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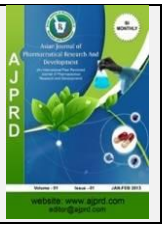

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Review Article

Gastro-Retentive Floating Drug Delivery System: A Comprehensive Review

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A B S T R A C T

Floating Drug Delivery Systems are an advanced gastroretentive approach designed to improve the bioavailability and therapeutic efficacy of drugs that have a narrow absorption window or are unstable in the intestinal environment. These systems remain buoyant in gastric fluids due to their low density or gas-generating mechanisms, allowing prolonged gastric retention and controlled drug release at the desired site. FDDS are broadly categorized into effervescent and non-effervescent systems, including bilayer tablets, raft-forming systems, and colloidal gel barrier formulations. Various formulation and physiological factors such as polymer type, tablet size, gastric motility, and fed or fasted state significantly influence the gastric retention time and drug release behavior. Among the preparation techniques, direct compression, wet granulation, and effervescent methods are widely employed. FDDS offer distinct advantages like enhanced bioavailability, reduced dosing frequency, and improved patient compliance, though they are unsuitable for drugs unstable in acidic media.

Key words: Floating drug delivery system, Gastroretentive, Controlled release, Bioavailability, Patient compliance.

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INTRODUCTION

Drug delivery systems are pure crude forms of drugs that can be solid, liquid, or semi-solid. They should be safe, effective, and stable enough to deliver the necessary quantity of the drug to the designated site in the body quickly, reach the right concentration, and then maintain the adjusted concentration. Oral medication delivery systems make up a large portion of the drug delivery systems that are sold.(1) Oral drug delivery is typically preferred due to its inexpensive treatment costs, easier administration, and higher patient compliance. The frequency of pharmaceutical dosing should be increased despite its many advantages because it is easily emptied from the stomach.(2)

In order to get beyond these obstacles, medication delivery needs to offer a longer period of stomach residency. Gastro retention helps to improve the time of medication release, boost bioavailability, reduce waste, and increase solubility of drugs that are less soluble in high ambient pH.(3) Due to their constant delay and regulation of release, many medications that are released in the stomach have the most therapeutic effect. Repeated dosing would not be necessary with this kind of drug delivery technique, which would also have relatively less adverse effects.(4)

Among various gastro-retentive approaches such as swelling, bioadhesive, high-density, and magnetic systems. The floating drug delivery systems (FDDS) have gained considerable attention. A floating tablet is a type of gastroretentive drug delivery system (GRDDS) that allows for regulated drug release and a longer gastric retention duration by staying afloat in gastric fluid for a long time. Low-density polymers or gas-generating compounds are used to create buoyancy, which keeps the tablet in place in the stomach by reacting with gastric fluids.(5) FDDS are low viscosity systems that float over the contents of the stomach for an extended amount of time without interfering with the gastric evacuation rate.(6) These are helpful for medications that are unstable in digestive fluids or not sufficiently absorbed. The medication is released from the system at a

regulated rate while the system is floating on the contents of the stomach. This eliminates the medication from the stomach after it has improved the gastric retention time, controlled the oscillations in the tube medicine attention, and reduced the remedial benefit of the medication substance.

Basic Gastrointestinal Tract Physiology and anatomy:

Stomach Anatomy (7)

The fundus, body, and antrum (pylorus) are the three anatomical divisions of the stomach.

1. **Fundus** - Proximal part.
2. **The body** - serves as a holding area for undigested material,
3. **The pylorus** - mixes the contents and propels activities to empty the stomach.

