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Review Paper

Natural Gums as Superdisintegrant in Fast Dissolving Tablets: Mechanistic Insights, Comparative Evaluation and Future Perspectives

**Santosh Kumar Dash, Tusara Kanta Behera*, Abdul Sayeed Khan, Reshma Ranbir,
Kshireswari Sahu, Pujarani Kalsai, Priyanka Sharma**

Department of Pharmaceutics, The Pharmaceutical College, Barpali, Odisha, 768029

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ABSTRACT

Fast dissolving tablets (FDTs) are solid oral dosage forms designed to disintegrate rapidly in the oral cavity without the need for water, thereby enhancing patient compliance, especially in pediatric, geriatric, and dysphagic populations. The performance of FDTs is largely governed by the efficiency of superdisintegrants incorporated into the formulation. Although synthetic superdisintegrants such as croscarmellose sodium, crospovidone, and sodium starch glycolate are widely employed, growing interest in sustainability, biocompatibility, and cost-effectiveness has directed attention toward natural gums derived from plant sources. Natural polysaccharides including guar gum, xanthan gum, locust bean gum, fenugreek mucilage, okra mucilage, and *Plantago ovata* mucilage exhibit intrinsic swelling, hydration, and wicking properties suitable for rapid tablet disintegration. This review critically examines the physicochemical characteristics, disintegration mechanisms, structure function relationships, modification strategies, comparative performance with synthetic agents, safety considerations, and regulatory aspects of natural gums used in FDT formulations. Emphasis is placed on mechanistic understanding, swelling kinetics, excipient drug compatibility, and formulation optimization. The review also highlights current limitations and future research directions aimed at enhancing the performance consistency and industrial applicability of natural superdisintegrants.

INTRODUCTION

Oral drug delivery remains the most preferred route of administration due to its convenience, safety, and patient acceptability¹. However, conventional tablets may present swallowing

difficulties for pediatric, geriatric, and neurologically impaired patients. To address this limitation, fast dissolving tablets (FDTs) were developed to disintegrate rapidly in the oral cavity without water, thereby improving compliance and therapeutic outcomes². The fundamental principle

***Corresponding Author:** Tusara Kanta Behera

Address: Assistant Professor; The Pharmaceutical College, Samleswari Vihar, Tingipali, Barpali, Odisha, 768029

Email ✉: tusaratkb@gmail.com

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behind FDT technology is rapid tablet disintegration facilitated by superdisintegrants excipients that enhance water uptake and promote matrix breakdown⁴. Synthetic superdisintegrants such as croscarmellose sodium, sodium starch glycolate, and crospovidone have been extensively studied for their rapid swelling and capillary action¹³. Despite their effectiveness, increasing attention is being given to natural polymers due to sustainability concerns, economic advantages, and regulatory acceptability⁷. Natural gums are hydrophilic polysaccharides derived from plant exudates, seeds, or microbial fermentation. Their swelling capacity, biodegradability, non-toxicity, and widespread availability make them promising alternatives in FDT formulations⁵. Examples include guar gum, xanthan gum, locust bean gum, fenugreek mucilage, and *Plantago ovata* mucilage. These polymers function primarily through swelling and wicking mechanisms, leading to rapid tablet disintegration⁸. Recent research has demonstrated that optimized natural gums can exhibit comparable disintegration efficiency to synthetic superdisintegrants when appropriately processed¹¹. However, variability in physicochemical properties, microbial contamination risk, and moisture sensitivity remain challenges for industrial application. This review aims to provide a comprehensive and critical analysis of natural gums as superdisintegrants in FDT systems, integrating mechanistic understanding with formulation science and future innovation perspectives.

2. Mechanisms of Tablet Disintegration

Tablet disintegration involves multiple physicochemical phenomena.

2.1 Swelling Mechanism

Swelling is the dominant mechanism for most hydrophilic natural gums. Upon contact with

saliva, polysaccharide chains hydrate and expand, generating internal pressure that disrupts tablet integrity⁴. The extent of swelling depends on polymer crosslinking density and molecular structure¹³.

2.2 Wicking (Capillary Action)

Capillary action facilitates rapid penetration of liquid into porous tablet matrices. Water replaces air within interparticulate spaces, weakening cohesive forces².

2.3 Deformation Recovery

Particles compressed during tableting may recover their original shape upon hydration, contributing to disintegration¹². Natural gums primarily operate via swelling and wicking, while synthetic superdisintegrants often rely on crosslinked swelling networks.

