

Gastro-Retentive Drug Target System: Its Needs, Advantages, Limitation, and Approaches

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Abstract

Background: Gastro-retentive drug delivery systems (GRDDS) address limitations of oral therapy for drugs with poor solubility, instability at intestinal pH, or narrow absorption windows by prolonging gastric residence and increasing contact with the gastric mucosa. **Objectives:** To review GRDDS approaches – floating systems, mucoadhesive systems, and super-porous hydrogels – with emphasis on formulation strategies and polymer–excipient selection to enhance gastric retention, modulate buoyancy/swelling/adhesion, and ultimately improve oral bioavailability and therapeutic outcomes for drugs with restricted absorption sites. **Methods:** Literature on GRDDS design and evaluation was examined, focusing on mechanisms (flotation, mucoadhesion, expansion, density-based retention), classification of floating and non-floating systems, critical polymer/excipient attributes that govern gelation, swelling and mucoadhesion, and typical in vitro and in vivo assessment methods including drug-release kinetics, mucoadhesive strength, and gastric residence measurements. **Results:** GRDDS variants successfully prolonged gastric residence relative to conventional dosage forms and provided sustained release profiles that reduced dosing frequency and improved patient compliance; floating (effervescent and non-effervescent), expanding, high-density and bioadhesive systems each show distinct advantages and limitations depending on drug properties and physiological factors. **Conclusions:** GRDDS represent a versatile platform for enhancing bioavailability of drugs with narrow absorption windows or pH-dependent stability, but translation requires optimization of polymer systems, improved in vitro–in vivo correlation, and consideration of scalability and safety for clinical use.

Keywords: Drug, delivery system, cell, gut microbiodata, medical research

INTRODUCTION

Despite rapid innovations in pharmaceutical technology, oral administration remains the preferred route for patients due to its convenience and non-invasive nature. To optimize this route, controlled-release systems are designed to distribute medication in a highly regulated, predictable, and pre-programmed manner. However, standard controlled-release designs often fail when treating drugs with poor bioavailability, typically caused by chemical instability or inadequate absorption within the lower digestive tract [1].

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To overcome these limitations, modern pharmaceutical research focuses on lengthening the time a dosage form remains inside the stomach. This specialized approach relies on Gastro-Retentive Drug Delivery Systems (GRDDS). These systems are uniquely suited for several categories of therapeutics:

- **pH-Dependent Solubility:** Drugs, like furosemide and diazepam, which dissolve poorly in the alkaline environment of the lower intestine.

- *pH-Sensitive Stability*: Compounds, like ranitidine and metformin, which degrade or lose efficacy in alkaline conditions.
- *Stomach-Targeted Absorption*: Medications, like albuterol, which are preferentially absorbed directly through the gastric mucosa [2].

NAVIGATING PHYSIOLOGICAL BARRIERS

Implementing a successful prolonged gastric system requires overcoming complex biological hurdles. The human gastrointestinal tract presents a brief transit window (roughly 8 to 12 hours) alongside highly unpredictable gastric emptying rates that fluctuate drastically from person to person. Additionally, many therapeutic agents feature a narrow “absorption window” restricted to the upper small intestine. When a standard drug formulation passes through this region too quickly – often averaging a mere 2 to 3 hours in humans – the overall clinical efficacy of the dose drops sharply.

These biological constraints have driven the development of specialized delivery mechanisms capable of maintaining a stable, prolonged presence in the stomach. By anchoring the dosage form within the gastric environment, these systems release medication in a steady, repeatable manner. Ultimately, this stabilizes plasma drug concentrations at a therapeutic steady-state, minimizing dangerous peaks and troughs while reducing how often a patient needs to take their medication.

Formulation Variables and Gastric Anatomy

Gastro-retentive systems successfully alter natural gastrointestinal motility patterns and slow down default gastric emptying times. They are particularly beneficial for drugs with short biological half-lives or poor absorption profiles in the lower intestine.

However, engineering a reliable gastro-retentive dosage form depends heavily on several interconnected formulation variables:

- *Polymer Attributes*: The choice between non-cationic and anionic polymers.
- *Physical Properties*: The molecular weight, total composition, and viscosity of the polymer matrix.
- *Drug Behavior*: The inherent solubility of the active pharmaceutical ingredient. Physiologically, these formulations are designed to operate within the stomach – the J-shaped, expandable segment of the digestive tract situated just below the diaphragm, acting as the critical bridge between the esophagus and the duodenum. For more than half a century, optimizing this gastric residence time has remained a primary goal for pharmaceutical scientists aiming to maximize both the medicinal and biopharmaceutical potential of oral therapies [3].

Improvements in the stomach’s local activity, concentrations, patient compliance as a result of dosage reduction, or the enhanced bioavailability of some medications with windows in the upper gastrointestinal tract [4].