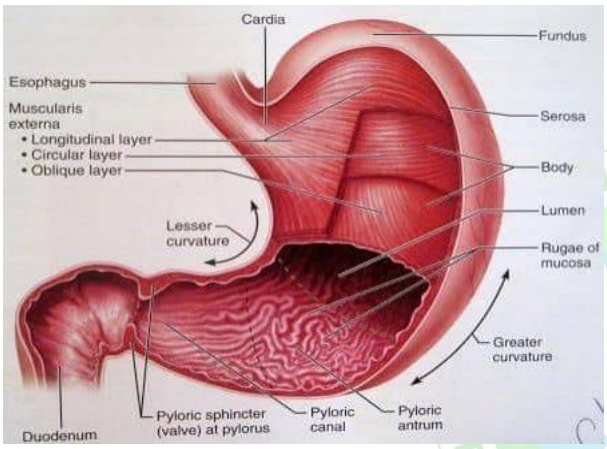

Figure1: Anatomy and physiology of gastrointestinal tract

Gastric motility (8,9)

An intricate network of hormonal and neurological signals regulates gastric motility. The parasympathetic (usually vagus caprice-whams) and sympathetic nervous systems, as well as the enteric nervous system, are the sources of nervous control. A wide range of hormones have been demonstrated to affect gastric motility; for example, gastrin and cholecystokinin both work to relax the proximal stomach and promote distal stomach condensation. The in vivo dissolving of the tablet form depends on the gastric volume. The stomach's resting volume is between 25 and 50 milliliters. Normal and achlorhydric individualities differ greatly in their stomach caching. The pH of the stomach has a noticeable impact on how well drugs are absorbed from the delivery method. When fasting, the stomach's pH ranges from 1.2 to 2.0, and when eaten, it ranges from 2.0 to 6.0.

Gastric empty rate

Both fasting and fed situations cause gastric evacuation. Both nations continue to have a different motility pattern. The interdigestive sequence of electrical events that occur during the fasting state cycles through the intestine and stomach every two to three hours. An acronym for this is the migrating myloelectric cycle (MMC) or interdigestive myloelectric cycle.(10)

The myloelectric migratory cycle (MMC), also known as the inter-digestive mylo-electric cycle, is further separated into four stages.

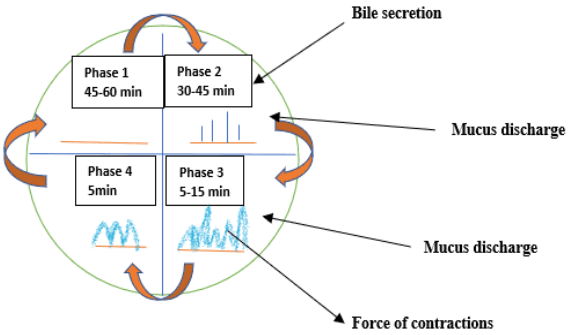

Figure 2: Myloelectric migratory cycle

1. **I phase** (Basal Phase) characterized by infrequent contractions, it lasts 40 to 60 minutes.
2. **Phase II** (preburst phase): characterized by sporadic contractions and action potentials, this period lasts 39 to 45 minutes.
3. **Phase III,** also known as the burst phase, lasts 5 to 15 minutes and is characterized by brief, strong contractions.
4. **Phase IV:** takes place in between phases III and I of two consecutive cycles and lasts 0 to 5 minutes. (11)

ADVANTAGES (12-14)

1. The oral bioavailability of medication is increased.
2. Improved bio-transformation in the initial drive.
3. Continuous drug administration and fewer doses.
4. The attention to tube medicine oscillates less.
5. Increased selectivity in receptor activation.
6. Provide superior efficacy because of the body's decreased counter-activity.
7. A prolonged period of "effective" or critical attention.
8. Reduced harmful strain at the colon.
9. A targeted treatment for the upper GIT's first affections.
10. Drug distribution at particular points.

DISADVANTAGES (15,16)

1. Drugs with GIT stability or solubility issues are not appropriate for Floating Drug Delivery System.
2. It is not desirable to seek medications that undergo first pass metabolism, such as nifedipine, propranolol, etc., which are well absorbed throughout the gastrointestinal tract.
3. Additionally, medications that irritate the stomach mucus are undesirable.
4. Drugs that are unstable in the stomach's acidic environment shouldn't be used in these kinds of systems.

