Spectrophotometer (IR)**

   Infrared (IR) spectroscopy was conducted and the spectrum was recorded in the wavelength region of 4000 to 400 cm^{-1}. The procedure consisted of, dispersing a sample (drug alone, polymers alone and mixture of drug and polymers (1:1)) in KBr and compressing into discs by applying a pressure of 7 tons for 5 min in a KBr press. The pellet was positioned in the light path and the spectrum was obtained.

3. UV SPECTRA

Ultraviolet spectral analysis of Diclofenac was obtained in phosphate buffer pH 7.4 andEthanol in the scanning range of 200-400 nm.

- **Preparation of phosphate buffer (PBS) pH 7.4 -**

  2.38 gm Disodium hydrogen phosphate, 0.19 gm Potassium dihydrogen phosphate and 8.0 gm of Sodium chloride was dissolved in sufficient water to produce 1000 ml.

- **Preparation of standard solution -**

  An accurately weighed 100 mg of diclofenac was dissolved in a combination of phosphate-buffered saline (PBS, pH 7.4) and ethanol to a final volume of 100 mL, yielding a final concentration of 100 µg/ml.

- **Construction of calibration curve -**

  A serial dilution was performed from the stock solution in the range of 2-10 µg/ml was generated at the compound's wavelength of maximum absorbance of 274 nm in PBS pH-7.4 and 279 nm in ethanol. [43-44]

B: POST-COMPRESSION PARAMETERS:

Sr. No.	INGREDIENTS	F-1	F-2	F-3	F-4	F-5	F-6	F7	F-8	F-9	F-10
1	Diclofenac	200	200	200	200	200	200	200	200	200	200
2	*Prunus armeniaca* L.gum	40	60	80	100	120					
3	Chitosan						40	60	80	100	120
4	MCCPH-102	145	125	105	85	65	145	125	105	85	65
5	PVP-K30	10	10	10	10	10	10	10	10	10	10
6	Mag. Stearate	4	4	4	4	4	4	4	4	4	4
7	Talc	1	1	1	1	1	1	1	1	1	1
8.	Isopropyl Alcohol	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.	q.s.

Table 1: FORMULATION BATCHES DETAILS OF DICLOFENAC SODIUM SUSTAINED RELEASE TABLETS

1. Appearance

The physical appearance of tablets is a key quality attribute that influences patient compliance and indicates the uniformity of the manufacturing process. A visual assessment was undertaken under adequate lighting conditions to examine the tablets for color, shape, surface texture etc.

A uniform surface with no visual defects indicates proper compression, optimal excipient selection, and effective granulation. All the evaluated tablets were detected to have a smooth, round shape with a consistent off-white color and no signs of mottling, cracking, or capping.

2. Weight Variation Test

The weight variation test verifies the consistency of drug content across individual tablets. For each formulation, twenty tablets were randomly chosen and weighed separately using a calibrated analytical balance. The mean tablet weight was computed, and the percentage deviation of each tablet from this mean was calculated using the following formula:

$$\text{Weight Variation (\%)} = \frac{\text{(Individual Weight} - \text{Average Weight)}}{\text{Average Weight}} \times 100$$

- For tablets >250 mg: ±5% deviation allowed.
- For tablets 130–250 mg: ±7.5% deviation.

3. Thickness and Diameter

Tablet thickness and diameter are critical parameters influencing packaging, tablet handling, and dose accuracy. Selection was made for ten tablets at random, and their thickness and diameter were quantified using a digital **Vernier caliper** for each formulation.

Uniform tablet thickness and diameter are indicative of consistent die fill and compression force. Significant deviations may suggest uneven distribution of granules or mechanical errors in the tablet press.

4. Hardness Test (Crushing Strength)

Hardness reflects the mechanical strength of tablets and their ability to withstand handling, transportation, and packaging. It also influences disintegration and dissolution.

The hardness of ten tablets chosen without bias was measured using a Monsanto or Pfizer hardness tester, which applies pressure until the tablet breaks. The results were conveyed in **kg/cm²**.

Tablets with a hardness between **4–8 kg/cm²** are generally considered acceptable for oral solid dosage forms. Excessively hard tablets may resist disintegration, while too soft tablets may break during handling. All tested tablets demonstrated adequate hardness, suggesting an optimal balance between mechanical robustness and release properties.

5. Friability Test

Friability assesses the tablet's resistance to abrasion and mechanical shock during handling, packaging, and transport. A sample of twenty tablets was placed in a **Roche Friabilator**, which rotates at 25 rpm for 4 minutes (total of 100 revolutions). After tumbling, tablets were dusted and reweighed. Friability was calculated using:

$$F = \left(1 - \frac{W_0}{W}\right) \times 100$$

According to **USP**, friability should be **less than 1%**. The test tablets met this criterion, indicating satisfactory mechanical integrity and suitability for commercial distribution.

