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Review Article

A Comprehensive Review on Liquid Suspension Containing Guar Gum

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Abstract:
Guar gum, a naturally occurring galactomannan polysaccharide derived from the seeds of Cyamopsis tetragonoloba, has emerged as a highly functional excipient in liquid pharmaceutical suspensions. Its unique capacity to form highly viscous, pseudoplastic solutions at low concentrations makes it an attractive suspending agent, thickener, and stabilizer in oral liquid dosage forms. Growing research interest in natural-based excipients driven by safety concerns over synthetic polymers has elevated the significance of guar gum in formulation science. This review aims to provide a comprehensive overview of the introduction, need for study, key features, mechanism of drug release, applications, limitations, and formulation and evaluation parameters of liquid suspensions containing guar gum. The article is intended to serve as a useful reference for pharmaceutical researchers and formulation scientists working with natural polymers.
Keywords: Guar gum; liquid suspension; natural polymer; galactomannan; suspending agent; drug release; colon-targeted delivery; pseudoplastic; pharmaceutical excipient; controlled release.

Introduction

Overview of Liquid Suspensions

Pharmaceutical suspensions are biphasic liquid dosage forms in which finely divided solid drug particles are dispersed in a liquid vehicle. They are among the most widely used oral dosage forms, particularly in pediatric and geriatric populations where swallowing solid dosage forms is difficult.

The key requirement of a stable suspension is that the dispersed particles remain uniformly distributed throughout the vehicle, resist caking upon sedimentation, and redisperse easily upon gentle shaking. Achieving this requires carefully selected suspending agents that impart appropriate rheological behavior to the vehicle.

Guar Gum as a Natural Excipient

Guar gum (also called guaran) is a galactomannan polysaccharide extracted from the endosperm of guar beans (Cyamopsis tetragonoloba, family Leguminosae). It is one of the most powerful naturally available water-soluble gums, capable of forming highly viscous colloidal dispersions at low concentrations without the need for heating. Chemically, guar gum consists of a linear backbone of β-(1→4)-linked D-mannopyranose units, with α-D-

galactose side chains attached at every second mannose residue via (1→6) glycosidic bonds. The mannose-to-galactose ratio is approximately 2:1, which governs its characteristic solubility and thickening behavior.

Physicochemical Properties

Guar gum appears as a white to off-white, nearly odourless, free-flowing powder with a bland taste. Its molecular weight ranges from approximately 50,000 to 8,000,000 Da, with pharmaceutical-grade material typically exhibiting molecular weights of 200,000–250,000 Da. A 1% aqueous solution exhibits viscosity between 3,000 and 5,000 centipoise (cP) at 25°C, which can reach up to 10,000 cP depending on concentration and processing parameters. It is stable at pH 5–7, non-ionic in water, and is not significantly affected by ionic strength under normal formulation conditions. Guar gum holds Generally Recognized as Safe (GRAS) status from the US FDA and complies with BP, EP, and USP pharmacopoeial monographs. [1]

Need for this Study

Limitations of Synthetic Suspending Agents

The pharmaceutical industry has traditionally relied on synthetic polymers such as sodium carboxymethylcellulose (CMC), carbomers, and polyvinylpyrrolidone (PVP) as suspending agents. However, increasing awareness of synthetic excipient-associated adverse effects including non-biodegradability, higher cost, and potential immunogenic reactions have prompted the search for safer, naturally derived alternatives. Patients and regulatory bodies alike are demanding pharmaceutical products that incorporate natural, herbal-based ingredients wherever possible.

Rise of Natural Polymer Research

Natural polymers derived from renewable resources have gained significant attention as pharmaceutical excipients in recent years due to their biocompatibility, biodegradability, and sustainability. Polysaccharides in particular occupy a special position because of their easy availability, non-toxic nature, ecofriendly profile, and biodegradable character. Among these, guar gum stands out for its multifunctionality and potential to replace or supplement synthetic suspending agents.

Specific Research Gap

Despite guar gum's widespread use in food and industrial sectors, rigorous scientific documentation of its performance as a suspending agent in liquid pharmaceutical formulations remains relatively limited. Studies have shown that guar gum's Newtonian flow behavior at certain concentrations makes it less effective than newer-generation polymers like xanthan gum for some formulations. Moreover, its susceptibility to microbial contamination, drop in viscosity on storage, and uncontrolled hydration rate present formulation challenges that need systematic investigation and optimization. Understanding these gaps through structured studies is critical to harnessing guar gum's full potential in liquid dosage forms. [2]

Key Features of this Study

Natural Origin and Regulatory Acceptance

One of the most important features of guar gum is its natural origin and regulatory acceptance. Derived from the seeds of Cyamopsis tetragonoloba, it carries GRAS status and is fully compliant with global pharmacopoeias. Its non-ionic, non-allergenic, and biodegradable nature makes it a highly suitable choice for patients with sensitivities to synthetic excipients.

