REVIEW ARTICLE ISSN:3139-8448 (print) & 3108-3218 (online)

BTS International Advanced Pharmaceutical Sciences Journal

Vol 01 | Issue 10 | October 2026 Journal homepage: www.btsempire.com

MANUSCRIPT ID: BTS1026006

Gastroretentive Drug Delivery Systems: A Comprehensive Review

Dr. Narendra Kumar Reddy Kolli, B. Mani Siva Charan, T. Krishna Ganesh, J. Suresh

Vikas group of Institutions, Nunna, NTR District, Vijayawada, India.

Corresponding Author Mail Id: drnkrkolli@gmail.com

Received: 26 September 2026 | **Revised & Accepted:** 24 October 2026

Keywords: Gastro-retentive drug delivery system, GRDDS, gastric retention, floating drug delivery, controlled release, gastro-retentive.

Abstract:

Oral drug administration is one of the most widely used routes because of its convenience, patient acceptability, and ease of administration. However, conventional oral dosage forms may have limitations such as variable gastric emptying, short gastrointestinal transit time, poor absorption of drugs from specific regions of the gastrointestinal tract, and rapid elimination of drugs having short biological half-lives. Gastro-retentive drug delivery systems (GRDDS) are designed to remain in the stomach for an extended period and release the drug in a controlled manner. This approach can improve drug bioavailability, maintain therapeutic drug concentrations, reduce dosing frequency, and provide site-specific delivery in the stomach and proximal small intestine. Various approaches have been developed, including floating, high-density, mucoadhesive, expandable, magnetic, raft-forming, and other gastro-retentive systems. This review summarizes the principle, need, physiological basis, approaches, factors affecting gastric retention, advantages, limitations, preparation methods, polymers, and evaluation parameters of GRDDS.

INTRODUCTION:

Oral drug delivery is traditionally the most commonly used method of drug administration. Conventional oral dosage forms, however, may pass rapidly through the gastrointestinal tract and may not remain at the desired site for a sufficient period. Variable and unpredictable gastric emptying, limited absorption windows in the upper small intestine, and short gastrointestinal transit time are important challenges [1, 2].

Gastro-retentive drug delivery systems are designed to prolong the residence time of a dosage form in the stomach and provide controlled drug release. Prolonged gastric retention can be particularly useful for drugs that are absorbed mainly from the proximal gastrointestinal tract, have poor solubility at alkaline pH, are degraded at higher pH, or are intended to produce a local effect in the stomach or proximal small intestine [2, 3].

Need for Gastro-Retentive Drug Delivery Systems

- Short biological half-life of some drugs.
- Rapid elimination of drugs from systemic circulation.
- Variable gastric emptying.
- Short gastrointestinal residence time.
- Limited absorption window in the upper gastrointestinal tract.
- Poor solubility of some drugs at alkaline pH.

© BTS Pharma Empire All Rights Reserved

BTS International Advanced Pharmaceutical Sciences Journal
Vol 01 | Issue 10 | October 2026 Journal homepage: www.btsempire.com

MANUSCRIPT ID: BTS1026006

• Requirement for local action in the stomach or proximal small intestine.
• Need for sustained and controlled drug release.
• Reduction in dosing frequency.
• Reduction in fluctuations in plasma drug concentration.

Pharmaceutical Importance of GRDDS

The principal pharmaceutical importance of GRDDS is its ability to retain a dosage form in the stomach and release the drug gradually at the required rate. This can be useful for drugs with a narrow absorption window or for drugs intended for local treatment of the stomach and upper gastrointestinal tract [4].

Important therapeutic benefits include improved bioavailability, prolonged drug release, improved therapeutic efficiency, reduced dosing frequency, reduced fluctuations in plasma drug concentration, improved patient compliance, reduction in drug wastage, improved drug solubility in suitable cases, site-specific drug delivery, and prolonged drug exposure to the absorption site [5].

Physiology of the Stomach

Understanding stomach physiology is essential for designing an effective GRDDS. The stomach consists mainly of three anatomical regions: fundus, body, and antrum/pylorus. The fundus and body mainly act as a reservoir for gastric contents, whereas the antrum contributes significantly to mixing and gastric emptying. The pylorus regulates the passage of gastric contents into the duodenum. Gastric motility differs between fed and fasting conditions.

Migrating Motor Complex (MMC): The migrating motor complex is an important physiological factor affecting gastric retention. It occurs in cycles and influences the movement and eventual emptying of dosage forms from the stomach [2, 6].

Approaches of Gastro-Retentive Drug Delivery

GRDDS can broadly be divided into floating and non-floating systems.

Floating Drug Delivery Systems

Floating drug delivery systems have a bulk density lower than gastric fluid and therefore remain buoyant in the stomach. While floating, the dosage form can gradually release the drug [7].

A. Effervescent Systems

These systems generate gas, usually carbon dioxide, which reduces the density of the dosage form and allows it to float. Sodium bicarbonate with citric or tartaric acid may be used as gas-generating components.

B. Non-Effervescent Systems

These systems generally use gel-forming polymers or hydrocolloids to maintain buoyancy. One important example is the hydrodynamically balanced system.