The primary goal of all drug delivery systems is to deliver a therapeutic dose of the medication to the right place in the body at the right time to establish and maintain optimal therapeutic concentrations and show the intended pharmacological activity with the fewest possible side effects. By sticking to the ideal route of administration and optimal dose frequency, this goal is met. Despite several developments in drug delivery systems, the oral route remains the most popular method because of its convenience of administration, affordability, patient compliance, and formulation flexibility. Route of administration plays a crucial role in drug release and efficacy. Solid oral dose forms are the recommended class of pharmaceuticals.

It is common knowledge that taking medication multiple times for the treatment of illnesses can cause the drug level in the body to fluctuate. To avoid this and maintain the therapeutic drug level in the body, the drug must be administered via a controlled release system. Several oral controlled release dose

formulations were created to maximize therapeutic efficacy. Although the medication release rate was planned, predictable, and regulated in an oral controlled release drug delivery system, certain medicines had limited bioavailability because of insufficient absorption or breakdown in the gastrointestinal tract [5].

Anatomy of GIT

GIT can be divided into three main areas:

- Stomach.
- Small Intestine – duodenum, jejunum, and ileum.
- Large Intestine.

From the mouth to the anus, the GIT is a continuous muscle tube that facilitates physiological functions including secretion, motility, digestion, absorption, and excretion to absorb nutrients and remove waste. The stomach, a J-shaped expansion of the gut GIT, is composed of the cardia, fundus, body, and antrum, which are its four anatomical sections. The fundamental role of the stomach is to act as a temporary reservoir, holding ingested material and blending it thoroughly with acidic gastric secretions. As a highly distensible organ, its volume fluctuates dramatically depending on its state: in a resting, empty condition, it maintains a volume of roughly 50 mL, but it can expand significantly to accommodate up to 1 L of content when fully distended [6].

Need for GRDDS

- *Limitations of Traditional Oral Dosing:* While the pharmaceutical sector heavily relies on standard oral medications to manage various diseases, traditional dosage forms suffer from significant drawbacks – most notably, their inability to target specific regions of the digestive tract.
- *The Challenge of Localized Absorption:* Many therapeutic agents possess a narrow absorption window, meaning they are only effectively taken up by the body at a particular physiological site. To optimize efficacy, these drugs require a delivery mechanism that releases the active ingredient precisely where it can achieve maximum local concentration and bioavailability.
- *A Shift Toward Targeted Design:* Consequently, current pharmaceutical research is highly focused on engineering formulations specifically tailored for these site-dependent compounds.
- *GRDDS as a Targeted Solution:* Gastro-retentive technology serves as an effective site-specific strategy for localized delivery within the upper gastrointestinal tract. By structurally anchoring the dosage form inside the gastric cavity, the system ensures the medication is gradually and continuously metered out directly into the stomach, duodenum, or upper small intestine [7].
- *Gastro retentive Dosage Form:* When taken orally, these formulations stay in the stomach for a few hours, extending the duration of the drug's gastric residence time. The drug is released gradually and under control, allowing the drug to be continuously supplied throughout the upper gastrointestinal tract. By prolonging the time, a formulation stays in the gastric cavity, this approach enhances the dissolution of compounds that exhibit poor solubility in alkaline conditions, ultimately boosting overall bioavailability and preventing unnecessary drug degradation [8, 9].

Ideal Characteristics of Drugs for GRDDS

For the formulation of GRDDS, drug molecules with better absorption in the upper part of the gastrointestinal tract but low absorption in the colon are preferred options. Prior to developing GRDDS, the drug's physical, chemical, and biological characteristics should be identified. Biopharmaceutical factors are also essential for medication distribution via the gastrointestinal tract. The incorporation of excipients into a drug delivery system is crucial, hence it is imperative to conduct a compatibility study between the drug and these excipients, or between specific excipients. Medication designs that are appropriate for GRDDS include misoprostol, benzodiazepines, captopril, and others [10–14].

Advantages of Gastroprotective Drug Delivery Systems

- GRDDS aids in sustaining a medication's therapeutic level for an extended length of time; beta lactam antibiotics are one example.

- These short half-lives of medications in controlled release formulations reduce dosage frequency, which enhances patient compliance.
- Therapeutic efficiency of drug is enhanced [15].
- They, such as non-steroidal anti-inflammatory medicines, lessen the irritation of pharmaceuticals on the mucosa by releasing the substance gradually and at a regulated pace.
- Greater drug efficiency is attained when the counteractivity of the is decreased [16].
- Enhanced bioavailability is attained [17].
- GRDDS is a tool for achieving medication targeting at a particular location [18].
- The use of this medication delivery method in chronotherapy is extensive [19, 20].