6. Disintegration Test

Disintegration time refers to the duration required for a tablet to break down into smaller granules or particles when exposed to gastrointestinal fluids, which is critical for drug dissolution and absorption.

The disintegration test was performed using a USP-compliant disintegration apparatus with distilled water as the immersion medium, maintained at a temperature of 37 ± 2 °C. Six tablets were evaluated concurrently, and the endpoint was defined as the complete disintegration of each tablet, with no visible residue remaining on the mesh screen.

For immediate-release tablets, USP specifies a disaggregation time not more than 15 minutes. All test tablets disintegrated within this time frame, indicating the formulation was suitable for immediate-release characteristics.

7. Drug Content Uniformity

"Content uniformity testing was performed to verify that each tablet contained the specified amount of active pharmaceutical ingredient (API), ensuring dose consistency and compliance with pharmacopeial standards. Ten tablets from each formulation batch were randomly selected, finely powdered, and accurately weighed. A quantity equivalent to one tablet was dissolved in a suitable solvent, such as phosphate buffer or methanol, then filtered and analyzed using UV-Visible spectrophotometry or HPLC at the appropriate wavelength (commonly around 276 nm for Diclofenac Sodium). “The potency of diclofenac in each sample was quantified using a validated standard calibration curve. As per USP guidelines, acceptable drug content ranges from 85% to 115% of the labeled claim. All analyzed tablets met this criterion, indicating uniform distribution of the API within the formulation.

1. IN –VITRO DRUG RELEASE STUDY:

The in-vitro dissolution study procedure includes introducing a tablet into a dissolution apparatus containing an appropriate medium, usually 900 mL of simulated gastric or intestinal fluid kept at $37 \pm 0.5°C$. The dissolution apparatus, either USP type I (basket) or type II (paddle), is operated at a controlled rotation speed, generally between 50 and 100 rpm. Aliquots were withdrawn at predetermined time intervals, filtered, and subjected to analytical evaluation by UV spectrophotometry or HPLC to measure the extent of drug release. To ensure sink conditions, a corresponding volume of fresh medium was replenished after each sample withdrawal. The total percentage of drug released over time is then plotted and evaluated against pharmacopeial specifications to determine the tablet’s release behavior and efficacy.[45-49]

CONCLUSION

This study focuses on the development of sustained release matrix tablets of Diclofenac Sodium using natural gum extracted from Prunus armeniaca L. (apricot) as a matrix-forming agent. The apricot gum demonstrated favorable physicochemical properties, including good compressibility, swelling ability, and sustained drug release capacity.

When compared to chitosan, a commonly used natural polymer, apricot gum offered comparable performance in controlling drug release. While chitosan is valued for its biodegradability, mucoadhesiveness, and ability to form gels, it is derived from animal sources and has solubility

limitations at neutral pH. In contrast, apricot gum is plant-based, more accessible, and cost-effective, making it a suitable alternative for vegetarian or allergen-sensitive populations.

Overall, the study suggests that apricot gum is a promising, natural, and sustainable matrix-forming agent for controlled release formulations, with potential to replace or complement chitosan in pharmaceutical applications. Further in-vivo studies and long-term stability assessments are recommended.

REFERENCES:

Nagaich, U., Kumar, P., & Gulati, N. (2014). Formulation and evaluation of diclofenac sodium sustained release matrix tablets using natural polymers. *International Journal of Pharmaceutical Sciences and Research*, *5*(9), 3732–3737.

Yadav, S., Saini, V., & Rana, A. C. (2018). Formulation, optimization and in vitro evaluation of diclofenac sodium-loaded sustained-release matrix tablet containing both natural and semi-synthetic polymers. *International Journal of Pharmaceutical Sciences and Research*, *9*(3), 1024–1032.

Brunton, L. L., Hilal-Dandan, R., &Knollmann, B. C. (Eds.). (2018). *Goodman & Gilman's: The pharmacological basis of therapeutics* (13th ed.). McGraw-Hill Education.

Rang, H. P., Dale, M. M., Ritter, J. M., Flower, R. J., & Henderson, G. (2012). *Rang & Dale's Pharmacology* (7th ed.). Elsevier Health Sciences.

Yadav, S., Saini, V., & Rana, A. C. (2018). Formulation, optimization and in vitro evaluation of diclofenac sodium-loaded sustained-release matrix tablet containing both natural and semi-synthetic polymers. *International Journal of Pharmaceutical Sciences and Research*, *9*(3), 1024–1032.