Pseudoplastic Rheological Behavior: A defining feature of guar gum suspensions is their pseudoplastic (shear-thinning) behavior. The suspension exhibits high viscosity during storage, which resists sedimentation and maintains dose uniformity. Upon shaking for administration, viscosity decreases, enabling easy pouring and accurate dosing. This ideal rheological profile is a key advantage over simple Newtonian vehicles.

Viscosity Synergy and Concentration Dependence

Guar gum demonstrates viscosity synergy with other hydrocolloids such as xanthan gum. At concentrations below 1% w/v, it effectively controls suspension stability; at 3% w/v, it forms thick gels. Pharmaceutical-grade guar gum at optimized concentrations achieves target viscosity values (approximately 99–101.3 cps) and sedimentation volumes (0.98–1.0) as established by Quality by Design (QbD) optimization studies.

Multifunctionality

Guar gum functions simultaneously as a suspending agent, thickener, stabilizer, binder, and controlled-release matrix. This multifunctionality reduces the number of excipients required in a formulation, simplifying the manufacturing process and minimizing incompatibility risks.

Mechanism of Drug Release in Liquid Suspension Containing Guar Gum

Viscosity-Controlled Drug Diffusion

In liquid suspensions, guar gum primarily controls drug availability by modifying the viscosity of the vehicle. The high viscosity of the guar gum network reduces the diffusion rate of drug molecules from the vehicle to the absorption site, thereby producing a controlled or sustained drug release profile. When guar gum forms a gel-like matrix in the vehicle, drug diffusion follows Fickian or non-Fickian kinetics depending on the polymer concentration and drug physicochemical properties.

4.2 Hydration and Gel Layer Formation

Upon contact with gastrointestinal fluids, guar gum hydrates rapidly, forming a viscous gel layer around or within the suspension vehicle. This gel acts as a diffusion barrier, regulating the rate at which drug molecules partition from the suspension into the surrounding fluid.

The rate of gel formation depends on particle size, temperature, pH, and concentration of the gum. The gel layer progressively erodes, contributing to sustained drug release.

Microbial Enzymatic Degradation

A distinctive and scientifically significant mechanism of guar gum relates to its behavior in the colon. The colonic microflora produces enzymes particularly β-mannanase and α-galactosidase that specifically degrade the galactomannan backbone of guar gum. This enzymatic degradation disrupts the gel matrix, triggering drug release specifically in the colonic environment. This property is the basis for developing colon-targeted drug delivery systems using guar gum as the primary carrier.

pH-Dependent Swelling

Guar gum also exhibits pH-dependent swelling behavior, with enhanced swelling in the intestinal pH range compared to the acidic gastric environment. In colonic drug delivery suspensions, the gum remains largely intact in the stomach and small intestine, protecting acid-labile drugs, and swells and degrades in the colon to release the drug at the target site. This property, combined with enzymatic degradation, makes it a dual-mechanism carrier for site-specific release. [3]

Application of Suspension Containing Guar Gum

Pediatric and Geriatric Formulations

Liquid suspensions containing guar gum are particularly valuable for pediatric and geriatric patients who have difficulty swallowing solid dosage forms. The mild taste, biocompatible nature, and adjustable viscosity of guar gum make it suitable for these special populations. The natural origin of guar gum also aligns with parental and caregiver preferences for natural-origin excipients in children's medicines.

Oral Controlled-Release Suspensions

Guar gum-based suspensions are used to develop oral sustained-release liquid formulations for drugs requiring prolonged therapeutic plasma levels. By controlling the gum concentration, drug-to-gum ratio, and vehicle composition, formulation scientists can fine-tune the release profile from immediate to extended release. Studies using propranolol hydrochloride have demonstrated that guar gum

at a drug-to-gum ratio of 1:3 provides a release profile fitting the Higuchi diffusion model.

