IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

Floating Tablets: A Novel Strategy for Prolonged Gastric Residence and Site-Specific Drug Delivery

Miss. Payal Gajanan Wade and Dr. Pankaj M. Pimpalshende
Hi-Tech College of Pharmacy, Morwa, Chandrapur, India

Abstract: *Oral drug delivery remains the most preferred route of administration due to its convenience, patient compliance, and cost-effectiveness. However, conventional oral dosage forms often face limitations, such as short gastric residence time and erratic absorption, especially for drugs with a narrow absorption window or poor stability in the intestinal environment. To overcome these challenges, gastroretentive drug delivery systems (GRDDS) have been developed to prolong gastric residence and improve drug bioavailability. Among these, floating tablets represent a promising strategy owing to their ability to remain buoyant on gastric fluids, thereby enhancing site-specific delivery and controlled drug release. Floating drug delivery systems (FDDS) are categorized into effervescent and non-effervescent systems based on their buoyancy mechanisms. Their formulation involves careful selection of drug candidates, polymers, gas-generating agents, and tablet technologies such as single-layer, bilayer, and multiparticulate systems. Various in vitro evaluation parameters, including buoyancy lag time, total floating duration, swelling index, and drug release profiles, are used to characterize these systems. Pharmacokinetic studies demonstrate improved bioavailability for several drugs delivered via floating tablets. Clinically, these systems have shown promise in the treatment of gastrointestinal disorders like peptic ulcers, GERD, and Helicobacter pylori infections. Recent advances include the use of novel biodegradable polymers, 3D printing techniques, and smart floating systems integrated with targeted and personalized drug delivery technologies. Despite physiological and manufacturing challenges, floating tablets continue to evolve as a reliable approach for enhanced therapeutic efficacy and patient-centric care in oral drug delivery.*

Keywords: Floating tablets, gastroretentive systems, effervescent systems, drug bioavailability, gastric retention, controlled release, 3D printing, smart drug delivery

I. INTRODUCTION

Oral drug delivery remains the most preferred and widely used route for the administration of therapeutic agents due to its convenience, patient compliance, cost-effectiveness, and ease of manufacturing. However, one of the major limitations of conventional oral dosage forms is their inability to retain in the stomach for a prolonged period, particularly for drugs that are absorbed primarily in the upper gastrointestinal (GI) tract or are unstable in the intestinal or colonic environment.

To address these limitations, gastroretentive drug delivery systems (GRDDS) have emerged as an effective approach. These systems are designed to prolong the gastric residence time of the dosage form, thereby enhancing the bioavailability of drugs with a narrow absorption window, increasing therapeutic efficacy, and reducing dosing frequency.

A key factor influencing the success of GRDDS is gastric residence time (GRT). The longer the dosage form remains in the stomach, the better the opportunity for the drug to be absorbed at its optimal site. Gastric emptying is a complex and variable process, affected by physiological factors such as gastric motility, pH, and the presence of food. Therefore, strategies that can retain the dosage form in the stomach, even during fasting conditions, are highly desirable.

Among the various GRDDS, floating drug delivery systems (FDDS)—commonly referred to as floating tablets—offer a promising solution. These systems are formulated to have a lower density than gastric fluids, allowing them to float on the stomach contents and resist gastric emptying for extended periods. By maintaining their position in the stomach,

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

floating tablets can provide controlled and site-specific drug delivery, improving the pharmacokinetic and pharmacodynamic profiles of many drugs.

This review aims to provide a comprehensive overview of floating tablets, focusing on their formulation design, mechanisms of floatation, evaluation parameters, clinical applications, and recent advances. The article also discusses the challenges and future prospects associated with this innovative gastroretentive approach.

II. GASTRORETENTIVE DRUG DELIVERY SYSTEMS (GRDDS)

Oral drug delivery is often hindered by the rapid transit of dosage forms through the gastrointestinal (GI) tract, especially for drugs that are preferentially absorbed in the stomach or upper small intestine. To address these challenges, **Gastroretentive Drug Delivery Systems (GRDDS)** have been developed with the primary objective of prolonging the gastric residence time (GRT) of dosage forms. These systems ensure that the drug remains in the stomach for a sufficient duration to achieve desired therapeutic outcomes.

III. TYPES OF GRDDS

Several strategies have been developed to enhance gastric retention, categorized based on the mechanism by which they achieve prolonged GRT:

1. Floating Systems (Low-Density Systems)

Floating Drug Delivery Systems (FDDS) are designed to remain buoyant on the gastric fluid without affecting gastric emptying. These systems float due to their lower density compared to gastric fluids (approximately 1.004 g/cm³).

- **Types:**
  - **Effervescent Systems:** Contain gas-generating agents like sodium bicarbonate and citric acid that produce CO_2 upon contact with gastric fluid, creating buoyancy.
  - **Non-Effervescent Systems:** Use swellable polymers (e.g., HPMC, xanthan gum) that form a gel barrier to entrap air and maintain floatation.

2. Bioadhesive (Mucoadhesive) Systems

These systems adhere to the gastric mucosa using bioadhesive polymers, thereby preventing the dosage form from leaving the stomach.

- **Common Polymers Used:** Carbopol, chitosan, polycarbophil, and hydroxypropyl methylcellulose (HPMC).
- **Mechanism:** Interaction between the mucin layer and the bioadhesive polymer through hydrogen bonding, electrostatic forces, or van der Waals interactions.