Jeganathan B, Prakya V, Deshmukh A. Preparation and evaluation of diclofenac sodium tablet coated with polyelectrolyte multilayer film using Hypromellose acetate succinate and polymethacrylates for pH-dependent, modified release drug delivery. AAPS PharmSciTech 2016;17:578-87.

Jogani V, Jinturkar K, Vyas T, Misra A. Recent patents review on intranasal administration for CNS drug delivery. Recent Pat Drug DelivFormul 2008;2:25-40.

Hoffman AS. Hydrogels for biomedical applications. Adv Drug Deliv Rev 2002;54:3-12.

Wadher KJ, Kakde RB, Umekar MJ. Study on sustained-release metformin hydrochloride from matrix tablet: Influence of hydrophilic polymers and in vitro evaluation. Int J Pharm Investig 2011;1:157-63.

Mehta DM, Parejiya PB, Barot BS, Shelat PK. Investigation of the drug release modulating effect of acidifiers in modified release oral formulation of cinnarizine. Asian J Pharm Sci 2012;7:193-201.

Miyazaki Y, Tanaka Y, Yakou S, Takayama K. In vitro drug release from Hydrophillic dextran tablets capable of forming polyion complex. J Control Release 2006;114:47-52.

Wadher KJ, Kakde RB, Umekar MJ. Formulation and evaluation of a sustained-release tablets of metformin hydrochloride using hydrophilic synthetic and hydrophobic natural polymers. Indian J Pharm Sci 2011;73:208-15

Nagaich, U., Kumar, P., & Gulati, N. (2014). Formulation and evaluation of diclofenac sodium sustained release matrix tablets using natural polymers. International Journal of Pharmaceutical Sciences and Research, 5(9), 3732–3737.

Yadav, S., Saini, V., & Rana, A. C. (2018). Formulation, optimization and in vitro evaluation of diclofenac sodium-loaded sustained-release matrix tablet containing both natural and semi-synthetic polymers. International Journal of Pharmaceutical Sciences and Research, 9(3), 1024–1032.

Patel, D. M., Shah, R. R., & Patel, C. N. (2015). Formulation and evaluation of sustained release matrix tablets of diclofenac sodium using natural gum. International Journal of Pharmaceutical Investigation, 5(3), 149–155.

Gilbert S. Banker, Christopher T. Rhodes, “Modern Pharmaceutics Fourth Edition,Revised and Expanded”.

Brunton, L. L., Hilal-Dandan, R., &Knollmann, B. C. (Eds.). (2018). Goodman & Gilman's: The pharmacological basis of therapeutics (13th ed.). McGraw-Hill Education.

Patel, D. M., Shah, R. R., & Patel, C. N. (2015). Formulation and evaluation of sustained release matrix tablets of diclofenac sodium using natural gum. International Journal of Pharmaceutical Investigation, 5(3), 149–155. https://doi.org/10.4103/2230-973X.160846

Yadav, S., Saini, V., & Rana, A. C. (2018). Formulation, optimization and in vitro evaluation of diclofenac sodium-loaded sustained-release matrix tablet containing both natural and semi-synthetic polymers. International Journal of Pharmaceutical Sciences and Research, 9(3), 1024–1032.

Bhumkar,D.R.,&Gautam,S.S.(2008) Chitosan-based nanoparticles as controlled drug delivery devices. Pharmaceutical Development and Technology, 13(3), 322-328.

Chen,M.,Liu,M.,Li,Z.,&Wang,X.(2011)Controlled release of diclofenac from chitosan-based microspheres: Formulation and in vitro evaluation. Journal of Microencapsulation, 28(7), 615-623.

Jain, P., Jain, S., & Soni, R. (2014) Prunus armeniaca gum: A review on its pharmaceutical applications. International Journal of Pharmaceutical Sciences Review and Research, 24(1), 191-197.

Kumar,S., & Maiti, S. (2013)The role of chitosan-based drug delivery systems in improving the bioavailability of poorly soluble drugs. European Journal of Pharmaceutics and Biopharmaceutics, 85(1), 58-70.

Tiwari, S., & Shah, P. (2017)Controlled drug delivery system using natural polysaccharides for sustained release: Focus on chitosan and Prunus armeniaca gum. Drug Development and Industrial Pharmacy, 43(10), 1674-1683.

Vijayalakshmi, M., & Jeyakumar, S. (2013)Preparation and characterization of diclofenac sodium-loaded chitosan and Prunusarmeniaca gum-based microparticles for sustained release. Pharmaceutical Development and Technology, 18(5), 394-400.