5. To maintain buoyancy and function well, the stomach's liquids must be in a high position.

FACTORS AFFECTING GASTRO RETENTIVE FLOATING DRUG DELIVERY SYSTEM

The effectiveness of gastro-retentive drug delivery systems largely depends on the ability of the dosage form to remain in the stomach for an extended period of time. Various formulation-related and physiological factors influence the gastric retention time (GRT) of these systems. Prolonged gastric residence improves drug absorption, particularly for drugs that are primarily absorbed in the upper part of the gastrointestinal tract. The major factors affecting the performance of gastro-retentive systems are described below.

Density of Dosage Form

Density plays a crucial role in determining the floating capability and gastric residence time of gastro-retentive dosage forms. For floating drug delivery systems, the density of the formulation should be lower than that of gastric fluid, which is approximately 1.004 g/cm³. When the density is lower than gastric fluid, the dosage form remains buoyant and floats on the surface of stomach contents. This buoyancy helps the system remain in the stomach for a longer duration and allows sustained drug release. On the other hand, if the density of the dosage form is greater than that of gastric fluid, it tends to sink and may be emptied rapidly through the pyloric sphincter, thereby reducing gastric retention time. (17)

Size of Dosage Form

The physical size of the dosage form significantly influences its retention in the stomach. Larger dosage forms are generally retained for a longer time compared to smaller ones because they cannot easily pass through the pyloric opening during gastric emptying. Studies have indicated that dosage forms with a diameter greater than 7.5 mm show improved gastric residence. In particular, units with diameters of approximately 9–10 mm or more demonstrate better retention characteristics compared to smaller formulations.

Shape of Dosage Form

The geometry of the dosage form is another important factor affecting gastric retention. Certain shapes have been reported to remain in the stomach for longer periods due to their ability to resist passage through the pylorus. For example, tetrahedral or ring-shaped gastro-retentive systems exhibit improved gastric retention compared to conventional shapes such as discs or capsules. These specially designed systems may unfold or expand after reaching the stomach, increasing their effective size and preventing premature gastric emptying. Such systems have demonstrated approximately 90–100% retention for up to 24 hours in some studies.

Single-Unit and Multiple-Unit Systems

Gastro-retentive drug delivery systems can be formulated as single-unit systems (tablets or capsules) or multiple-unit systems such as pellets, beads, or microspheres. Multiple-unit systems are often preferred because they provide a more uniform and predictable drug release profile. In addition, they reduce the risk of dose dumping and minimize the possibility of formulation failure. These systems also allow the incorporation of different release patterns or even incompatible drugs within the same formulation, which increases formulation flexibility and safety. (18)

Effect of Fed and Fasting State

Gastric motility patterns vary significantly between fed and fasting states, which can influence the retention of gastro-retentive systems. During the fasting state, the stomach undergoes cyclic motor activity known as the migrating myoelectric complex (MMC). This cycle occurs approximately every 2–3 hours and functions to clear undigested material from the stomach into the small intestine. If a dosage form is administered during this phase, it may be rapidly expelled from the stomach. In contrast, when food is present in the stomach, the MMC cycle is delayed and gastric motility becomes less intense, resulting in prolonged gastric retention time.

Nature of Meal

The type and composition of food consumed can also influence gastric emptying. Meals containing indigestible materials such as cellulose, starch, polydextrose, and raffinose may alter gastric motility patterns. These substances tend to slow down gastric emptying by delaying the onset of the MMC cycle. As a result, the dosage form remains in the stomach for a longer period, which enhances the effectiveness of gastro-retentive formulations.

Caloric Content of the Meal

The caloric value of food plays an important role in controlling gastric emptying rate. Meals with high caloric content, particularly those rich in fats and proteins, can significantly delay gastric emptying. Such meals may prolong gastric retention time by approximately 4–10 hours. This extended residence time can improve the performance of gastro-retentive drug delivery systems by allowing sustained drug release in the stomach.