3. Swelling and Expanding Systems

These dosage forms swell or expand upon contact with gastric fluids to a size that prevents them from passing through the pyloric sphincter.

- **Mechanism:** Utilization of superdisintegrants or swellable hydrophilic polymers that increase the size of the dosage form.
- **Advantages:** Simple design and effective mechanical retention.
- **Caution:** Risk of gastric obstruction if not formulated properly.

4. High-Density Systems

These systems sink to the bottom of the stomach and remain in the gastric region due to their higher density (>1.5 g/cm³).

- **Materials Used:** Barium sulfate, zinc oxide, iron powder, titanium dioxide.
- **Limitation:** Must maintain sufficient density throughout the gastric retention period; otherwise, the system may leave the stomach prematurely.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

Advantages of GRDDS

- **Improved Bioavailability:** Especially for drugs with a narrow absorption window in the upper GI tract (e.g., levodopa, riboflavin).
- **Reduced Dosing Frequency:** Sustained and controlled drug release extends therapeutic effects.
- **Better Patient Compliance:** Less frequent dosing and improved efficacy enhance adherence.
- **Localized Drug Delivery:** Ideal for drugs intended to act locally in the stomach (e.g., antacids, antibiotics for H. pylori).
- **Minimized Fluctuations in Drug Levels:** Maintains steady plasma concentrations.

Limitations of GRDDS

- **Variability in Gastric Emptying Time:** Affected by food, pH, and individual physiology, which may affect dosage form retention.
- **Unsuitable for Certain Drugs:** Not ideal for drugs that are poorly soluble or unstable in gastric fluids, or those primarily absorbed in the colon.
- **Risk of Dose Dumping:** Especially with floating systems if floatation fails.
- **Formulation Challenges:** Requires careful selection of polymers, excipients, and balancing of floatation/swelling properties.
- **Potential for Gastric Irritation:** Prolonged retention may irritate the gastric mucosa.

IV. FLOATING DRUG DELIVERY SYSTEMS (FDDS)

Floating Drug Delivery Systems (FDDS) are a specialized category of gastroretentive drug delivery systems designed to prolong the gastric residence time of dosage forms. The key principle behind FDDS is their **lower density than gastric fluids**, which allows them to float on the surface of the stomach contents. This floating behavior ensures that the drug remains in the upper gastrointestinal tract for an extended duration, allowing for sustained and site-specific drug release.

4.1 Classification of FDDS

Floating drug delivery systems can be broadly classified into two main types based on their mechanism of floatation:

A. Effervescent Systems

Effervescent FDDS utilize gas-generating agents that react with gastric fluid to produce carbon dioxide (CO_2), which is entrapped within the dosage form to reduce its density and achieve buoyancy.

1. Gas-Generating Systems

These systems typically contain combinations of acid and base components such as:

- **Sodium bicarbonate**
- **Citric acid**
- **Tartaric acid**

Mechanism: Upon contact with gastric fluid, the acid-base reaction generates CO_2, which gets trapped in the gel matrix formed by hydrophilic polymers (e.g., HPMC, carbopol). The entrapped gas lowers the density of the system and allows it to float.

Advantages:

- Rapid buoyancy (short floating lag time)
- Suitable for controlled drug release

2. Volatile Liquid-Containing Systems

These contain **volatile, low-boiling point liquids** (e.g., ether, cyclopentane) that vaporize at body temperature and create internal pressure, helping the system float.

Formulation Example: Sealed hollow microspheres or chambers filled with volatile liquid. Upon warming in the stomach, the liquid vaporizes and causes the dosage form to become buoyant.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

Limitation: Handling and encapsulation of volatile compounds can be challenging, and system integrity must be carefully maintained.

B. Non-Effervescent Systems

These systems achieve floatation by swelling in gastric fluid to form a viscous, cohesive gel barrier that traps air and decreases the overall density of the dosage form.

1. Hydrodynamically Balanced Systems (HBS)

These are single-unit dosage forms that include gel-forming agents like **hydroxypropyl methylcellulose (HPMC)**, **methylcellulose**, and **polyethylene oxide**.

Mechanism: Upon contact with gastric fluid, these polymers hydrate and swell to form a gelatinous layer that helps the tablet remain buoyant for an extended period.

Advantages:

- Simple design
- Extended floatation time
- Consistent drug release

2. Matrix-Forming Systems

These involve embedding the drug in a swellable matrix made of polymers such as **xanthan gum**, **carbopol**, or **ethyl cellulose**.

Mechanism: The matrix swells upon hydration, maintaining its shape and buoyancy. The drug is released in a controlled manner through diffusion and erosion mechanisms.

Variants:

- Single-layer tablets
- Bilayer or multilayer tablets (to separate drug from effervescent components or control release rate)

4.2 Mechanism of Floatation

The fundamental principle behind Floating Drug Delivery Systems (FDDS) is the ability of the dosage form to remain buoyant on the gastric contents for a prolonged period, thereby improving gastric retention and facilitating site-specific drug delivery. This is achieved through the interplay of **density control**, **gas entrapment**, and **gastric motility dynamics**.

Low-Density Principle

The floatation of FDDS primarily relies on the density of the dosage form being **lower than that of gastric fluids**, which is approximately **1.004 g/cm³**.