Limitations of Gastroprotective Drug Delivery System

- Drugs that produce gastric lesions, are less soluble in acid, or are unstable in an acidic environment should not be used with GRDDS.
- Medications that experience first-pass metabolism are not good choices.
- Violent gas production, dosage form disintegration, dosage dumping, alkaline microenvironment, etc. are some additional restrictions on GRDDS.
- Low in vivo and in vitro correlation combined with increased formulation costs.
- In the event of toxicity, poisoning, or hypersensitive response, recovering drugs might be challenging [21].

The controlled gastric retention of solid dosage forms may be achieved by the mechanism of:

- Mucoadhesion.
- Flotation.
- Sedimentation.
- Expansion.
- Modified shape systems OR
- By the simultaneous administration of pharmacological agents that delay gastric emptying [22].

DIFFERENT APPROACHES OF GASTROINTESTINAL DRUG DELIVERY SYSTEM

Various strategies have been tried to improve oral dose forms' stomach retention. Certain dosage forms are composed of a single component, whereas others are composed of many components. Generally speaking, GRDDS may be divided into floating and non-floating systems (Figures 1–3).

- Floating system.
- Non-Floating system.

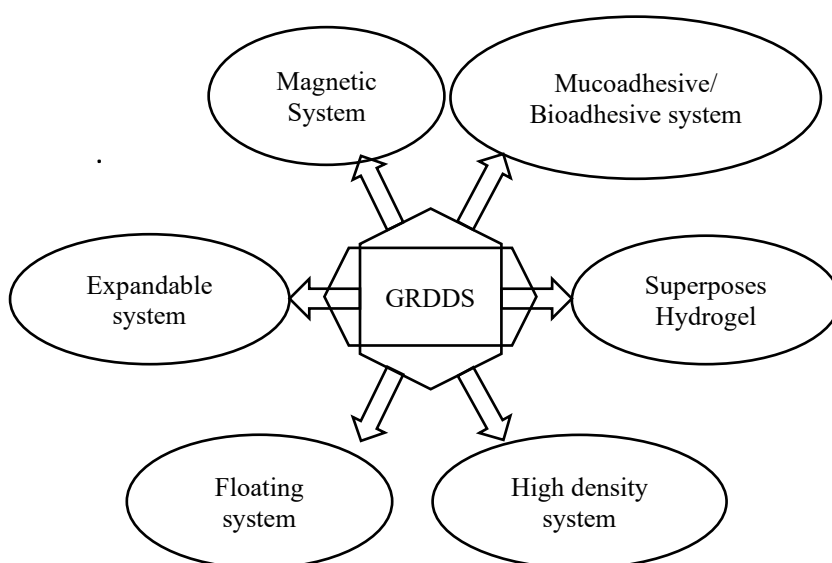


Figure 1. Different approaches of gastrointestinal drug delivery system.

Bioadhesive System

- Swelling system.
- High density system.
- Expandable system.

Floating Drug Delivery System (FDDS)

The goal of the floating system is to lengthen the gastric retention time (GRT) by floating in and above the stomach content. Owing to its lower density than gastric fluids, the system floats within the stomach and provides sustained drug release without affecting the normal gastric emptying process. Once the drug is fully released, the delivery device is naturally expelled from the gastrointestinal tract [23].

Mechanics of Floating Drug Delivery Systems (FDDS)

Floating systems are low-density formulations designed with inherent buoyancy, allowing them to swim atop the stomach's gastric contents without accelerating the natural emptying rate. While remaining suspended in the gastric cavity, the dosage form continuously dispenses the therapeutic agent at a controlled velocity. This prolonged residence time stabilizes drug absorption and dampens the plasma concentration fluctuations often seen with standard medications.

The Buoyancy Force Equation

To ensure the dosage form remains safely afloat on the chyme's surface, the system requires a baseline volume of gastric fluid alongside a critical threshold of upward hydrodynamic force. The total vertical force (F) acting on the floating object can be calculated over time to track its buoyancy kinetics. This relationship is determined by the balance between the upward buoyant force and the downward pull of gravity [24]:

$$F = (F_{\text{buoyancy}} - F_{\text{gravity}}) = (D_f - D_s)gv$$

where:

- F = Total resultant vertical force.
- D_f = Density of the fluid inside the stomach.
- D_s = Bulk density of the dosage form object.