Frequency of Feeding

The frequency at which food is consumed also affects gastric retention. When meals are taken repeatedly at shorter intervals, the MMC cycle is postponed or suppressed. This results in slower gastric emptying and consequently increases gastric retention time. Studies have shown that multiple meals may increase gastric retention by more than 400 minutes compared with a single meal condition.(19,20)

Gender

Physiological differences between males and females may influence gastric emptying patterns. Several studies have reported that gastric emptying tends to be slower in females than in males of similar age and body characteristics. As a result, females may exhibit longer gastric retention times compared to males.

Age

Age is another physiological factor that can affect gastric motility and emptying. Gastric emptying tends to become slower with increasing age. Elderly individuals, especially those above 70 years, often experience delayed gastric emptying compared to younger adults. This may lead to prolonged gastric retention of gastro-retentive dosage forms.(21)

Posture

Body posture can influence the behavior of floating dosage forms within the stomach. When a person is in an upright or ambulatory position, floating systems tend to remain on the surface of gastric contents and are less likely to be expelled from the stomach. However, when the patient is in a supine position, the distribution of gastric contents may change, which can affect the retention behavior of the dosage form.(22)

Concomitant Drug Administration

The simultaneous administration of certain drugs can alter gastric motility and influence gastric retention time. Drugs such as codeine, clonidine, lithium, nicotine, progesterone, and anticholinergic agents (e.g., atropine and propantheline) tend to slow gastric emptying, thereby increasing gastric retention time. Conversely, drugs such as erythromycin and octreotide may stimulate gastric motility and accelerate gastric emptying.

Biological Factors

Certain pathological conditions may also influence gastric motility and emptying patterns. Diseases such as diabetes mellitus, Crohn's disease, and other gastrointestinal disorders can alter the normal functioning of the gastrointestinal tract. These changes may affect the gastric residence time of gastro-retentive drug delivery systems and consequently influence drug absorption and therapeutic response.(23,24).

Polymers and Excipients Used in Gastro-Retentive Floating Drug Delivery System

Table 1: Polymers Used in Floating Drug Delivery System (25-28)

Polymers	**Types**	**Role in Gastro retentive Floating drug**
Hydroxypropyl Methylcellulose	Hydrophilic polymer	Forms gel barrier and controls drug release
Sodium Alginate	Natural polymer	Forms gel matrix and improves floating behavior
Xanthan Gum	Natural polymer	Increases viscosity and sustains drug release
Carbopol 934	Synthetic polymer	Provides high swelling and controlled drug release
Guar Gum	Natural polymer	Acts as matrix-forming polymer
Chitosan	Natural polymer	Enhances mucoadhesion and gastric retention
Ethyl Cellulose	Hydrophobic polymer	Retards drug release
Hydroxypropyl Cellulose	Semi-synthetic polymer	Provides swelling and controlled release
Pectin	Natural polymer	Forms gel matrix and sustains drug release
Gellan Gum	Natural polymer	Used in in-situ gel and raft-forming systems
Locust Bean Gum	Natural polymer	Enhances viscosity and gel formation
Pullulan	Natural polymer	Forms film and improves matrix stability
Polyethylene Oxide	Synthetic polymer	Provides swelling and controlled drug release

Table 2: Excipients Used in Gastro-Retentive Floating Drug Delivery Systems (GRFDDS) (29-34)

Excipient	Category	Function in Gastro Retentive Floating Drug Delivery System
Sodium Bicarbonate	Gas-generating agent	Produces CO_2 gas which helps the system float in gastric fluid
Citric Acid	Effervescent agent	Reacts with sodium bicarbonate to generate gas
Tartaric Acid	Effervescent agent	Reacts with sodium bicarbonate to generate gas
Calcium Carbonate	Gas-forming agent	Generates CO_2 and improves floating property
Microcrystalline Cellulose	Diluent	Improves bulk and compressibility of formulations