- **Formulation Strategy:** By incorporating **low-density polymers**, **gas-generating agents**, or **hollow structures**, the bulk density of the dosage form is reduced.
- **Outcome:** A dosage form with a density lower than gastric fluid floats on the surface of stomach contents, resisting peristaltic movement and gastric emptying.

This low-density characteristic can be maintained either by:

- Entrapping generated gases within a **hydrophilic polymeric matrix**, or
- Using **hollow microspheres**, **air-entrapped capsules**, or **expandable materials**.

Buoyancy Forces and Gastric Motility

Role of Gastric Motility

- Gastric motility includes phases of **migrating myoelectric complex (MMC)**, which influences the movement of dosage forms in the GI tract.
- **During the fasting state**, the MMC sweeps residual contents through the GI tract; however, **floating systems are designed to resist these movements** due to their buoyancy.
- In the **fed state**, gastric emptying is delayed, and floating dosage forms can remain in the stomach for a longer duration, particularly if they avoid sinking or premature disintegration.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

The effectiveness of FDDS is directly related to its ability to generate and maintain sufficient buoyant force to counteract gravity and withstand gastric motility. This requires careful formulation design using appropriate polymers, gas-generating agents, and matrix structures to ensure low density and prolonged floatation.

V. FORMULATION ASPECTS OF FLOATING TABLETS

Formulating effective floating tablets requires a strategic approach that incorporates appropriate drug selection, excipient compatibility, and dosage form design to ensure prolonged gastric retention and controlled drug release. The success of a floating tablet depends not only on its buoyancy but also on its mechanical strength, stability, and consistent drug release profile.

5.1 Selection of Drug Candidates

Not all drugs are suitable for inclusion in floating drug delivery systems. The following **criteria** are typically considered:

- **Narrow absorption window**: Drugs that are primarily absorbed in the stomach or upper part of the small intestine (e.g., levodopa, furosemide).
- **Poor colonic absorption**: Drugs that are unstable or poorly absorbed in the colon benefit from prolonged gastric retention.
- **Stability in acidic pH**: The drug should remain stable in the acidic environment of the stomach (pH 1.2–3.5).
- **Good solubility in gastric fluids**: Adequate dissolution is essential for effective absorption.
- **Targeting local gastric conditions**: Useful for drugs acting locally in the stomach (e.g., antacids, antibiotics for H. pylori infection).

5.2 Excipients Used in Floating Tablets

Excipients play a crucial role in ensuring floatation, swelling, matrix formation, and sustained release.

1. Polymers (Matrix Formers / Gel Formers):

These are responsible for forming a swellable and cohesive gel layer upon hydration, which traps air or gas and reduces tablet density.

- **Hydroxypropyl methylcellulose (HPMC)**: Most commonly used for controlled release and gel formation.
- **Carbopol 934P**: Provides high viscosity and mucoadhesive properties.
- **Xanthan gum, Guar gum**: Natural polymers used for matrix formation and swelling.
- **Ethyl cellulose**: Used as a hydrophobic matrix or coating polymer.

2. Effervescent Agents:

These are incorporated to generate carbon dioxide upon contact with gastric fluid, helping the tablet float.

- **Sodium bicarbonate**
- **Citric acid**
- **Tartaric acid**
- Often used in a fixed ratio to control gas generation and floating lag time.

3. Fillers, Binders, Lubricants, and Other Additives:

- **Fillers**: (e.g., lactose, microcrystalline cellulose) used to adjust tablet size and density.
- **Binders**: (e.g., PVP, starch paste) improve tablet cohesiveness.
- **Lubricants**: (e.g., magnesium stearate, talc) reduce friction during compression.
- **Pore formers or swelling agents**: Improve floatation and drug release (e.g., sodium starch glycolate, crospovidone).

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

5.3 Tablet Technologies

Several designs are used to develop floating tablets based on the intended release profile and formulation requirements:

1. Single-Layer Tablets:

- Simplest form, where all ingredients are compressed into a single matrix.
- Suitable for immediate to moderately sustained drug release.
- May contain both gas-generating agents and matrix-forming polymers.

2. Bilayer and Multilayer Tablets:

- Designed to **separate incompatible components** or **control release in multiple phases**.
- One layer may contain the drug, while another contains floating agents.
- Allows sequential release or dual drug loading.

3. Multiparticulate Systems:

- Composed of small floating units (e.g., **microspheres**, **beads**, **granules**).
- Distribute uniformly in the stomach and reduce variability in gastric emptying.
- Offer greater surface area, improved absorption, and more predictable drug release. The formulation of floating tablets requires a delicate balance between buoyancy, drug release kinetics, and mechanical integrity. Proper selection of drug and excipients, along with the appropriate technology, ensures enhanced gastric retention and improved therapeutic efficacy.

VI. EVALUATION AND CHARACTERIZATION OF FLOATING TABLETS

A comprehensive evaluation of floating tablets is essential to ensure their quality, efficacy, and performance in terms of floatation and drug release. The characterization studies are broadly categorized into **precompression** and **post compression** parameters, with specific focus on **buoyancy**, **release kinetics**, and **stability**.

6.1 Precompression Parameters

These tests assess the flow and compressibility characteristics of the powder blend before tablet formation:

- **Angle of Repose**: Indicates flowability of the powder; a value below 30° typically suggests good flow.
- **Bulk Density and Tapped Density**: Used to calculate compressibility index and Hausner's ratio.
- **Carr's Index and Hausner's Ratio**: Predict compressibility; values <15% (Carr's Index) and <1.25 (Hausner's Ratio) indicate good flow and packing properties.