Brunton, L. L., Hilal-Dandan, R., &Knollmann, B. C. (Eds.). (2017). Goodman & Gilman's: The Pharmacological Basis of Therapeutics (13th ed.). McGraw-Hill Education.

Sweetman, S. C. (Ed.). (2017). Martindale: The Complete Drug Reference (39th ed.). Pharmaceutical Press.

Hardman, J. G., &Limbird, L. E. (2001). Goodman and Gilman's The Pharmacological Basis of Therapeutics (10th ed.). McGraw-Hill.

Trelle, S., Reichenbach, S., Wandel, S., Hildebrand, P., Tschannen, B., Villiger, P. M., ... &Jüni, P. (2011). Cardiovascular safety of non-steroidal anti-inflammatory drugs: network meta-analysis. BMJ, 342, c7086.

Tabasum et al., formulation and evaluation of diclofenac sodium matrix Tablets using abelmoschus esculentus mucilage as a polymer, international journal of pharmaceutical, chemical and biological sciences, 2013; 418..

Chethan, M and Vijay R, Patil (2012), "Formulation and evaluation of sustained release matrix tablets of Metformin hydrochloride", World Journal of Pharmacy and Pharmaceutical Sciences Vol. 1(2), 717 730.

Kumar S.A., R. Panner S., Sivakumar T., "Isolation, characterisation and formulation properties of a new plant gum obtained from mangiferaindica", " International Journal of Pharmaceutical and biomedical Research", Int J Pharm Biomed Res 2010, Vol.1(2), pg.35-41.

Aulton, M. E., & Taylor, K. M. G. (2021). Aulton's Pharmaceutics: The Design and Manufacture of Medicines (5th ed.). Elsevier.

Gibson, M. (2016). Pharmaceutical Preformulation and Formulation: A Practical Guide from Candidate Drug Selection to Commercial Dosage Form (2nd ed.). CRC Press.

Sinko, P. J. (2017). Martin's Physical Pharmacy and Pharmaceutical Sciences (7th ed.). Wolters Kluwer Health.

Lachman, L., Lieberman, H. A., &Kanig, J. L. (1987). The Theory and Practice of Industrial Pharmacy (3rd ed.). Lea &Febiger. USP <616> – Bulk Density and Tapped Density of Powders. United States Pharmacopeia.

Aulton, M. E. (2018). Aulton's Pharmaceutics: The Design and Manufacture of Medicines (5th ed.) Elsevier.

Aulton, M. E., & Taylor, K. M. G. (2017). Aulton's Pharmaceutics: The Design and Manufacture of Medicines (5th ed.). Elsevier Health Sciences.

Lachman, L., Lieberman, H. A., &Kanig, J. L. (1987). The Theory and Practice of Industrial Pharmacy (3rd ed.). Lea &Febiger.

Allen, L. V. (2003). The art, science, and technology of pharmaceutical compounding (2nd ed.). American Pharmacists Association. 61. United States Pharmacopeia (2023). <731> Loss on Drying

United States Pharmacopeia (2023). <731> Loss on Drying. The United States Pharmacopeial Convention.

Carstensen, J. T., & Rhodes, C. T. (2000). Drug stability: Principles and practices (3rd ed.). Marcel Dekker.

Pavia, D. L., Lampman, G. M., & Kriz, G. S. (2014). Introduction to Spectroscopy (5th ed.). Cengage Learning.

Skoog, D. A., Holler, F. J., & Crouch, S. R. (2017). Principles of Instrumental Analysis (7th ed.). Cengage Learning.

Lachman, L., Lieberman, H. A., &Kanig, J. L. (2009). The theory and practice of industrial pharmacy (3rd ed.). CBS Publishers & Distributors.

Ray, S., & Ray chaudhuri, U. (2007). Release of diclofenac sodium from chitosan matrix: Influence of polymer concentration, pH and processing conditions. Journal of Scientific and Industrial Research, 66(8), 642–646.

Aulton, M. E., & Taylor, K. M. G. (2017). Aulton's pharmaceutics: The design and manufacture of medicines (5th ed.). Elsevier Health Sciences.

Shah, V. P., Elkins, J., Cisar, E., & Chen, M. L. (1998). Dissolution testing as a prognostic tool for quality control of modified-release dosage forms. Pharmaceutical Research, 15(2), 191–195. https://doi.org/10.1023/A:1011918627404

Higuchi, T. (1963). Mechanism of sustained-action medication: Theoretical analysis of rate of release of solid drugs dispersed in solid matrices. Journal of Pharmaceutical Sciences, 52(12), 1145–1149.