High-Density Drug Delivery Systems

High-density systems are designed to have a density greater than gastric contents and settle in the lower part of the stomach. Their effectiveness in humans remains limited.

Mucoadhesive/Bioadhesive Systems

These systems attempt to prolong gastric residence by adhering to the gastric mucosa. Materials include chitosan, Carbopol, polycarbophil, lecithin, gliadin, and carboxymethyl cellulose.

Magnetic Systems

A magnetic system contains a small magnet within the dosage form, while an external magnet is positioned over the stomach to help retain the dosage form.

Expandable Systems

Expandable systems increase in size after administration and remain in the stomach for a prolonged period.

Raft-Forming Systems

Raft-forming systems contain gel-forming polymers and effervescent components. In

© BTS Pharma Empire All Rights Reserved

BTS International Advanced Pharmaceutical Sciences Journal
Vol 01 | Issue 10 | October 2026 Journal homepage: www.btsempire.com
MANUSCRIPT ID: BTS1026006

gastric fluid they form a cohesive floating gel layer known as a raft.

Other Multiparticulate Floating Systems

Examples include hollow microspheres/micro balloons, microporous compartments, alginate beads, intragastric floating systems, and osmotically controlled systems [3, 7].

Factors Controlling Gastric Retention

1. Density
2. Size
3. Shape
4. Single or multiple units
5. Fed or fasting state
6. Nature of food
7. Frequency of food intake
8. Caloric content
9. Age
10. Posture
11. Disease state
12. Concomitant drugs

Gastric retention depends on formulation factors, gastric motility, food intake, patient characteristics, and medicines that alter gastrointestinal motility.

Advantages of GRDDS

• Enhanced bioavailability.
• Sustained drug delivery.
• Reduced dosing frequency.
• Improved patient compliance.
• Site-specific therapy.
• Reduced plasma drug concentration fluctuations.
• Prolonged therapeutic concentration.
• Reduced drug exposure to the colon for suitable drugs.

Disadvantages and Limitations

• May not be suitable for drugs with poor stability or solubility in the gastrointestinal tract.
• Drugs that irritate the gastric mucosa may not be appropriate.
• Mucoadhesive systems face difficulties because gastric mucus is continuously renewed.
• Drugs primarily absorbed from the colon may not benefit.
• Floating systems require sufficient gastric fluid to maintain buoyancy.
• Certain drugs may not be appropriate for prolonged exposure to the acidic gastric environment.

Methods for Preparation of Gastro-Retentive Multiparticulate Systems

Solvent Evaporation Method

The drug and polymer are incorporated into an organic phase and emulsified into an aqueous phase. Removal of the organic solvent results in polymer precipitation and formation of hollow or porous particles with floating characteristics.

Ionotropic Gelation

Ionotropic gelation is based on cross-linking of polymers in the presence of oppositely charged ions. Materials such as alginate, gellan gum, chitosan, and carboxymethyl cellulose can be used.

Emulsion Solvent Diffusion

The drug is dissolved in an organic solvent and dispersed in an aqueous medium. Diffusion of solvents between the phases results in formation of particles and drug crystallization.

Foam Powder Method

Low-density foam-based multiparticulate systems can provide good floating behavior and controlled drug release.

Melt Granulation

Melt granulation involves formation of granules using a molten or meltable binder. Hydrophilic binders can be used for immediate-release systems, whereas hydrophobic binders are more suitable for prolonged-release formulations.

Polymeric Materials Used in GRDDS

Important polymers include hydroxypropyl methylcellulose (HPMC), hydroxypropyl cellulose (HPC), hydroxyethyl cellulose (HEC), carboxymethyl cellulose (CMC), guar gum, carrageenan, gellan gum, xanthan gum, alginate, chitosan, pectin,

© BTS Pharma Empire All Rights Reserved

BTS International Advanced Pharmaceutical Sciences Journal
Vol 01 | Issue 10 | October 2026 Journal homepage: www.btsempire.com
MANUSCRIPT ID: BTS1026006

gelatin, Carbopol, polycarbophil, polyethylene oxide, and Kollidon SR.
Polymers are important because they control swelling, buoyancy, adhesion, matrix formation, and drug release.

Evaluation of Gastro-Retentive Dosage Forms

Major evaluation parameters include:
1. Buoyancy lag time.
2. Density/specific gravity.
3. Resultant weight.
4. Swelling index.
5. Water uptake.
6. Particle size and shape.
7. Entrapment efficiency.
8. Floating behavior.
9. In-vitro drug release.
10. Drug–excipient compatibility using techniques such as FT-IR and DSC.
11. In-vivo evaluation using suitable methods such as radiography, scintigraphy, gastroscopy, magnetic marker monitoring, ultrasonography, and breath tests [3, 9].

GRDDS Compared with Conventional Drug Delivery

Conventional drug delivery generally has limited gastric retention, whereas GRDDS is specifically designed for prolonged gastric residence. GRDDS may be more suitable for drugs with a narrow absorption window, local gastric therapy, sustained drug release, and upper-GIT absorption. It can also reduce dosing frequency and plasma drug fluctuations in suitable formulations [10].