6.2 Postcompression Parameters

After tablet compression, various quality control parameters are evaluated:

- **Hardness (Crushing Strength)**: Measures mechanical strength; typically in the range of 4–8 kg/cm².
- **Friability**: Determines tablet resistance to abrasion using a friabilator; acceptable limit is <1%.
- **Weight Variation**: Ensures uniformity of tablet weight as per pharmacopeial limits.
- **Thickness and Diameter**: Measured using a vernier caliper to ensure uniformity.
- **Drug Content Uniformity**: Confirms the amount of active drug in each tablet is within specified limits.

6.3 Buoyancy Studies

Key characteristic tests for floating tablets:

- **Floating Lag Time (FLT)**:
  - Time taken for the tablet to rise to the surface of the medium.
  - Ideal FLT is less than 1 minute.
- **Total Floating Time (TFT)**:
  - Duration the tablet remains buoyant on gastric fluids.
  - Desired floating time is typically >8–12 hours.

These are tested in **simulated gastric fluid (pH 1.2)** using USP dissolution apparatus.

6.4 In Vitro Drug Release Studies

- Conducted using **USP dissolution apparatus (Type II – Paddle method)** in 900 mL of 0.1N HCl (pH 1.2) at 37 ± 0.5 °C.

DOI: 10.48175/568

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

- Samples are withdrawn at specific time intervals and analyzed (e.g., by UV spectrophotometry).
- Data analyzed for **release kinetics** (e.g., zero-order, first-order, Higuchi, Korsmeyer-Peppas models) to understand drug release mechanisms.

6.5 Swelling Index

- Evaluates the swelling behavior of tablets over time.
- Tablets are weighed before and after immersion in 0.1N HCl at different time intervals.
- Swelling Index (%) is calculated as:

Swelling Index=Wt−W0W0×100\text{Swelling Index} = \frac{W_t - W_0}{W_0} \times 100Swelling Index=W0Wt −W0×100

where WtW_tWt = weight at time t, W0W_0W0 = initial weight.

- Reflects polymer hydration and matrix integrity.

6.6 Stability Studies

- Conducted as per **ICH guidelines** (e.g., 40 °C ± 2 °C / 75% RH ± 5% RH for accelerated conditions).
- Evaluated for:
  - Physical appearance
  - Drug content
  - Buoyancy parameters
  - In vitro release profile
- Ensures long-term performance and shelf-life of the product.

Robust evaluation and characterization confirm the functionality and reliability of floating tablets. These parameters guide formulation optimization and ensure consistent therapeutic efficacy.

VII. PHARMACOKINETIC AND PHARMACODYNAMIC CONSIDERATIONS

Floating tablets are specifically designed to **prolong gastric residence time**, enhance **site-specific delivery**, and improve **bioavailability** of drugs with absorption windows limited to the upper gastrointestinal tract. Their pharmacokinetic (PK) and pharmacodynamic (PD) advantages over conventional oral dosage forms make them a promising platform in targeted therapy.

7.1 Impact on Drug Bioavailability

The enhancement of **oral bioavailability** is a key goal of floating drug delivery systems (FDDS), especially for drugs with:

- **Narrow absorption windows** in the stomach or upper intestine
- **Instability in alkaline pH**
- **Poor solubility at higher pH**
- **Short biological half-life requiring frequent dosing**

Floating tablets improve bioavailability by:

- Maintaining the drug at its **optimal absorption site** for a longer period.
- Ensuring **controlled and prolonged release**, leading to more stable plasma concentration-time profiles.
- Minimizing the **first-pass metabolism** for drugs absorbed in the stomach.

7.2 Gastric Retention Time and Site-Specific Delivery

FDDS prolongs gastric retention time by:

- Avoiding premature emptying of the dosage form into the intestine.
- Floating in the gastric contents due to low density, especially during the **fasted state** where MMC (Migrating Myoelectric Complex) governs gastric motility.

Site-specific delivery is particularly useful for:

- **Local gastric treatment** (e.g., for ulcers, gastritis)
- **Eradication of H. pylori** using antibiotics

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

- **Drugs absorbed primarily in the stomach or upper intestine**

Key factors influencing gastric retention:

- **Density and size** of the tablet
- **Fed vs fasted state**
- **Posture and motility pattern** of the stomach

7.3 Examples of Marketed and Experimental Drugs

Several drugs have been developed into floating tablet formulations to exploit their site-specific advantages:

Drug	Indication	Formulation Status
Ciprofloxacin	Bacterial infections	Marketed floating tablet (India)
Metformin HCl	Type 2 diabetes mellitus	Floating formulation (investigational and commercial)
Ranitidine	Gastric ulcers	Floating tablet (investigational)
L-Dopa + Carbidopa	Parkinson's disease	Floating microspheres (experimental)
Domperidone	Gastroesophageal reflux	Floating granules and tablets (research)
Gabapentin	Neuropathic pain	Floating controlled-release tablet (research)
Furosemide	Hypertension, edema	Floating bilayer tablet (investigational)

Floating tablets offer significant pharmacokinetic and pharmacodynamic benefits, particularly for drugs with limited absorption windows or localized gastric activity. Their ability to enhance **bioavailability**, **targeted delivery**, and **therapeutic effectiveness** makes them an attractive alternative in oral controlled release systems.

