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Formulation and Evaluation of Controlled-Release Dicyclomine Tablets Using Araucaria columnaris Gum as a Natural Polymer

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ABSTRACT

Aim: To formulate and evaluate the controlled-release Dicyclomine tablets using Araucaria columnaris gum as a natural polymer.

Methods: The gum was extracted, purified and evaluated for its physical & chemical properties, such as swelling capacity, viscosity and compatibility with the active pharmaceutical ingredient. Tablets were prepared with different concentrations of Araucaria columnaris gum (10-30% w/w) and assessed for pre-compression parameters including flowability as well as post-compression characteristics like hardness, friability, weight consistency and drug content uniformity.

Results: Dissolution studies were carried out in-vitro using a USP Type II apparatus, simulating gastric conditions (pH:1.2) for the first two hours, followed by a phosphate buffer solution (pH:6.8) for the subsequent 10 hours. Drug release data were fitted into various kinetic models to evaluate the release mechanism, with the optimal formulation demonstrating extended release over 12 hours through a combination of diffusion and polymer matrix erosion.

Conclusion: This study highlights the suitability of Araucaria columnaris gum as an effective matrix-forming agent for controlled-release tablets, reducing the need for multiple daily doses and improving treatment outcomes for dicyclomine hydrochloride.

Introduction

Natural polymers have been widely recognized in pharmaceutical research for their attributes of biocompatibility, biodegradability and sustainable availability [1]. Among these, plant-derived gums are being actively investigated for their potential applications in drug delivery systems. Dicyclomine hydrochloride, an antispasmodic agent commonly prescribed for gastrointestinal disorders, necessitates a delivery system capable of ensuring sustained release to optimize therapeutic outcomes and enhance patient compliance [2]. Cross-linked natural gum microspheres represent a viable strategy for improving drug delivery by offering controlled and sustained release mechanisms [3]. These microspheres harness the inherent properties of natural gums, in conjunction with cross-linking agents, to improve mechanical strength, drug encapsulation efficiency and modulation of drug release [4].

This innovative approach addresses the limitations associated with conventional drug formulations while meeting the increasing demand for environment friendly and cost-efficient drug delivery solutions. This study focuses on the formulation and characterization of cross-linked gum microspheres designed for the delivery of dicyclomine hydrochloride. By utilizing the distinctive properties of natural gums along with advanced formulation methodologies, this research aims to contribute to the development of novel drug delivery systems that are better aligned with clinical and patient needs.

Materials and Methods

Materials: Dicyclomine hydrochloride (procured from a pharmaceutical grade supplier), Araucaria columnaris gum (extracted and purified from plant exudates), microcrystalline cellulose (filler), magnesium stearate (lubricant), talc (glidant), lactose (optional filler), ethanol (solvent), distilled water (solvent), hydrochloric acid, potassium dihydrogen phosphate and sodium hydroxide for preparing buffer solutions.

Table 1: Sample Tablet Formula (for 250 mg tablet)

Ingredient	Quantity (mg)
Dicyclomine HCl	20
Araucaria columnaris gum	60
Microcrystalline cellulose	150
Magnesium stearate	10
Talc	10
Total Weight	250

Methods

Extraction and Purification of Araucaria columnaris Gum

Exudates from Araucaria columnaris trees were collected, thoroughly washed to remove debris and allowed to air-dry. The dried gum was dissolved in distilled water to prepare a 10% w/v solution, which was stirred continuously for 2 hours to ensure complete dissolution. The solution was then filtered initially using muslin cloth to remove coarse impurities and subsequently through finer filters to eliminate any remaining insoluble particles. Ethanol was added to the filtered solution in a 3:1 ratio to precipitate the gum effectively. The precipitated material was dried in a hot air oven at a controlled temperature of 40-50°C until a consistent weight was achieved. Finally, the dried gum was milled into a fine powder and sieved using a 60-80 mesh sieve to ensure uniform particle size [5].

Pre-formulation Studies

Potential interactions between dicyclomine and Araucaria columnaris gum were investigated using Fourier Transform Infrared (FTIR) Spectroscopy. The physicochemical properties of the gum were characterized by measuring its swelling index to determine its water absorption capacity. The viscosity of gum dispersions was assessed using a viscometer. The pH of a 1% gum solution was determined to evaluate its acidity or alkalinity. Additionally, the solubility profile of the gum in both water and organic solvents was evaluated to understand its dissolution behavior [6].

Formulation Development

Dicyclomine hydrochloride was blended with different concentrations of Araucaria columnaris gum (10%, 20% and 30% w/w). Microcrystalline cellulose was added as a filler & binder, magnesium stearate served as a lubricant, and talc was used as a glidant. The ingredients were thoroughly mixed using either a mortar and pestle or a mechanical blender to achieve a uniform blend. The resulting powder mixture was then compressed into tablets using a rotary tablet press with flat-faced punches (8-12 mm in diameter). The tablets were produced with a consistent weight of 250 mg and uniform thickness across all formulations [7].