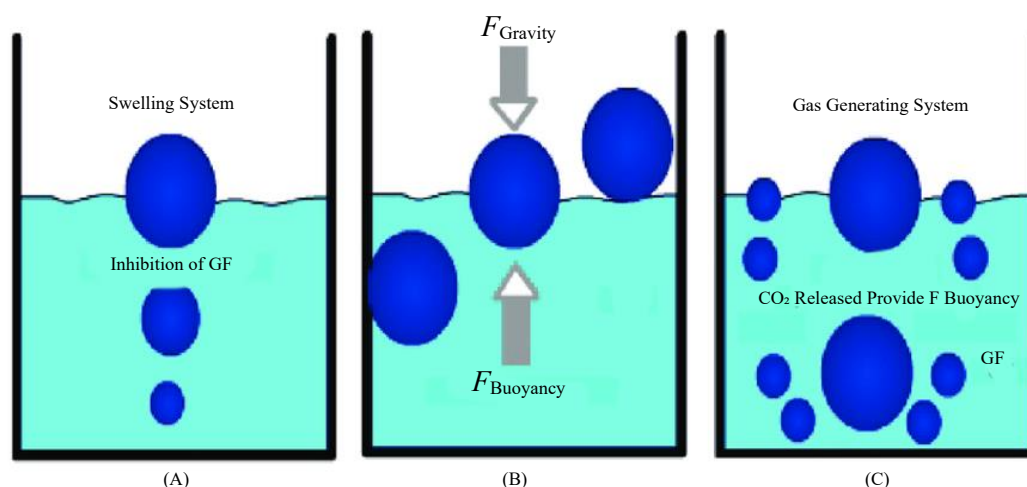


Figure 2. Mechanism of floating system. <https://images.app.goo.gl/9vzecpbJkFRjcWj98> [25].

CLASSIFICATION OF FLOATING DRUG DELIVERY SYSTEM

Based on the bouncy mechanism, floating system is classified as follows:

Effervescent System

- Gas generating system.
- Volatile liquid containing system.

Non-Effervescent System

- Colloidal barrier system.
- Micro porous compartment system.
- Floating microspheres.
- Alginate floating beads.
- Raft forming system [8].

Effervescent System***Effervescent Floating Systems***

Effervescent formulations are matrix-based configurations engineered using a combination of swellable hydrophilic polymers (such as chitosan or methylcellulose) and gas-producing reactive agents. Typical effervescent components include sodium bicarbonate alongside organic acids like citric or tartaric acid.

These platforms are structurally designed to initiate a chemical reaction upon contact with gastric fluid, generating carbon dioxide (CO₂) gas. As the gas is produced, it becomes entrapped within the hydrating, swollen polymer network, which imparts buoyancy to the dosage form. A prominent application of this mechanism is found in asymmetric, swellable triple-layer tablet configurations [26].

Gas-Generating Systems

The operational foundation of a gas-generating system relies on an acid-base neutralization reaction – typically between sodium bicarbonate and organic acids (citric and tartaric) – to liberate CO₂ gas [27–29].

Mechanism of Buoyancy

- *Gas Entrapment:* As the CO₂ gas is liberated, it becomes localized inside the rapidly gelling outer hydrocolloid matrix of the formulation.
- *Density Reduction:* The trapped gas bubbles drastically decrease the overall bulk density and specific gravity of the tablet, allowing it to rise and remain afloat on top of the gastric chyme.

Structural Composition

These delivery vehicles frequently utilize a multi-layered design built around a central, sustained-release core:

- *The Effervescent Layer:* An interior coating comprising a compressed mixture of sodium bicarbonate and tartaric acid.
- *The Swellable Membrane:* A protective exterior layer composed of expandable, polymeric materials such as polyvinyl alcohol (PVA) or shellac.

Floating Capsule

A combination of sodium bicarbonate and sodium alginate is used to produce them. When an acidic environment is encountered, CO₂ gas is produced. This gas becomes trapped in the hydrating gel network, causing the device to float.

Floating Pills

These are a class of formulations known as sustained release, which are essentially different kinds of unit dosage forms. There are two layers around the sustained release tablet. The swellable membrane makes up the outside layer, while the effervescent agents make up the interior layer. Because of the swellable membrane, the systems swell and then descend. The system floats because of the release of CO₂ caused by the effervescent ingredient.

Floating System with Ion Exchange Resin

The most popular method for creating these systems is using resin beads that have been loaded with bicarbonates. Next, ethyl cellulose, which is normally insoluble but permeable to water, is applied on top of this. As a result, the system begins to float and carbon dioxide is released.

Volatile Liquid-Containing Systems

These specialized systems utilize an internal, expandable chamber loaded with a volatile organic liquid (such as cyclopentane or ether). Because these liquids possess boiling points below normal human body temperature, they vaporize upon entering the stomach. The resulting gas causes the chamber to inflate, inducing buoyancy. Structurally, these platforms are floating, osmotically managed units that house a flexible, hollow compartment. The device is typically divided into two distinct functional zones: one containing the active therapeutic agent and the other containing the volatile substance [30–32].

CLASSIFICATION OF VOLATILE AND OSMOTIC SYSTEMS

Intragastric Floating Gastrointestinal Drug Delivery Systems

This variant features a dual-compartment design:

- *Drug Reservoir*: A core compartment that safely houses the medication, bounded by a microporous membrane to regulate release.
- *Flotation Chamber*: An adjacent, sealed chamber filled with an inert, non-toxic gas (or maintained under a vacuum) to provide permanent buoyancy [33].