VIII. CLINICAL APPLICATIONS

Floating tablets have been successfully applied in clinical settings to address challenges associated with conventional oral drug delivery systems. Their ability to **prolong gastric residence time** and offer **controlled, site-specific drug delivery** makes them particularly effective in treating gastric and duodenal conditions, improving drug absorption, and enabling time-dependent (chronotherapeutic) treatments.

8.1 Treatment of Peptic Ulcer, GERD, and *Helicobacter pylori* Infection

Floating tablets are especially useful in managing **gastric pathologies**, where localized action in the stomach enhances therapeutic efficacy:

- **Peptic Ulcer Disease (PUD)**:
  - Drugs like **ranitidine**, **famotidine**, and **sucralfate** benefit from prolonged stomach retention.
  - Localized delivery promotes ulcer healing and reduces dosing frequency.
- **Gastroesophageal Reflux Disease (GERD)**:
  - Floating systems can release **prokinetic and acid-suppressing agents** such as **domperidone** and **omeprazole** gradually, reducing nighttime acid breakthrough and improving symptom control.
- **Helicobacter pylori Eradication**:
  - Prolonged gastric retention enhances the efficacy of antibiotics like **clarithromycin**, **amoxicillin**, and **metronidazole**, improving contact time at the site of infection.

8.2 Enhanced Bioavailability of Drugs with Narrow Absorption Windows

Certain drugs are primarily absorbed in the upper gastrointestinal tract and have poor absorption beyond the duodenum. Floating tablets improve their **bioavailability** by maintaining the drug in the absorption zone for extended periods:

- **Examples**:
  - **Levodopa** (Parkinson's disease)
  - **Gabapentin** (Neuropathic pain)
  - **Metformin HCl** (Diabetes)
  - **Furosemide** (Edema, hypertension)

Such drugs, when formulated as floating tablets, show improved **plasma concentrations**, **reduced dosing frequency**, and **improved patient compliance**.

DOI: 10.48175/568

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

8.3 Chronotherapy Using Floating Systems

Chronotherapy involves timing drug release according to **biological rhythms** of disease symptoms, which may vary throughout the day:

- **Floating tablets** can be designed to:
  - Release drugs at specific times (e.g., overnight or early morning).
  - Synchronize drug release with disease peak symptoms (e.g., **morning acid reflux**, **nocturnal asthma**, **early morning hypertension**).
- **Example Applications**:
  - **Night-time dosing of antihypertensives** or **NSAIDs** to counter early-morning symptom peaks.
  - **Floating matrix tablets of verapamil** or **propranolol** with extended release profiles for improved circadian alignment.

Floating tablets represent a clinically valuable approach in managing both localized gastric conditions and systemic diseases requiring prolonged and site-specific drug delivery. Their utility in **peptic disorders**, **drug absorption optimization**, and **chronotherapeutic applications** underscores their growing importance in personalized and efficient pharmacotherapy.

IX. CHALLENGES AND LIMITATIONS

Despite the numerous advantages of floating tablets in enhancing drug bioavailability and achieving site-specific delivery, several **technical and physiological limitations** hinder their universal applicability. These challenges must be carefully addressed during formulation development, clinical evaluation, and commercial manufacturing.

9.1 Variability in Gastric Emptying

- Gastric retention time is **highly variable** among individuals and even within the same individual at different times.
- The **migrating myoelectric complex (MMC)** in the fasted state can cause the abrupt emptying of dosage forms.
- If the floating tablet is not buoyant quickly enough (i.e., has a long **floating lag time**), it may pass into the intestine before becoming effective.
- This variability can **compromise therapeutic consistency** and **drug bioavailability**.

9.2 Influence of Physiological Conditions

Several physiological factors significantly influence the **buoyancy and retention** of floating tablets:

- **Food intake**:
  - A fed stomach delays gastric emptying and supports retention.
  - In contrast, in the **fasted state**, tablets may be rapidly cleared.
- **Posture and body position**:
  - Supine position may reduce floating efficacy.
  - Gastric transit time can differ in sitting, standing, or lying down.
- **Gastric motility and pH**:
  - Patients with gastrointestinal disorders (e.g., gastroparesis) may experience **unpredictable drug release**.
  - The **pH-dependent solubility** of certain drugs can be affected by these variations.

9.3 Scalability and Manufacturing Constraints

Formulating floating tablets at an industrial scale presents **technical challenges**:

- **Balancing buoyancy and mechanical strength**:
  - High porosity and low density required for floating may compromise **tablet hardness**, **friability**, and **shelf life**.
- **Reproducibility of performance**:

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

- Ensuring consistent **floating lag time**, **drug release profiles**, and **tablet uniformity** in large batches can be difficult.

- **Complex formulation techniques**:
  - Multilayered, matrix, or gas-generating systems may require **specialized equipment** and **cost-intensive processes**.
- **Stability concerns**:
  - Effervescent components (e.g., citric acid, sodium bicarbonate) are sensitive to **moisture** and **temperature**, posing challenges in packaging and storage.

While floating tablets are a promising solution for site-specific drug delivery, addressing their limitations related to **gastric variability**, **physiological influences**, and **formulation complexity** is crucial. Overcoming these barriers through innovative formulation design and patient-centric approaches will enable wider clinical and commercial success.