Colon-Targeted Drug Delivery

The susceptibility of guar gum to microbial degradation in the colon makes it a leading natural excipient for colon-targeted drug delivery systems in suspension form. Such formulations are clinically relevant for conditions including inflammatory bowel disease (IBD), colorectal cancer, Crohn's disease, and colonic infections. The ability of guar gum to protect drugs during upper gastrointestinal transit and release them specifically in the colon is highly advantageous. [4]

Therapeutic Benefits beyond Drug Delivery

In addition to serving as an excipient, guar gum itself exerts therapeutic effects when incorporated into pharmaceutical suspensions. It acts as a dietary fiber supplement with evidence supporting its use in reducing serum cholesterol by 10–15%, improving bowel function in patients with irritable bowel syndrome (IBS), and modulating blood glucose levels in non-insulin-dependent diabetic patients. Clinical studies have demonstrated that guar gum also helps normalize moisture content of stool and may reduce blood pressure.

Topical and Other Applications

Beyond oral use, guar gum-based suspension principles extend to topical creams, gels, and semi-solid preparations. Its strong mucoadhesive behavior and hydrophilic nature help localize drugs at specific tissue sites, improving local drug concentrations. Nanoparticle-based guar gum formulations have been explored for cancer drug delivery and targeted therapy. [5]

Limitations of Liquid Suspension Containing Guar Gum

Uncontrolled Hydration and Viscosity Instability: One of the most significant limitations of guar gum in liquid suspensions is its uncontrolled rate of hydration. The viscosity of guar gum solutions is sensitive to temperature, pH, particle size, and storage conditions, making it difficult to maintain consistent rheological properties over the shelf life of the product. A drop in viscosity on storage particularly at temperatures above 30°C — has been reported, which can compromise the stability and uniformity of the suspension. [6]

Newtonian Flow Behavior at Lower Concentrations

At concentrations below the critical gel point, guar gum solutions may exhibit Newtonian flow behavior rather than the desirable pseudoplastic (non-Newtonian) behavior required for stable pharmaceutical suspensions. A study evaluating guar gum as a suspending agent for metronidazole found that only the 0.7% w/v concentration exhibited acceptable non-Newtonian behavior at 30°C, while lower concentrations were inadequate for effective suspension stabilization. [7]

Susceptibility to Microbial Contamination

As a natural polysaccharide, guar gum is highly susceptible to microbial contamination during storage, particularly in aqueous liquid formulations. Microbial degradation of the polymer chains leads to a progressive decrease in viscosity and physical instability of the suspension. This necessitates the addition of appropriate preservatives (e.g., sodium benzoate, methylparaben), which adds to formulation complexity and cost. [8]

Turbidity and Aesthetic Concerns

Guar gum imparts color and produces translucent or turbid solutions in liquid dosage forms, which can be aesthetically unacceptable to patients and caregivers. This turbidity also complicates spectrophotometric assay methods for drug content determination during quality control testing.

Restricted Drug Range and Particle Control

At low concentrations, guar gum induces the formation of highly viscous solutions that restrict the type of drug that can be uniformly dispersed in the vehicle. Additionally, controlling the size and shape of drug particles

within the suspension matrix is challenging because of the gel-forming nature of guar gum at higher concentrations. These issues can limit its application to drugs with specific physicochemical profiles. [9]

Formulation and Evaluation of Liquid Suspension Containing Guar Gum

Formulation Considerations

Selection and Concentration of Guar Gum

The selection of guar gum concentration is the most critical formulation variable. Pharmaceutical-grade guar gum is typically used at concentrations below 1% w/v as a suspending agent. Quality by Design (QbD)-based optimization studies have demonstrated that a guar gum concentration of 0.1 g in 20 g sucrose vehicle can achieve target viscosity (99–101.3 cps) and sedimentation volume (0.98–1.0), satisfying both stability and pourability requirements. The gum should be slowly dispersed in cold water to prevent lump formation, and the dispersion should be allowed to hydrate completely before adding other excipients. [10]

Vehicle and Sweetener Selection

The suspension vehicle must be compatible with guar gum's ionic character. Since guar gum is non-ionic, it is compatible with a broad range of vehicles, sweeteners, and preservatives. Sucrose is commonly used as both a sweetener and a viscosity co-modifier.

The vehicle pH should be maintained between 5 and 7 for optimal guar gum stability, as strong acidic or basic conditions degrade the polymer chain and reduce viscosity.