Inflatable Gastrointestinal Drug Delivery Systems

These platforms rely on temperature-induced phase changes to secure gastric retention:

- *Gasification and Inflation*: Upon ingestion, the liquid ether inside the chamber reaches body temperature, vaporizes, and expands the unit within the gastric cavity.
- *Controlled Collapse*: The inflatable compartment is secured by a bioerodible polymer filament (such as a polyvinyl alcohol–polyethylene copolymer). Over time, this filament gradually degrades in the gastric juice, causing the chamber to safely deflate and release the trapped gas so the empty shell can exit the stomach [34].

Intragastric Osmotically Controlled Drug Delivery Systems

This architecture merges osmotic pressure principles with buoyancy mechanics by combining an inflatable floating capsule with an osmotic core [35]:

- *Gastric Activation*: When the outer capsule shell reaches the stomach, it dissolves or activates to inflate the floating component.
- *Osmotic Release*: The internal assembly – consisting of an osmotic engine compartment and a separate drug reservoir – then uses osmotic pressure gradients to pump out the medication at a highly controlled, predictable rate.

Non-Effervescent System

These are a particular kind of gel-forming hydrocolloid, polysaccharide, and matrix-forming polymers, such as polycarbonate, polystyrene, and polymethacrylate, that are utilized in floating gastro-retentive drug delivery systems. These are divided into the following categories:

- A. *Colloid Gel-Based System*: In 1975, Sheath and Tossounian invented the first hydrodynamically balanced system (HBS), which comprises medications including gel-forming hydrocolloids.
- B. *Non-Effervescent Hydrodynamic Balanced Systems*: These formulations rely on a high concentration – typically ranging from 20% to 75% w/w – of one or more highly swellable, gel-forming agents such as cellulose-based hydrocolloids, polysaccharides, or matrix polymers.

Upon entering the stomach, the hydrocolloids immediately absorb gastric fluid, initiating rapid hydration. This process forms a dense, continuous colloidal gel layer that envelops the entire outer surface of the dosage form.

This viscous gel barrier serves two critical regulatory functions:

- *Inward Diffusion*: It controls the velocity at which gastric juice can penetrate the core of the tablet.
- *Outward Release*: It restricts and governs the rate at which the dissolved active drug diffuses out of the matrix and into the digestive tract.

Microporous Compartment Systems

This design architecture encapsulates a central medication core between the upper and lower boundaries of a multi-layered, perforated compartment.

To protect the gastric lining, the perimeter walls of this internal drug reservoir are hermetically sealed. This structural barrier prevents any undissolved active pharmaceutical ingredients from making direct, abrasive contact with the stomach's mucosal surface, ensuring that the medication is released strictly through the designated micropores.

Floating Microspheres

A core hollow region within the microsphere makes hollow microspheres more beneficial and the most promising buoyant system. With the use of a unique emulsion solvent diffusion process, hollow microspheres with drug-loaded exterior polymer shelves were created [35].

Alginate Floating Beads

Multi-unit floating delivery systems can be successfully engineered using freeze-dried calcium alginate matrices. To manufacture these formulations, a sodium alginate solution is added dropwise into an aqueous receiver solution of calcium chloride. This initiates a cross-linking reaction, causing calcium alginate to precipitate into uniform, spherical beads with an approximate diameter of 2.5 mm.

Once formed, the beads are harvested, rapidly frozen using liquid nitrogen, and subjected to a 24-hour lyophilization (freeze-drying) process under specialized thermal conditions. This treatment sublimates the internal water, leaving behind a highly porous structure. This low-density internal framework allows the beads to maintain stable buoyancy for over 12 hours, prolonging the actual in vivo gastric residence time to approximately 5.5 hours [35].

Raft-Forming Systems

Raft-forming technologies have gained significant traction as an effective approach for administering antacids or treating localized gastrointestinal infections and esophageal disorders.

Upon ingestion, the liquid or chewable gel-forming formulation reacts immediately with the acidic gastric juices. This interaction triggers rapid gelation, creating a thick, cohesive, and viscous barrier. As the formulation simultaneously generates carbon dioxide (CO₂), the gas bubbles become trapped within this expanding network. This causes the entire structure to float like a continuous "raft" on top of the gastric fluid contents, where it acts as a physical shield against gastroesophageal reflux while gradually distributing medication into the stomach [36].

Non-Floating Drug Delivery Systems

Unlike buoyant formulations, non-floating gastro-retentive systems utilize distinct physical and biological mechanisms to prevent passage through the pylorus, ensuring prolonged retention in the gastric cavity.

- *Bioadhesive/Mucoadhesive Systems*: These formulations incorporate specialized bioadhesive polymers that bind directly to the gastric mucosa or biological membranes. By establishing intimate, long-term contact with the stomach lining, the device resists peristaltic clearance and continuously releases the active ingredient.
- *Swelling Systems (Plug Type)*: Constructed from highly expandable hydrogels, these systems rapidly imbibe gastric fluid upon entry. They swell to a cross-sectional size that physically blocks

passage through the pyloric sphincter, effectively trapping the formulation in the stomach until the polymer matrix eventually degrades.