X. RECENT ADVANCES AND FUTURE PERSPECTIVES

Floating tablets have seen substantial progress in recent years due to advancements in **materials science**, **drug delivery technologies**, and **personalized medicine**. These innovations are enhancing the performance, reliability, and clinical relevance of gastroretentive systems.

10.1 Novel Polymers and Biodegradable Materials

- **Smart polymers** with **pH-responsive**, **mucoadhesive**, and **bioerodible** properties are being explored to improve **buoyancy**, **drug release control**, and **biocompatibility**.
- **Natural and biodegradable polymers** like **chitosan**, **pectin**, and **xanthan gum** are gaining popularity due to their **non-toxicity**, **biodegradability**, and **environmental friendliness**.
- **Polymer blends** are being designed to achieve **tailored drug release profiles** and **mechanical strength** while ensuring effective floating properties.

10.2 3D Printing of Floating Tablets

- **Additive manufacturing (3D printing)** enables **precise control** over tablet geometry, porosity, and drug distribution, which is vital for floating systems.
- This technique facilitates the production of **complex multilayer or compartmentalized tablets**, enhancing **drug loading**, **release kinetics**, and **buoyancy control**.
- **Personalized 3D-printed floating tablets** allow for **dose customization**, particularly useful for drugs with narrow therapeutic indices or pediatric/geriatric populations.

10.3 Smart Floating Systems and Targeted Delivery

- **Intelligent delivery systems** are being developed using **responsive polymers** and **sensor-based mechanisms** that can respond to **pH**, **enzymes**, or **gastric motility**.
- Systems incorporating **magnetically responsive materials** or **microelectromechanical systems (MEMS)** can improve **positional control** and **targeted delivery** to specific sites in the stomach.
- **Floating-in-situ gels** and **nanoparticle-loaded floating platforms** offer hybrid solutions with enhanced control and bioavailability.

10.4 Future Directions in Personalized Medicine

- Integration of **floating drug delivery with pharmacogenomics** and **AI-based modeling** can pave the way for **personalized therapy**, optimizing drug type, dose, and release rate based on individual gastric physiology.
- Future systems may utilize **real-time feedback** from ingestible sensors to dynamically adjust drug release or send alerts to healthcare providers.
- Regulatory and manufacturing frameworks must evolve to support **customized gastroretentive technologies** at scale.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

The future of floating tablet technology is aligned with the global shift toward **precision medicine**, **advanced manufacturing**, and **eco-friendly materials**. Continued research into smart systems, novel excipients, and individualized treatment strategies will shape the next generation of gastroretentive drug delivery.

XI. CONCLUSION

Floating tablets represent an innovative and effective approach to prolonging gastric residence time and enhancing the bioavailability of orally administered drugs. Through the strategic use of polymers, gas-generating agents, and advanced formulation techniques, these systems offer site-specific delivery, reduced dosing frequency, and improved patient adherence. Although challenges such as variability in gastric emptying and scalability persist, recent advances—particularly in smart materials and 3D printing—highlight the growing potential of this technology in modern pharmaceutics. Continued research and development will pave the way for highly personalized and efficient floating drug delivery systems in the near future.

REFERENCES

[1]. **Mohan, S., & Choudhury, P. K.** (2011). Gastroretentive drug delivery systems: An overview. Asian Journal of Pharmaceutics, 5(1), 35-39.
[2]. **Jain, S., & Sharma, S.** (2014). Floating drug delivery systems: A review. International Journal of Pharmaceutical Sciences and Research, 5(9), 3482-3493.
[3]. **Singh, B., & Kim, J.** (2000). Floating drug delivery systems: An approach to oral controlled drug delivery via gastric retention. Journal of Controlled Release, 63(3), 235-259.
[4]. **Jain, S., & Jain, N.** (2006). Gastroretentive drug delivery systems: A review. Asian Journal of Pharmaceutical Sciences, 1(1), 52-60.
[5]. **Chandel, A., & Shukla, S.** (2013). Floating drug delivery system: A review. International Journal of Research in Pharmaceutical and Biomedical Sciences, 4(1), 7-11.
[6]. **Patel, M. M., & Patel, N. M.** (2010). Development and evaluation of gastroretentive floating drug delivery systems: A review. Journal of Advanced Pharmaceutical Technology & Research, 1(1), 15-23.
[7]. **Sankpal, S. D., & Dhanraj, P. K.** (2012). Floating drug delivery system: A review. International Journal of PharmTech Research, 4(3), 1106-1115.
[8]. **Chourasia, M. K., & Jain, S. K.** (2004). Gastroretentive drug delivery systems. Critical Reviews in Therapeutic Drug Carrier Systems, 21(3), 327-358.
[9]. **Hwang, S. J., & Park, H. J.** (2001). Gastroretentive floating drug delivery systems. Critical Reviews in Therapeutic Drug Carrier Systems, 18(2), 267-289.
[10]. **Bodmeier, R., & McGinity, J. W.** (1997). Floating dosage forms: An approach to oral controlled drug delivery. Pharmaceutical Technology, 11(4), 23-34.
[11]. **Matsumoto, M., & Ohtani, Y.** (1997). Preparation of floating tablets for controlled drug release. Journal of Pharmaceutical Sciences, 86(3), 370-375.
[12]. **Jain, S., & Jain, N.** (2004). Controlled drug delivery: Concepts and advances. Pharmaceutical Technology, 4(5), 54-65.
[13]. **Rao, M. E., & Gupta, P. R.** (2004). Design and evaluation of gastroretentive drug delivery systems. Journal of Controlled Release, 95(2), 245-260.
[14]. **Chourasia, M. K., & Jain, D.** (2008). Development and evaluation of floating drug delivery systems: A review. Journal of Controlled Release, 101(2), 224-240.
[15]. **Sharma, S., & Sharma, N.** (2012). Floating drug delivery systems: Recent advancements. International Journal of Drug Development and Research, 4(2), 44-59.
[16]. **Jani, G., & Singh, K.** (2016). Formulation and evaluation of floating drug delivery systems: A review. International Journal of Pharmaceutical Sciences and Research, 7(12), 4802-4814.
[17]. **Patel, V., & Patel, M.** (2013). Design and evaluation of floating drug delivery systems for sustained drug delivery. Journal of Pharmaceutics, 2013, Article ID 524093.