3. Physicochemical Properties of Natural Gums

Natural gums are primarily composed of complex polysaccharides such as galactomannans, arabinoxylans, and uronic acid-containing polymers, which contribute to their hydrophilic and swelling characteristics⁵. The functional performance of these gums in fast dissolving tablets (FDTs) is strongly influenced by several physicochemical parameters, including molecular weight, degree of branching, particle size, swelling index, and viscosity. Molecular weight and branching determine the polymer's hydration capacity and gel-forming behavior, while particle size affects surface area and water penetration rate. The swelling index plays a critical role in promoting rapid tablet disintegration by facilitating water uptake and expansion within the matrix. However, viscosity must be carefully balanced; excessively high viscosity can hinder water diffusion and delay disintegration, whereas moderate viscosity combined with a high swelling

index supports rapid tablet breakup without forming a dense gel barrier. Therefore, an optimal combination of high swelling capacity and controlled viscosity is considered ideal for achieving efficient disintegration and overall performance in FDT formulations.

Table 1. Selected Natural Gums Used in FDTs

Natural Gum	Source	Major Component	Mechanism	Reference
Guar gum	Cyamopsis tetragonoloba	Galactomannan	Swelling	8
Xanthan gum	Xanthomonas campestris	Heteropolysaccharide	Swelling	6
Fenugreek mucilage	Trigonella foenum-graecum	Galactomannan	Rapid hydration	9
Plantago ovata mucilage	Psyllium husk	Arabinoxylan	Wicking	10

4. Comparative Performance with Synthetic Superdisintegrants

Comparative investigations have demonstrated that natural gums, when optimized in formulation, can achieve rapid disintegration times in the range of 20–40 seconds, which is comparable to many conventional superdisintegrants used in fast dissolving tablets (FDTs)¹¹. In contrast, synthetic superdisintegrants such as croscarmellose sodium, crospovidone, and sodium starch glycolate generally produce slightly faster disintegration times of 15–30 seconds and are often effective at lower concentrations¹³. Nevertheless, natural gums present several significant advantages, including excellent biodegradability, minimal toxicity, cost effectiveness, and availability from renewable plant or microbial sources, making them environmentally sustainable alternatives. Their natural origin also enhances patient acceptability and supports the growing demand for green pharmaceutical excipients. However, certain limitations must be considered, such as the need for relatively higher concentrations to achieve comparable performance and their sensitivity to moisture, which may affect stability and flow properties. Therefore, while synthetic agents may offer greater efficiency at lower levels, natural gums represent a promising, eco-friendly option for FDT formulations when appropriately optimized.

Table 2. Comparative Evaluation

Parameter	Natural Gums	Synthetic Superdisintegrants
Disintegration time	20–40 s	15–30 s
Swelling capacity	High	Very high (crosslinked)
Cost	Lower	Higher
Environmental impact	Biodegradable	Synthetic origin
Batch variability	Moderate	Low

5. Modification and Co-Processing Approaches

Chemical modification and co-processing techniques are commonly utilized to improve the functional performance of excipients used as superdisintegrants in fast dissolving tablets (FDTs). Modifications such as crosslinking and carboxymethylation notably enhance the water absorption, swelling capacity, and disintegration effectiveness of natural polymers. Crosslinking minimizes excessive solubility while facilitating quick hydration and controlled swelling, whereas carboxymethylation adds hydrophilic carboxymethyl groups that boost water penetration and swelling kinetics, resulting in faster tablet disintegration^{14,15}. Alongside chemical modification, co-processing methods that involve merging two or more excipients at the sub-particle level are employed to synergistically enhance

physicomechanical properties without changing the chemical structure. Chemical modification such as crosslinking or carboxymethylation improves swelling kinetics¹². Co-processing with microcrystalline cellulose enhances compressibility³. For example, combining natural polymers with microcrystalline cellulose (MCC) improves compressibility, flow characteristics, and tablet hardness while still allowing for quick disintegration because of MCC's superior binding and wicking properties¹⁶. Therefore, both chemical alterations and co-processing are viable strategies to enhance excipient functionality, leading to better swelling behavior, mechanical strength, and overall efficacy of fast-dissolving tablet (FDT) formulations.

6. Drug–Excipient Compatibility

Compatibility studies between drugs and excipients are crucial for ensuring the stability, effectiveness, and safety of pharmaceutical formulations, especially in fast dissolving tablets that use natural gums as superdisintegrants. Analytical methods like differential scanning calorimetry (DSC), Fourier transform infrared spectroscopy (FTIR), and X-ray diffraction (XRD) are commonly used to assess possible physicochemical interactions between the drug and excipients. DSC is useful for identifying changes in melting endotherms or thermal properties, while FTIR detects potential chemical interactions by noting shifts or the loss of specific functional group peaks. XRD is employed to examine changes in crystallinity patterns. Compatibility studies using DSC, FTIR, and XRD confirm minimal chemical interaction between natural gums and most APIs¹. However, hygroscopicity may influence stability. Numerous studies have indicated that natural gums, including guar gum, xanthan gum, and gum karaya, typically demonstrate minimal chemical interactions with most active pharmaceutical ingredients (APIs),

suggesting good compatibility and appropriateness for solid dosage forms¹⁷. Nevertheless, because of their hydrophilic and frequently hygroscopic characteristics, natural gums can take up moisture from the atmosphere, potentially impacting drug stability, leading to hydrolytic degradation, or altering tablet hardness and disintegration properties. Consequently, it is advisable to conduct suitable stability studies and utilize moisture-resistant packaging to guarantee the long term stability of the formulation.