- **High-Density Systems:** These devices utilize a high-density matrix that exceeds the specific gravity of natural gastric juice (approx. 1.004 g/mL). By layering or mixing the drug with heavy, inert compounds – such as titanium dioxide, zinc oxide, or iron powder – the dosage form sinks to the bottom of the stomach, anchoring itself in the lower folds of the gastric cavity against standard emptying currents.
- **Expandable Systems:** Typically packaged as compressed, folded structures inside a gelatin capsule shell, these platforms deploy mechanically upon ingestion. Once the outer shell dissolves in the gastric environment, the inner structure unfolds or expands into an intricate geometry that prevents it from passing through the pylorus.

FACTORS DICTATING GASTRIC RETENTION TIME (GRT)

The duration for which a dosage form remains in the stomach is regulated by a combination of formulation design choices and host physiology:

Formulation Parameters

- **Density:** Formulations requiring true buoyancy must maintain a bulk density strictly below that of gastric fluid (<1.004 g/mL), whereas high-density versions must significantly exceed it.
- **Size and Shape:** The structural dimensions strongly influence transit. For example, dosage forms with a diameter exceeding 7.5 mm generally exhibit a more prolonged gastric residence than smaller units. Geometrically, tetrahedral shapes show superior retention times compared to alternative configurations of equivalent volume.
- **Unit Configuration:** Multi-unit systems (e.g., microparticles or beads) offer distinct advantages over single-unit monolithic tablets. They provide a more predictable, uniform release profile, permit the co-administration of incompatible compounds with varied release kinetics, and lower the clinical risk of dose-dumping caused by single-unit structural failure.

Physiological and Dietary Factors

- **Prandial State (Fed vs. Fasted):** In a fasted state, the stomach undergoes cyclic inter-digestive motility driven by the Migrating Motor Complex (MMC), which recurs every 1.5 to 2 hours. If a formulation is administered during Phase III of the MMC (the “housekeeper wave”), it is rapidly swept into the small intestine. Conversely, the presence of food delays the MMC, shifting the stomach into a digestive (“fed”) pattern that drastically increases GRT.
- **Meal Composition and Caloric Content:** The ingestion of dense macromolecular nutrients, particularly high-protein and high-fat meals, triggers feedback mechanisms that slow gastric emptying, extending GRT by roughly 4% to 10%. Administering certain fatty acids or indigestible polymers can artificially induce this fed state motility pattern [37].
- **Feeding Frequency:** Repetitive or multiple small meals prolong the fed pattern and suppress the resumption of the MMC, extending the retention window beyond 400 minutes compared to a single isolated meal.

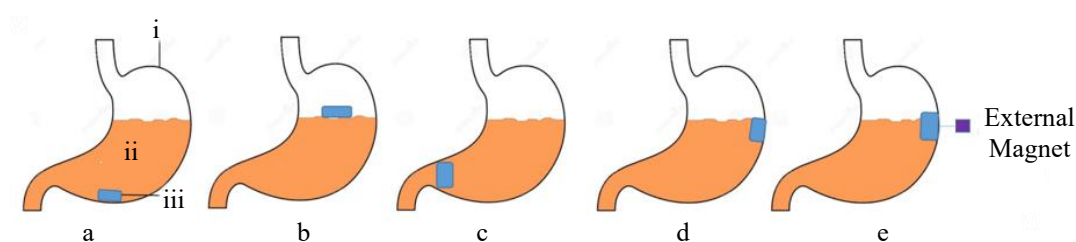


Figure 3. (a) high density system, (b) floating/low density system, (c) inflatable system, (d) mucoadhesive system, and (e) magnetic system (i – stomach, ii – gastric fluid, iii – dosage form). <https://images.app.goo.gl/4sAeZo6SPt8qSF9KA> [37].

Patient Demographics and Co-Medications

- *Gender and Age:* Clinical data indicates that gastric transit varies by demographic factors. For instance, the mean ambulatory GRT is shorter in males (averaging 3.4 hours) than in age- and race-matched female counterparts (averaging 4.6 hours). Additionally, geriatric patients over the age of 70 exhibit significantly prolonged gastric retention times.
- *Concomitant Drug Interactions:* The co-administration of drugs that alter gastrointestinal motility directly impacts retention. Anticholinergic agents (such as atropine and propantheline) and opioid analgesics (such as codeine) slow gastric emptying, thereby increasing the retention window of the co-administered gastro-retentive form (Tables 1 & 2) [38–42].

Table 1. Drugs used in formulation of GRDDS.

