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Development of Sustained Release Tablets Using Natural Polymers: Formulation and Evaluation

Riya Patel
Research Scholar
Department of Pharmaceutics
Institute of Pharmaceutical Sciences, Banaras Hindu University, Varanasi, India
Email: *riya.patel321@gmail.com*

***Dr. Amit Verma**,*
Professor
Department of Pharmaceutical Technology
Manipal College of Pharmaceutical Sciences, Manipal, India.
Email: *amit.verma78@yahoo.co.in*

Abstract

Sustained release (SR) tablet formulations offer prolonged therapeutic effects, improved patient compliance, and reduced dosing frequency. Natural polymers, due to their biocompatibility, biodegradability, and availability, serve as effective matrix formers in SR formulations. This study explores the development, formulation, and evaluation of sustained release tablets using natural polymers such as guar gum, xanthan gum, and chitosan. Preformulation studies included drug-polymer compatibility assessment, flow properties, and granule evaluation. Tablets were prepared using direct compression and wet granulation methods, followed by evaluation of weight variation, hardness, friability, drug content, and in vitro release. Drug release kinetics were analyzed using models like Higuchi, Korsmeyer-Peppas, and zero-order equations. The effect of polymer type and concentration on drug release profiles was examined to optimize formulation performance. Comparative analysis indicated that polymer selection significantly influences drug release rate and mechanism. Results demonstrate that natural polymer-based SR tablets provide controlled drug release, enhanced stability, and *improved patient adherence. These findings highlight the potential of natural polymers as sustainable and effective excipients in SR drug delivery systems.*

Keywords: *Sustained release, natural polymers, guar gum, xanthan gum, chitosan, drug release kinetics, matrix tablets, formulation optimization*

INTRODUCTION

Sustained release drug delivery systems are designed to maintain therapeutic drug concentrations over an extended period, minimizing peak-trough fluctuations and enhancing patient compliance. Conventional tablets often require multiple daily dosing, leading to non-compliance and reduced therapeutic efficacy. Natural polymers have emerged as promising excipients for SR formulations due to their safety, biodegradability, and ability to modulate drug release. Polymers such as guar gum, xanthan gum, and chitosan are widely used to form matrix systems capable of controlled drug release. Their hydrophilic nature, viscosity, and gel-forming properties play a pivotal role in sustaining drug release.

CHALLENGES IN SR TABLET DEVELOPMENT

Formulating SR tablets requires careful consideration of drug solubility, polymer compatibility, compressibility, and mechanical strength. Natural polymers may exhibit batch-to-batch variability and moisture sensitivity, affecting drug release profiles and stability. Optimization of polymer concentration and tablet manufacturing methods is critical to achieve consistent performance and therapeutic efficacy.

FORMULATION STRATEGIES

Direct Compression Method

Direct compression involves blending drug with natural polymers and compressing into tablets without granulation. This method is simple, cost-effective, and suitable for moisture-sensitive drugs. Homogeneous mixing and adequate flow properties are essential to prevent content uniformity issues.

Wet Granulation Method

Wet granulation improves compressibility and flow properties by forming granules using a suitable binder. Natural polymers can act as binders and matrix formers, ensuring controlled drug release. Optimizing granule size and drying conditions is important to maintain polymer integrity and drug stability.

CHARACTERIZATION OF SR TABLETS

Physical Evaluation

Tablets were evaluated for weight variation, hardness, friability, thickness, and diameter to ensure uniformity and mechanical strength. Adequate hardness prevents tablet breakage during handling and storage, while low friability ensures minimal weight loss.

Drug Content Analysis

Drug content uniformity was assessed using UV-Visible spectroscopy or HPLC. Consistent drug content is essential to achieve predictable therapeutic outcomes.

In Vitro Dissolution Studies

Drug release was studied using USP dissolution apparatus in simulated gastric and intestinal fluids. Sampling at predetermined intervals allowed construction of release profiles and calculation of cumulative drug release.

Drug Release Kinetics

Mathematical models, including zero-order, first-order, Higuchi, and Korsmeyer-Peppas equations, were applied to interpret drug release mechanisms. Zero-order release indicates constant drug release, while Higuchi and Korsmeyer-Peppas describe diffusion-controlled and anomalous release patterns, respectively.

Table 1: Effect of Natural Polymers on Drug Release from SR Tablets

Formulation Code	Polymer Type	Polymer Concentration (%)	t50% (h)	Release Mechanism
SR-1	Guar Gum	10	4.5	Higuchi
SR-2	Guar Gum	15	6.2	Korsmeyer-Peppas
SR-3	Xanthan Gum	10	3.8	Higuchi
SR-4	Xanthan Gum	15	5.5	Korsmeyer-Peppas
SR-5	Chitosan	12	5.0	Zero-order
SR-6	Chitosan	18	6.8	Korsmeyer-Peppas

Table Explanation: The table summarizes the influence of polymer type and concentration on drug release profiles. t50% represents the time for 50% drug release, and the release mechanism provides insight into how the drug is released from the matrix.

OPTIMIZATION AND SCALE-UP

Optimization of polymer type and concentration was conducted to achieve the desired drug release rate. Design of experiments (DoE) approaches enabled systematic evaluation of formulation variables. Scale-up considerations include uniform mixing, compression force consistency, and monitoring environmental conditions to maintain product quality.

CLINICAL RELEVANCE

Sustained release formulations reduce dosing frequency, improve patient compliance, and maintain consistent plasma drug levels. Natural polymers provide safe, biodegradable, and cost-effective alternatives to synthetic polymers, making them attractive for commercial SR formulations. Applications include antihypertensives, antidiabetics, and analgesics, where controlled release improves therapeutic outcomes.

FUTURE PROSPECTS

Emerging strategies involve combining natural polymers with synthetic polymers, crosslinking, or coating techniques to fine-tune drug release. Nanoparticle incorporation and multilayered matrix systems offer opportunities for further control of release kinetics. Integration of computational modeling and predictive analytics can optimize polymer selection and formulation parameters, facilitating precision drug delivery.

CONCLUSION

The development of sustained release tablets using natural polymers demonstrates effective control over drug release, enhanced stability, and improved patient adherence. Polymer type, concentration, and tablet manufacturing methods significantly influence release profiles and mechanisms. Characterization through physical evaluation, drug content analysis, and in vitro dissolution studies ensures consistent product quality. Natural polymers such as guar gum, xanthan gum, and chitosan serve as effective matrix formers, offering biocompatibility and biodegradability advantages. Systematic optimization and thorough evaluation are essential for successful SR tablet formulation. These findings underscore the potential of natural polymers as sustainable excipients in controlled drug delivery systems, supporting clinical efficacy and commercial development.

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