Key Points of the Review

• GRDDS is designed to prolong gastric residence time.
• It addresses limitations associated with rapid gastrointestinal transit.
• It is especially useful for drugs with an upper-GIT absorption window.
• Floating systems are one of the major approaches.
• Other approaches include high-density, mucoadhesive, magnetic, expandable, and raft-forming systems.
• Gastric retention is influenced by density, size, shape, food, gastric motility, posture, age, disease state, and concomitant medication.
• Multiparticulate systems can be prepared using solvent evaporation, ionotropic gelation, emulsion solvent diffusion, foam-based methods, and melt granulation.
• Evaluation includes buoyancy, density, swelling, particle size, entrapment efficiency, floating behavior, drug release, compatibility, and in-vivo gastric-retention studies.
• Major therapeutic advantages include improved bioavailability, sustained release, reduced dosing frequency, reduced plasma fluctuations, and site-specific delivery.
• GRDDS is not appropriate for every drug; drug stability, solubility, gastric irritation, absorption site, and gastric fluid availability must be considered [11].

Conclusion

Gastro-retentive drug delivery systems are an important approach within oral controlled drug delivery. By prolonging the residence of a dosage form in the stomach, GRDDS can provide controlled and sustained drug release and improve drug exposure at appropriate absorption sites. The technology is particularly promising for drugs with short half-lives, limited upper-GIT absorption windows, poor solubility at alkaline pH, or a requirement for local gastric action.
Different approaches including floating, mucoadhesive, high-density, expandable, magnetic, raft-forming, and multi particulate systems provide different mechanisms for achieving gastric retention. However, gastric physiology and patient-related factors make the development of an effective GRDDS challenging. Therefore,

© BTS Pharma Empire All Rights Reserved

BTS International Advanced Pharmaceutical Sciences Journal
Vol 01 | Issue 10 | October 2026 Journal homepage: www.btsempire.com

MANUSCRIPT ID: BTS1026006

appropriate selection of the drug, polymer, formulation design, preparation method, and evaluation parameters is essential.

References

1. Patole R, Chaware B, Mohite V, Redasani VK. A review for gastro-retentive drug delivery system. Asian J Pharm Res Dev. 2023;11(4):79-94. doi:10.22270/ajprd.v11i4.1291.
2. Das S, Kaur S, Rai VK. Gastro-retentive drug delivery systems: a recent update on clinical pertinence and drug delivery. Drug Deliv Transl Res. 2021;11(5):1849-1877. doi:10.1007/s13346-020-00875-5.
3. Shah K, Singh D, Agrawal R, Garg A. Current developments in the delivery of gastro-retentive drugs. AAPS PharmSciTech. 2025;26(2):57. doi:10.1208/s12249-025-03052-4.
4. Rajora A, Nagpal K. A critical review on floating tablets as a tool for achieving better gastric retention. Crit Rev Ther Drug Carrier Syst. 2022;39(1):65-103. doi:10.1615/CritRevTherDrugCarrierSyst.2021038568.
5. Waqar MA, Mubarak N, Khan AM, Khan R, Shaheen F, Shabbir A. Advanced polymers and recent advancements on gastroretentive drug delivery system; a comprehensive review. J Drug Target. 2024;32(6):655-671. doi:10.1080/1061186X.2024.2347366.
6. Vinchurkar K, Sainy J, Khan MA, Mane S, Mishra DK, Dixit P. Features and facts of a gastroretentive drug delivery system-a review. Turk J Pharm Sci. 2022;19(4):476-487. doi:10.4274/tjps.galenos.2021.44959.
7. Mora-Castaño G, Domínguez-Robles J, Himawan A, Millán-Jiménez M, Caraballo I. Current trends in 3D printed gastroretentive floating drug delivery systems: a comprehensive review. Int J Pharm. 2024;663:124543. doi:10.1016/j.ijpharm.2024.124543.
8. Singh M, Das MK. A comprehensive review on role of natural polymers in gastro retentive drug delivery system (GRDDS). Drug Deliv Lett. 2025;15(2):83-94. doi:10.2174/0122103031301526241010021238.
9. Omidian H. Gastroretentive drug delivery systems: a holy grail in oral delivery. Drug Discov Today. 2025;30(4):104340. doi:10.1016/j.drudis.2025.104340.
10. Bachhar A, Barman S, Sarkar A, Bose A, Biswas P, Mandal S. Advances in biopolymer-based floating raft drug delivery systems for gastroretentive therapy. J Biomater Sci Polym Ed. 2026:1-39. doi:10.1080/09205063.2026.2636795.
11. Dubey A, Ovais M, Bisen AC, Rajendiran A. Advancements and challenges in gastroretentive drug delivery systems: a comprehensive review of research innovation, technologies, and clinical applications. Recent Adv Drug Deliv Formul. 2026;20(1):41-65. doi:10.2174/0126673878342430250414114531.

© BTS Pharma Empire All Rights Reserved