S.N.	Dosage form	Drug
1	Floating tablets	Acetaminophen, Acetylsalicylic acid, Ampicillin, Amoxicillin trihydrate, Atenolol, Captopril, Cinnerrzine, Chlorpheniramine maleate, Ciprofloxacin, Diltiazem, Fluorouracil, Isosorbide dintrate, Isosorbide mononitrate, P-Aminobenzoic acid (PABA), Prednisolone, Nimodipine, Sotalol, Theophylline, Verapamil.
2	Floating capsule	Chlordiazepoxide HCL, Diazepam, Furosemide, L-DOPA, Benserazide, Nicardipine, Misoprostol, Propranolol, Pepstain.
3	Floating microcapsule	Aspirin, Griseofulvin, P-Nitro Aniline, Ibuprofen, Terfenadine, Tranilast.
4	Floating granules	Diclofenac sodium, Indomethacin, Prednisolone.
5	Powders	Several basic drugs.

Table 2. Commercially available marketed products.

Brand name	Drugs	Dosage forms	Dose	Company
Cifran O. D	Ciprofloxacin	Tablet	500 mg and 1 gm	Ranbaxy, India.
Liquid Gavison	Al hydroxide and Mg carbonate	Liquid	95 mg and 358 mg, respectively	GlaxoSmithKline, India.
Madopar	Levodopa and Benserazide	Capsule	100 mg and 25 mg, respectively	Roche Products, USA.
Glumetza	Metformin hydrochloride	Tablet	500 mg and 1000 mg	Depomed, Canada.
Valrelease	Diazepam	Capsule	15 mg	F. Hoffmann-La Roche Ltd, USA.
Topalkan	Aluminium 7& agnesium antacids	Liquid alginate	–	Pierre Fabre Drug, France.
Cytotec	Misoprostal	Bilayer capsule	100 mcg/200 mcg	Pharmacia, USA.
Convion	Ferrous sulphate	Colloidal gel	–	Ranbaxy, India.
Oflin OD	Ofloxacin	Tablet	400 mg	Ranbaxy, India.

CONCLUSION

Current scientific evidence indicates that gastro-retentive drug delivery provides a highly effective strategy for optimizing therapeutic compounds characterized by restricted bioavailability. By anchoring the dosage form within the stomach, this approach successfully overcomes the limitations of medications whose absorption is strictly confined to the upper segments of the gastrointestinal tract. In addition, their delivery may be optimized to maximize absorption and improve total bioavailability as well. Pharmacies with a limited absorption window close to the stomach can be delivered most effectively using gastro-retentive drug delivery methods. Research is still ongoing because of the variety of FDDS methods that have been created for gastro retentive drug administration. These methods include single and multiple unit HBS, gas producing systems, hollow microspheres, and raft forming systems. Each method has its own benefits and limitations.

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REFERENCES

1. Vinchurkar K, Sainy J, Khan MA, Mane S, Mishra DK, Dixit P. Features and facts of a gastro retentive drug delivery system—a review. *Turk J Pharm Sci.* 2021 Jun;19(4).
2. Jassal M, Nautiyal U, Kundlas J, Singh D. A review: Gastro retentive drug delivery system (GRDDS). *Indian J Pharm Biol Res.* 2015 Mar;3(1).
3. Dividevara S, Kumar KN, Preethi K. Gastro retentive drug delivery system: A review. *Int J Res Pharm Chem.* 2020 Apr;10(1).
4. Krishna, Kumar A, Srivastava R. In vitro in vivo studies on floating microspheres for gastro retentive drug delivery system: A review. *Asian J Pharm Clin Res.* 2020 Nov;14(1).
5. Khanam N, Alam MI, Mian SS, Srinivas N. A review on novel approaches incorporated in the formulation of gastro retentive drug delivery system. *Int J Pharm Biol Sci.* 2017 Jan;7(1).
6. Guyton AC. Movement of food through the alimentary tract. In: *Human Physiology and Mechanisms of Disease.* Vol. 3. London: W.B. Saunders Co.; 1982. p. 487–497.
7. Pant S, Badola A, Kothiyal P. A review on gastro retentive drug delivery system. *Int J Res Dev Pharm Life Sci.* 2016 Jul;5(4).
8. Garg AK, Kapoor G, Sachdeva RK. Formulation and evaluation of nizatidine floating tablets. *Am J PharmTech Res.* 2012 Oct;2(5).
9. Kesarla RS, Vora PA, Sridhar BK, et al. Formulation and evaluation of floating tablet of H2–receptor antagonist. *Drug Dev Ind Pharm.* 2015 Apr;41(4).
10. Kagan L, Hoffman A. Systems for region drug delivery in the gastrointestinal tract: Biopharmaceutical considerations. *Expert Opin Drug Deliv.* 2008 Jun;5(6).
11. Strübing S, Metz H, Mäder K. Characterization of poly(vinyl acetate)-based floating matrix tablets. *J Control Release.* 2008 Sep;126(2).
12. Khan F, Dehghan M. Enhanced bioavailability of atorvastatin calcium from stabilized gastric resident formulation. *AAPS PharmSciTech.* 2011 Dec;12(4).
13. Oth M, et al. The bilayer floating capsule: A stomach-directed drug delivery system for misoprostol. *Pharm Res.* 1992 Oct;9(3).
14. Streubel A, Siepmann J, Bodmeier R. Floating microparticles based on low density foam powder. *Int J Pharm.* 2002 Sep;241(2).
15. Singh BN, Kim KH. Floating drug delivery systems: An approach to oral controlled drug delivery via gastric retention. *J Control Release.* 2000 Nov;63(1–2).
16. Deshpande AA, Shah NH, Rhodes CT, et al. Controlled release drug delivery systems for prolonged gastric residence: An overview. *Pharm Res.* 1996 Jun;22(6).
17. Klausner EA, Lavy E, Friedman M, et al. Novel levodopa gastro retentive dosage form: In vivo evaluation in dogs. *J Control Release.* 2003 Mar;88(1).
18. Hoffman A, Stepensky D. Pharmacodynamic aspects of modes of drug administration for optimization of drug therapy. *Crit Rev Ther Drug Carrier Syst.* 1999 Aug;16(6).
19. Smolensky MH, Peppas NA. Chronobiology, drug delivery, and chronotherapeutics. *Adv Drug Deliv Rev.* 2007 Dec;59(9–10).
20. Roy P, Shahiwala A. Statistical optimization of ranitidine HCl floating pulsatile delivery system for chronotherapy of nocturnal acid breakthrough. *Eur J Pharm Sci.* 2009 Apr;37(6).
21. Pawar VK, Kansal S, Asthana S, et al. Industrial perspective of gastro retentive drug delivery system: Physiochemical, biopharmaceutical, technological and regulatory considerations. *Expert Opin Drug Deliv.* 2012 Jun;9(1).