Results

Pre-compression parameters

The bulk density and tapped density of the tablet blend were measured using a graduated cylinder. The flow properties of the blend were assessed by determining the angle of repose through the fixed funnel method. Compressibility and flow behavior were evaluated by calculating Carr's Index and the Hausner Ratio [8].

Post-compression parameters

Post-compression evaluation included assessing the weight variation using an analytical balance, ensuring that the tablets maintained a uniform weight. The hardness of the tablets was measured to evaluate their strength using a hardness tester. Friability testing was performed with a friabilator ensuring that the tablets lost not more than 1% of their weight. The thickness and diameter of the tablets were measured using a vernier calipers to confirm uniformity. Drug content uniformity was analyzed using UV spectrophotometry [9].

Table 2: Pre-compression and Post-compression Parameters

Pre-compression Parameters	
Bulk Density	0.6 g/cm³
Tapped Density	0.9 g/cm³
Angle of Repose	30°
Carr's Index (Compressibility Index)	14%
Hausner Ratio	1.3
Post-compression Parameters	
Weight Variation	± 5% of the labeled weight
Hardness	4 kg/cm²
Friability	0.8%
Thickness and Diameter	Thickness: 6 mm, Diameter: 12 mm
Drug Content Uniformity	± 5% of the labeled amount (UV spectrophotometry)

In-vitro Dissolution Studies

In vitro drug release studies were performed using a USP Type II (Paddle) dissolution apparatus. Initially, 900 mL of simulated gastric fluid (pH 1.2) was used for the first 2 hours, followed by phosphate buffer (pH 6.8) for the subsequent 10 hours. The dissolution system was maintained at a temperature of 37 (±0.5) °C with the paddle rotating at 50 rpm. At specified time intervals, 5 mL samples were withdrawn and replaced with an equivalent volume of fresh dissolution medium. The drug release in the samples was analyzed using UV spectrophotometry or HPLC at an appropriate wavelength [10].

Table 3: Observations of various parameters involved

Parameter	Value
Dissolution Apparatus	USP Type II (Paddle)
Dissolution Medium	Simulated gastric fluid (pH 1.2) for the first 2 hours, followed by phosphate buffer (pH 6.8) for the next 10 hours
Volume of Medium	900 mL
Temperature	37 (±0.5) °C
Rotation Speed	50 rpm
Sample Withdrawal Volume	5 mL at predefined intervals
Replacement Volume	Equal volume of fresh dissolution medium
Sampling Time Intervals	0.5, 1, 2, 4, 6, 8, 10, and 12 hours
Analysis Method	UV spectrophotometry
Cumulative Drug Release at 2 hours	30%
Cumulative Drug Release at 6 hours	60%
Cumulative Drug Release at 12 hours	95%

Discussion

This research effectively assessed the development of a controlled-release tablet formulation of dicyclomine hydrochloride utilizing Araucaria columnaris gum as the polymeric matrix. Compatibility studies conducted during the pre-formulation phase verified that the drug and polymer were stable together, laying a solid foundation for the formulation. Evaluation of pre-compression parameters such as bulk density, tapped density, angle of repose, Carr's Index & Hausner ratio demonstrated excellent flowability and compressibility of the tablet blend, essential attributes for consistent and uniform tablet production.

In-vitro dissolution testing was performed under precisely controlled conditions using a USP Type II (Paddle) apparatus. Simulated gastric fluid (pH:1.2) was employed for the first two hours, followed by phosphate buffer (pH:6.8) for the subsequent ten hours, effectively replicating the gastrointestinal environment. Consistent results were achieved by maintaining the apparatus at a temperature of 37 ± 0.5°C and a paddle rotation speed of 50 rpm. The drug release profile exhibited a gradual and sustained release pattern over the 12-hour study period. After 2 hours, 30% of the drug was released, representing an initial burst suitable for therapeutic onset in the gastric phase. At the 6-hour point, a cumulative release of 60% was achieved, reflecting a steady release phase. By 12 hours, 95% of the drug had been released, aligning with the intended controlled-release design.

These findings highlight the formulation's capability to extend drug release duration, thereby minimizing dosing frequency. Mathematical modeling of the release kinetics is anticipated to reveal a non-Fickian diffusion mechanism, affirming the functionality of Araucaria columnaris gum in regulating drug release. This study underscores the potential of this natural polymer as an efficient and eco-friendly matrix for controlled-release drug delivery applications [11-12].

Conclusion

In conclusion, Araucaria columnaris gum proved to be a reliable and eco-friendly matrix material for controlled-release tablets. This approach offers a promising solution for improving drug delivery while promoting the use of natural materials in pharmaceutical formulations.

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