DOI: 10.48175/568

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

[18]. Kumar, S., & Bansal, M. (2012). Floating drug delivery systems: An overview. Journal of Pharmaceutics and Pharmacology, 64(4), 480-495.

[19]. Chandel, A., & Sharma, S. (2014). Floating drug delivery system: Recent advances. World Journal of Pharmacy and Pharmaceutical Sciences, 3(7), 1027-1041.

[20]. Harris, D., & Ho, Y. L. (2015). Design and evaluation of floating tablet for controlled release of acetaminophen. International Journal of Pharma and Bio Sciences, 6(1), 297-305.

[21]. Tiwari, G., & Yadav, S. (2012). Floating drug delivery system: A recent review. Asian Journal of Pharmaceutics, 6(3), 145-151.

[22]. Srinivas, M., & Desai, M. (2006). Gastroretentive floating drug delivery systems: A review. Indian Journal of Pharmaceutical Sciences, 68(6), 761-769.

[23]. Mishra, D., & Soni, S. (2006). Floating drug delivery system: A new approach for controlled drug delivery. Journal of Pharmacy and Bioallied Sciences, 3(2), 81-90.

[24]. Patel, M., & Patel, N. (2014). Gastroretentive floating drug delivery systems: An updated review. International Journal of Pharmaceutical Sciences and Research, 5(2), 32-47.

[25]. Sahu, P., & Bansal, A. (2015). A review on gastroretentive floating drug delivery systems. International Journal of Advanced Research in Pharmaceutical & Bio Sciences, 5(2), 97-104.

[26]. Gupta, M., & Sharma, R. (2015). Gastroretentive drug delivery systems: A review. Journal of Drug Delivery and Therapeutics, 5(2), 11-23.

[27]. Yadav, A., & Kumar, R. (2011). Floating drug delivery system: A novel approach. Pharmaceutical Review, 9(4), 123-132.

[28]. Patel, R., & Patel, M. (2010). Development and evaluation of floating tablets for controlled drug delivery. International Journal of Pharmaceutical Sciences and Research, 1(2), 61-70.

[29]. Mann, R. K., & Singh, J. (2007). Development of a floating drug delivery system for the controlled release of ranitidine. Drug Development and Industrial Pharmacy, 33(2), 181-187.

[30]. Kumar, R., & Prakash, S. (2013). Gastroretentive drug delivery systems: An overview. International Journal of Pharmaceutical Sciences and Research, 4(1), 1-12.

[31]. Hussain, R., & Choudhary, R. (2012). Floating drug delivery system: A brief review. International Journal of Pharmaceutical Sciences and Drug Research, 4(3), 132-137.

[32]. Verma, S., & Patel, M. (2016). Floating tablets: A strategy for controlled drug delivery. International Journal of Pharmaceutics, 506(1-2), 133-145.

[33]. Garg, R., & Gupta, S. (2014). Floating drug delivery system: A novel approach for controlled drug release. International Journal of Drug Development and Research, 6(3), 182-193.

[34]. Shah, V. P., & Tuan, L. T. (2009). Controlled drug delivery systems: Fundamentals and applications. Journal of Controlled Release, 133(1), 20-34.

[35]. Vemuri, S. S., & Lee, J. S. (2015). Gastroretentive floating systems: An efficient strategy for controlled drug delivery. Pharmaceutical Technology, 7(1), 45-55.

[36]. Yadav, A. K., & Gupta, P. R. (2013). Floating drug delivery systems: A review. International Journal of Pharmaceutical Sciences and Research, 4(4), 188-202.

[37]. Mishra, B., & Pandit, S. (2015). Formulation and evaluation of floating tablets of metformin hydrochloride for controlled drug delivery. International Journal of Pharmacy and Pharmaceutical Sciences, 7(1), 235-240.

[38]. Sreedhar, S., & Narmada, R. (2015). Floating drug delivery system: A recent approach. Journal of Drug Delivery and Therapeutics, 5(3), 48-56.

[39]. Patil, S. B., & Chaurasia, M. K. (2013). Gastroretentive floating drug delivery systems: Recent advancements. Journal of Controlled Release, 171(1), 125-139.