Incorporation of Preservatives

To address guar gum's susceptibility to microbial contamination, appropriate preservatives must be incorporated. Commonly used preservatives in guar gum-based suspensions include methylparaben (0.1–0.2% w/v) and propylparaben (0.01–0.02% w/v). The preservative system must be validated for compatibility with the drug and guar gum, as some ionic preservatives can interact with the polymer.

Wetting and Dispersing Agents

Hydrophobic drug powders require wetting agents to achieve uniform dispersion in the aqueous guar gum vehicle. Low concentrations of surfactants such as polysorbate 80 or sodium lauryl sulfate are used to improve wettability of the drug particles prior to levigation and incorporation into the gum suspension. [11]

Evaluation Parameters

Sedimentation Volume (F)

Sedimentation volume is the primary parameter for assessing physical stability of a pharmaceutical suspension. It is calculated using the formula:

F=VuV0F=V0Vu

Where VuVu is the ultimate volume of the sediment and V0V0 is the original volume of the suspension. A value of F close to 1 (ideally ≥ 0.98) indicates a highly stable suspension with minimal compacted sedimentation. Measurements are recorded at regular intervals (e.g., every 5 days up to 45 days) to assess long-term stability.

Viscosity Measurement

Viscosity of guar gum suspensions is measured using a Brookfield digital viscometer at multiple rotational speeds (e.g., spindle No. 2 at 60 rpm). The target viscosity range for stable pharmaceutical suspensions is typically 99–101.3 cps for optimized guar gum-based formulations. Multiple speed readings should be taken to characterize shear-thinning behavior, which is the hallmark of a pharmaceutically acceptable pseudoplastic suspension.

Redispersibility

Redispersibility is evaluated by counting the number of inversions (180°) required to completely resuspend the settled particles after a defined storage period. Fewer inversions indicate better redispersibility and superior suspension stability. A maximum of 20

inversions is generally considered acceptable in pharmaceutical practice for redispersible suspensions.

pH Measurement

The pH of each formulation batch is measured using a calibrated digital pH meter at time zero and at subsequent storage intervals (e.g., at 0, 10, 20, and 30 days). Stability of pH within the range of 5–7 confirms both formulation stability and polymer integrity over time.

Drug Content Uniformity

Drug content uniformity is determined by withdrawing aliquots from different positions (top, middle, bottom) of the suspension and assaying them by validated UV-Vis spectrophotometry or HPLC methods. Acceptable content uniformity requires that drug content in each aliquot falls within 90–110% of the labeled drug content, confirming uniform drug distribution throughout the vehicle. [12]

Particle Size and Size Distribution

Particle size analysis is performed using optical microscopy or laser diffraction particle size analyzers. Smaller and uniform particle sizes improve suspension stability, reduce sedimentation rate, and enhance bioavailability of the suspended drug. For pharmaceutical suspensions, a mean particle diameter below 5 μm is generally desirable for oral formulations.

Rheological Assessment (Flow Behavior)

Rheological parameters are assessed by measuring flow rate and constructing flow curves (shear stress vs. shear rate plots). Pseudoplastic (non-Newtonian, shear-thinning) behavior characterized by a decrease in viscosity with increasing shear rate is the target profile for stable pharmaceutical suspensions. Guar gum suspensions exhibit a clear low-shear viscosity plateau and are strongly shear-thinning, which is ideal for the purpose.

Stability Studies

Accelerated stability studies are conducted at 40°C ± 2°C / 75% RH ± 5%. Samples are evaluated for physical appearance, pH, viscosity, sedimentation volume, drug content, and microbial limits at defined intervals. [13]

Conclusion

Guar gum represents a versatile, cost-effective, and safe natural excipient for the development of liquid pharmaceutical suspensions. Its unique pseudoplastic rheological behavior, GRAS status, biocompatibility, and multifunctionality position it as a preferred choice over several synthetic alternatives.

The mechanisms of drug release encompassing viscosity-controlled diffusion, gel layer formation, microbial enzymatic degradation, and pH-dependent swelling enable formulation of suspensions ranging from immediate to colon-targeted drug delivery. Systematic optimization of guar gum concentration using QbD approaches, combined with rigorous evaluation of sedimentation volume, viscosity, redispersibility, and drug content uniformity, ensures the development of stable and efficacious liquid suspension formulations. Future research should focus on chemical modification strategies, such as carboxymethylation and grafting, to overcome the known limitations of uncontrolled hydration, viscosity instability, and microbial susceptibility, thereby unlocking the full pharmaceutical potential of this remarkable natural polymer. [14]

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