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Formulation and Evaluation of Metformin Controlled Release Tablets Using Tamarind Seed Gum Powder as a Natural Polymer

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ABSTRACT

Aim: This research aims to develop controlled-release tablets of metformin using tamarind seed gum powder as the matrix-forming agent.

Methods: Tamarind seeds were thoroughly cleaned, boiled and dehulled manually to remove the seed coat. The dehulled seeds were then dried, ground into a fine powder and sieved using a 60-mesh screen. The resulting gum powder was purified and subjected to drying under controlled conditions to ensure its suitability for use as a polymer. Controlled-release tablets were prepared through direct compression. Tamarind seed gum powder was incorporated at varying concentrations (5%-20% w/w) to optimize the drug release profile. The evaluation of the tablets included both pre-compression and post-compression parameters.

Results: The drug release profile of metformin from the tablets showed sustained release over a 12-hour period. Increasing the concentration of tamarind seed gum in the formulations led to a slower release rate, which can be attributed to the gum's ability to swell and form a gel-like matrix, thereby controlling the drug release. The optimized formulation best fit the Higuchi model, suggesting that diffusion was the predominant mechanism governing the release of metformin from the tablets. As the concentration of tamarind seed gum increases (from 5% to 20%), the rate of drug release decreases, showing a slower release over the 12-hour period. This can be explained by the enhanced gel formation and swelling capacity of tamarind seed gum, which restricts the diffusion of the drug. Tablets stored at 40°C/75% RH for three months showed no significant changes in drug release or physicochemical properties, confirming the stability of the formulation.

Conclusion: Tamarind seed gum powder exhibits significant potential as a natural polymer for controlled-release formulations of metformin hydrochloride. This study underscores its ability to achieve sustained drug release, maintaining consistent pharmacokinetic profiles. The results support the development of cost-effective, biocompatible drug delivery systems that harness the benefits of natural resources, offering a sustainable alternative to synthetic polymers in pharmaceutical applications.

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Introduction

Controlled-release drug delivery systems are designed to improve therapeutic outcomes by providing a consistent and sustained drug release. In recent years, natural polymers like tamarind seed gum powder have gained attention for their advantages, including biocompatibility, biodegradability and affordability. Metformin hydrochloride is a widely used oral anti-diabetic agent which is an ideal candidate for controlled-release formulations due to its short biological half-life and the need for frequent dosing [1]. This research aims to develop controlled-release tablets of metformin using tamarind seed gum powder as the matrix-forming agent.

Materials and Methods

Materials: Metformin hydrochloride was obtained from an authorized pharmaceutical supplier as the active ingredient. Tamarind seed gum powder, prepared by drying, grinding and sieving tamarind seeds to ensure uniform particle size, was utilized as the polymer. Additional excipients included microcrystalline cellulose as a filler, magnesium stearate as a lubricant and talc as a glidant [2].

Table 1: Components used in the study

Component	Quantity (per tablet)	Purpose
Metformin Hydrochloride	500 mg	Active ingredient (Anti-diabetic drug)
Tamarind Seed Gum Powder	25 mg (5% w/w)	Polymer for controlled release and matrix formation
Microcrystalline Cellulose	150 mg	Filler (diluent) to provide tablet bulk
Magnesium Stearate	2 mg	Lubricant to prevent sticking during compression
Talc	5 mg	Glidant to improve flow properties of the powder

Preparation of Tamarind Seed Gum Powder

Tamarind seeds were thoroughly cleaned, boiled and dehulled manually to remove the seed coat. The dehulled seeds were then dried, ground into a fine

powder and sieved using a 60-mesh screen. The resulting gum powder was purified and subjected to drying under controlled conditions to ensure its suitability for use as a polymer [3].

Formulation of Controlled-Release Tablets

Controlled-release tablets were prepared through direct compression. Tamarind seed gum powder was incorporated at varying concentrations (5%-20% w/w) to optimize the drug release profile. The ingredients were uniformly blended to ensure homogeneity and compressed into tablets using a rotary tablet press [4].

Evaluation of Tablets

The evaluation of the tablets included both pre-compression and post-compression parameters. Pre-compression parameters such as bulk density, tapped density, Carr's index and angle of repose were measured to assess the flow properties of the powder blend. Post-compression evaluations involved determining tablet thickness, hardness, friability, weight variation and drug content uniformity to ensure compliance with standard quality requirements.

In vitro drug release studies were conducted using a USP type-II dissolution apparatus in phosphate buffer (pH:6.8) maintained at 37°C to simulate gastrointestinal conditions. The release kinetics was analyzed using mathematical models, including zero-order, first-order, Higuchi and Korsmeyer-Peppas equations to understand the mechanism of drug release from the tablets [5].