[40]. Singh, B. N., & Sahoo, S. K. (2017). Floating drug delivery systems: A comprehensive review on formulation techniques, applications

[41]. Mali, R. S., & Gupta, M. (2014). Development of floating drug delivery systems for controlled drug release. Indian Journal of Pharmaceutical Education and Research, 48(1), 18-22.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

[42]. Vyas, S. P., & Khar, R. K. (2002). Controlled drug delivery: Concepts and advances. CBS Publishers & Distributors.

[43]. Kumar, A., & Yadav, S. (2010). Development of floating tablets for controlled release of a model drug. International Journal of Pharmaceutical Sciences and Research, 1(1), 48-57.

[44]. Kaur, S., & Chawla, A. (2015). Floating drug delivery systems: Current strategies. Pharmaceutical Development and Technology, 20(1), 1-12.

[45]. Srinivasan, V., & Ramaswamy, R. (2015). Recent advances in gastroretentive floating drug delivery systems. Indian Journal of Pharmaceutical Education and Research, 49(2), 102-113.

[46]. Patel, M., & Patel, R. (2015). Floating drug delivery systems: A comprehensive review. International Journal of Pharmaceutical Sciences and Research, 6(6), 2374-2386.

[47]. Singh, B., & Arora, S. (2006). Floating drug delivery systems: An approach to oral controlled drug delivery via gastric retention. Pharmaceutical Technology, 18(4), 50-62.

[48]. Patel, P., & Patel, R. (2013). Development of floating tablets of ranitidine hydrochloride. International Journal of Pharmaceutical Sciences and Research, 4(1), 74-85.

[49]. Liu, J., & Hu, F. (2016). Floating drug delivery systems: An effective strategy for prolonging the gastric residence time of drugs. International Journal of Pharmaceutics, 514(1), 41-53.

[50]. Jain, D., & Mital, N. (2012). Development of floating tablets of aceclofenac. Asian Journal of Pharmaceutics, 6(2), 144-149.

[51]. Meena, S., & Kaur, G. (2013). Design and characterization of floating tablets for controlled release of diclofenac sodium. International Journal of Pharmacy and Pharmaceutical Sciences, 5(3), 137-144.

[52]. Pradeep, M., & Ghosh, A. (2014). Gastroretentive floating drug delivery systems: An overview. Indian Journal of Pharmaceutical Sciences, 76(3), 201-211.

[53]. Patil, R. S., & Dhole, S. R. (2013). Gastroretentive drug delivery systems: An overview. International Journal of Drug Development and Research, 5(1), 11-22.

[54]. Garg, R., & Gupta, S. (2008). Gastroretentive drug delivery systems: A review. International Journal of Pharmaceutics, 363(1-2), 1-10.

[55]. Chaudhary, S. A., & Kumar, S. (2015). Formulation and evaluation of floating tablets: An approach for controlled drug delivery. Pharmaceutical Sciences and Research, 7(4), 79-91.

[56]. Kumar, P., & Singh, N. (2015). Floating drug delivery system: A novel approach for controlled drug release. Journal of Drug Delivery and Therapeutics, 5(3), 46-55.

[57]. Patel, M., & Patel, N. (2012). Design and characterization of floating tablets of famotidine. Journal of Young Pharmacists, 4(4), 230-234.

[58]. Raza, K., & Kumar, A. (2015). Formulation and evaluation of floating tablets of metformin hydrochloride. International Journal of Pharmaceutical Sciences and Research, 6(3), 1145-1152.

[59]. Prajapati, S. K., & Mishra, P. (2012). Gastroretentive drug delivery systems: An overview. International Journal of Pharmaceutical Sciences and Drug Research, 4(5), 242-247.

[60]. Soni, G., & Yadav, V. (2015). Floating drug delivery systems: A controlled drug release system. International Journal of Pharmaceutical Sciences and Research, 6(12), 4745-4752.

[61]. Ranjan, S., & Choudhury, P. (2016). Floating drug delivery system: A comprehensive review. International Journal of Advanced Research in Pharmaceutical & Bio Sciences, 6(3), 101-109.

[62]. Shah, S., & Patel, R. (2014). Development and evaluation of floating drug delivery systems for sustained release. Journal of Advanced Pharmaceutical Research, 5(4), 170-176.

[63]. Mathur, R., & Koul, V. (2014). Recent advancements in floating drug delivery systems. Journal of Pharmacy and Pharmacology, 66(12), 1624-1635.

[64]. Kumar, D., & Singh, R. (2015). Design and evaluation of floating tablets of ranitidine hydrochloride. International Journal of Pharmaceutical and Biomedical Research, 6(4), 101-110.

[65]. Nivetha, S., & Pasha, S. K. (2016). A review on floating drug delivery systems: Challenges and advances. Journal of Pharmaceutical Sciences and Research, 8(4), 228-236.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 5, Issue 4, May 2025
Impact Factor: 7.67

[66]. Hussain, S., & Mehmood, A. (2013). Design and development of floating tablets. Journal of Pharmaceutical Sciences and Research, 5(2), 26-30.

[67]. Patel, D., & Gupta, P. (2014). Gastroretentive floating drug delivery systems. Asian Journal of Pharmaceutical Sciences, 9(2), 61-72.

[68]. Rathi, S., & Kadian, R. (2014). Floating drug delivery systems: Novel approaches. Asian Journal of Pharmaceutical and Clinical Research, 7(1), 17-23.

[69]. Saha, S., & Saha, S. (2014). Floating drug delivery systems: A controlled drug release system. International Journal of Pharmaceutics, 482(1-2), 1-10