22. Badoni A, Ojha A, Gnanarajani G, et al. Review on gastro retentive drug delivery system. *Pharma Innovation*. 2012 Feb;1(8).
23. Chien YW. *Novel Drug Delivery System*. p. 1–42.
24. Wilson CG, Washington N. The stomach: Its role in oral drug delivery. In: Rubinstein MH, editor. *Physiological Pharmaceutical: Biological Barriers to Drug Absorption*. Chichester (UK): Ellis Horwood; 1989. p. 47–70. <https://images.app.goo.gl/9vzecpbJkFRjcWj98>
25. Khar RK. *Controlled Drug Delivery: Gastro Retentive System*. 4th ed. p. 202–203.
26. Khan FN, Dehghan HG. *Int J Health Res*. 2009 Mar;2(1).
27. Kamalakkannan V, Puratchikody A, Prasanth VV, Masilamani K. Enhancement of drugs bioavailability by floating drug delivery system—a review. *Int J Drug Deliv*. 2011 Dec;1(1).
28. Suryawanshi A, Hiremath SP. Floating drug delivery system—a review. *Am J PharmTech Res*. 2011 Aug;2(1). www.google.com
29. Jain NK. *Advances in Controlled and Novel Drug Delivery*. New Delhi: CBS Publishers & Distributors; p. 76–95.
30. Brahmanekar DM. *Biopharmaceutics and Pharmacokinetics*. New Delhi: Vallabh Prakashan; p. 335–370.
31. Narang N. An updated review on floating drug delivery system (FDDS). *Int J Appl Pharm*. 2011 Feb;3(1).
32. Chandiran S, Kumar BP, Narayanan V. Formulation and in vitro evaluation of floating drug delivery system for salbutamol sulphate. *Int J Pharma Biomed Sci*. 2010 Apr;1(1).
33. Jain A. New concept: Floating drug delivery system. *Indian J Nov Drug Deliv*. 2011 Jun;3(3).
34. Geetha A, Rajendra K, Mohan CHK, Sateesh V, Raju PN. A review on floating drug delivery systems. *Int J Pharm Res Biomed Anal*. 2012 Jan;1(1). <https://images.app.goo.gl/4sAeZo6SPt8qSF9KA>
35. Sharma D, Sharma A. Gastro retentive drug delivery system: A mini review. *Asian Pac J Health Sci*. 2014 Mar;1(2).
36. Robinson J, Lee R. *Controlled Drug Delivery*. 2nd ed. 1987. p. 418.
37. Bardonnnet PL, Faivre V, Pugh WJ, Piffaretti JC, Falson F. Gastro retentive dosage forms. *J Control Release*. 2006 Aug;1:18.
38. Arora S, Javed A, Ahuja A, Khar RK, Baboota S. Floating drug delivery system: A review. *AAPS PharmSciTech*. 2000 Jun;6(3).
39. Patel GM, Patel HR, Patel M. Floating drug delivery system: An innovative approach to prolong gastric retention. *Pharmainfo.net*. 2007 Oct;4(1).