Results and Discussion

Physicochemical Properties

The formulations demonstrated satisfactory physicochemical properties, meeting the required standards for both pre-compression and post-compression evaluations. The inclusion of tamarind seed gum notably enhanced the flow characteristics of the powder blend, contributing to improved uniformity and ease of tablet compression.

Bulk density indicates the powder's packing ability, with higher values suggesting better flow properties. Tapped density provides insight into the compaction characteristics of the powder, while Carr's index measures the powder's compressibility and flowability. The angle of repose assesses the powder's flowability, where a lower angle indicates better flow. Tablet thickness ensures uniformity in tablet size and tablet hardness reflects the strength of the tablets and their ability to withstand mechanical stresses. Friability measures the tablet's resistance to breakage during handling, while weight variation ensures uniformity in tablet weight within specified limits. Lastly, drug content uniformity ensures consistent drug distribution throughout the tablets [6].

Table 2: Evaluation of various parameters for different formulations involved in the study

Parameter	F- 1 (5%)	F- 2 (10%)	F-3 (15%)	F-4 (20%)
Bulk Density (g/cm³)	0.45	0.48	0.52	0.54
Tapped Density (g/cm³)	0.56	0.58	0.62	0.65
Carr's Index (%)	17.85	17.24	16.13	16.92
Angle of Repose (°)	28.5	29.3	30.1	31.2
Tablet Thickness (mm)	4.2	4.3	4.4	4.5
Tablet Hardness (kg/cm²)	5.0	5.2	5.4	5.5
Friability (%)	0.35	0.30	0.25	0.20
Weight Variation (%)	±2.5	±2.3	±2.1	±2.0
Drug Content Uniformity (%)	98.5	99.0	98.8	99.2

Drug Release Profile

The drug release profile of metformin from the tablets showed sustained release over a 12-hour period. Increasing the concentration of tamarind seed gum in the formulations led to a slower release rate, which can be attributed to the gum's ability to swell and form a gel-like matrix, thereby controlling the drug release. The optimized formulation best fit the Higuchi model, suggesting that diffusion was the predominant mechanism governing the release of metformin from the tablets.

Table 3: Drug release profile for different formulations involved in the study

Time (hours)	F- 1 (5%)	F- 2 (10%)	F-3 (15%)	F-4 (20%)
0.5	15	13	11	9
1	28	24	20	17
2	40	35	30	25
4	55	48	42	38
6	67	59	51	46
8	78	70	60	54
10	87	78	68	61
12	94	85	75	67

As the concentration of tamarind seed gum increases (from 5% to 20%), the rate of drug release decreases, showing a slower release over the 12-hour period. This can be explained by the enhanced gel formation and swelling capacity of tamarind seed gum, which restricts the diffusion of the drug. The drug release profile for all formulations follows a sustained-release pattern, with the release continuing

over the entire 12-hour period. The optimized formulation, which likely corresponds to the higher polymer concentrations, best fits the Higuchi model, where the release is governed predominantly by diffusion through the gel matrix. This is evident from the gradual and controlled release observed over the testing period.

Stability Studies

Tablets stored at 40°C/75% RH for three months showed no significant changes in drug release or physicochemical properties, confirming the stability of the formulation.

Table 4: Observations of Stability Studies

Storage Condition	Observation	Conclusion
Temperature: 40°C	No significant changes in drug release or physicochemical properties	The formulation remains stable under stress conditions
Humidity: 75% RH	No degradation or alteration in tablet characteristics	Formulation shows no signs of instability
Duration: 3 months	Consistent release profile and physical properties	The tablets maintain their stability over time

This table summarizes the stability studies performed on the tablets stored at 40°C and 75% relative humidity for three months, showing that the formulation remained stable throughout the study period.

Advantages of Tamarind Seed Gum

Tamarind seed gum offers several advantages, including its non-toxic nature and easy availability. It provides performance that is comparable to synthetic polymers such as HPMC, making it an effective and viable alternative for controlled-release formulations. Its natural origin, along with its favorable biocompatibility, positions it as an environment friendly and cost-effective choice for pharmaceutical applications [7].

Conclusion

Tamarind seed gum powder exhibits significant potential as a natural polymer for controlled-release formulations of metformin hydrochloride. This study underscores its ability to achieve sustained drug release, maintaining consistent pharmacokinetic profiles. The results support the development of cost-effective, biocompatible drug delivery systems that harness the benefits of natural resources, offering a sustainable alternative to synthetic polymers in pharmaceutical applications.

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