7. Safety and Regulatory Considerations

Many natural gums are widely used in food and pharmaceutical applications and are considered safe⁷. Nevertheless, microbial limits and quality control are critical. Natural gums are widely used in food and pharmaceutical products because of their compatibility with biological systems, ability to decompose naturally, and safety profiles that are commonly accepted. Various polymers like guar gum, xanthan gum, acacia, and locust bean gum are categorized as Generally Recognized as Safe (GRAS) substances and are included in prominent pharmacopeias, which supports their use as pharmaceutical excipients^{14,18}. Their long-standing history of safe human consumption and minimal toxicity make them appealing alternatives to synthetic excipients in solid dosage forms, such as fast-dissolving tablets. However, since these natural gums are sourced from plants or microbes, they may face issues such as variability between batches, risk of microbial contamination, pesticide residues, and possible endotoxin presence. Consequently, it is crucial to rigorously follow pharmacopeial standards, conduct microbial limit tests, and implement good manufacturing practices (GMP) to guarantee the safety, purity, and quality of products¹⁹. Thorough quality control protocols, such as measuring moisture content and evaluating microbial load, play a vital role in ensuring

formulation stability and adhering to regulatory requirements.

8. Challenges

Although natural gums have many benefits, they also pose several formulation and manufacturing difficulties. Because they are obtained from plant or microbial sources, they are inherently at risk for microbial contamination, which requires thorough microbial limit testing and suitable storage conditions to guarantee safety and adherence to regulations. Their hydrophilic characteristics make them very sensitive to moisture; excessive moisture absorption can hinder powder flow, encourage degradation of drugs (especially those prone to hydrolysis), and negatively impact tablet hardness and disintegration time. Furthermore, natural gums frequently display variability from batch to batch due to variations in geographical origin, harvesting conditions, and purification methods, which can result in inconsistencies in viscosity, swelling properties, and overall efficacy. Additionally, certain natural gums have restricted mechanical strength and inadequate compressibility, leading to tablets that may exhibit reduced hardness or increased friability unless they are modified or combined with appropriate excipients. As a result, meticulous quality control, optimization techniques, and suitable formulation design are crucial to address these challenges and guarantee reliable product performance.

9. Future Perspectives

The future evolution of natural gums as pharmaceutical excipients is anticipated to emphasize innovative modification techniques and sustainable design methods. Nanostructured gums, created through approaches like nanoparticle formation, nano-crosslinking, or surface functionalization, present increased surface area, enhanced swelling kinetics, and better control over

drug release, making them attractive candidates for advanced fast-dissolving and controlled-release formulations. The surge in developing co-processed hybrid excipients that blend natural gums with synthetic or multifunctional materials is noteworthy, as these combinations can jointly enhance compressibility, flow characteristics, mechanical strength, and disintegration efficiency. Additionally, cutting-edge characterization methods such as scanning electron microscopy (SEM) and rheological analysis offer greater understanding of surface structure, particle architecture, swelling behavior, and viscoelastic properties, facilitating more accurate structure-function relationships. Significantly, the increasing focus on green chemistry and sustainability is leading to the investigation of renewable, biodegradable, and low-carbon-footprint excipients, making natural gums essential elements in creating environmentally friendly pharmaceutical formulations.

CONCLUSION

To conclusion, natural gums are turning out to be effective and sustainable substitutes for synthetic superdisintegrants in the creation of fast dissolving tablets (FDTs). Thanks to their natural properties of swelling, hydration, and wicking, plant derived polysaccharides like guar gum, xanthan gum, fenugreek mucilage, and *Plantago ovata* mucilage can significantly enhance rapid tablet disintegration while ensuring safety, biodegradability, and cost-effectiveness. Despite synthetic superdisintegrants typically providing slightly quicker disintegration at lower amounts, well-optimized natural gums have demonstrated similar efficacy when properly processed and formulated. Their renewable source, acceptance by regulatory bodies, and low toxicity further enhance their appeal in both industrial and environmental contexts. Nonetheless, issues such as variability between batches, sensitivity to



moisture, risk of microbial contamination, and limitations in mechanical strength need careful attention through modification methods, co-processing techniques, and rigorous quality control. Future advancement in nanostructuring, the creation of hybrid excipients, and sophisticated physicochemical analysis is likely to improve the reliability, scalability, and market potential of natural gums. In summary, ongoing research and technological advancements could significantly transform sustainable excipient development within modern pharmaceutical formulation science.

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