Lactose	Diluent	Enhances solubility and increases formulation bulk
Mannitol	Diluent	Improves solubility and stability of formulations
Polyvinylpyrrolidone	Binder	Provides mechanical strength and binds particles
Magnesium Stearate	Lubricant	Reduces friction during manufacturing
Talc	Glidant	Improves powder flow properties
Stearic Acid	Lubricant	Facilitates smooth processing of dosage forms
Colloidal Silicon Dioxide	Glidant	Enhances flowability and stability
Calcium Chloride	Cross-linking agent	Used in beads and microspheres for gel formation
Sodium Citrate	Buffering agent	Maintains pH and stabilizes formulation

CLASSIFICATION OF GASTRO RETENTIVE FLOATING DRUG DELIVERY SYSTEM

A. Effervescent Floating Drug Delivery System

1. Gas generating system
2. Volatile liquid containing system

B. Non-Effervescent Floating Drug Delivery System

1. Colloidal gel barrier system
2. Bi-layer floating tablets
3. Microporous compartment system
4. Floating Beads/ Alginate Beads
5. Micro balloons/ Hollow Microspheres

C. Raft forming system

A. Effervescent Floating Drug Delivery System: Effervescent Floating Drug Delivery System uses organic acids like citric or tartaric acid along with gas-generating substances like sodium bicarbonate. These components react to form carbon dioxide (CO2) when they come into contact with gastric fluid, which lowers the system's density and allows it to float on the contents of the stomach. As an alternative, the formulation might include a matrix of liquid ingredients that, when evaporating at body temperature, produce gas, which would help with buoyancy and regulated medication release.(35,36)

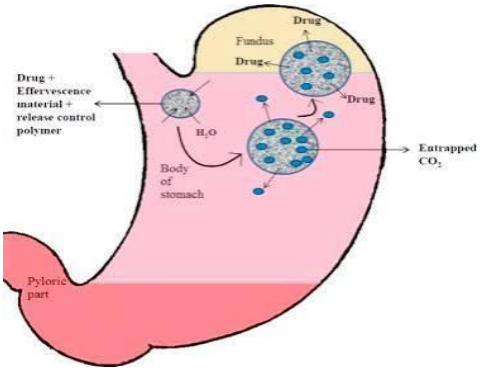

Figure 3: Effervescent Floating Drug Delivery24

1. Gas generating system:

The buoyant delivery mechanism lowers its specific gravity and causes it to float over by releasing CO2 through the effervescence reaction between citric acid or tartaric acid and carbonate or bicarbonate salts.(37)

2. Volatile liquid-containing systems:

Volatile liquid-containing devices allow for prolonged stomach retention during drug delivery by using an inflatable chamber that is filled with fluids. These systems include volatile liquids such as ether and cyclopentane, which extend the stomach chamber when they gasify at body temperature. They are made up of hollow deformable units, which are floating constructions that are osmotically controlled. Two compartments make up the system: one houses the volatile liquid, and the other the drug.(38)

B. Non-Effervescent Floating Drug Delivery System: The non-effervescent Floating Drug Delivery System achieves gastric retention by means of the swelling characteristics of polymers or their bioadhesive contacts with the gastrointestinal (GI) mucosa. Polycarbonate, polyacrylate, polymethacrylate, and polystyrene are matrix-forming polymers that are used in these systems, along with gel-forming agents or highly swellable hydrocolloids such cellulose derivatives. Chitosan and carbopol, two bioadhesive substances, also improve adherence to the stomach lining, extending system retention and guaranteeing continuous drug release.

1. Colloidal Gel Barrier System

The colloidal gel barrier system, commonly referred to as a hydrodynamically balanced system (HBS), is one of the earliest floating drug delivery approaches developed to prolong gastric residence time. This system is designed in such a way that the dosage form remains buoyant in the gastric environment, thereby enhancing drug absorption in the upper part of the gastrointestinal tract. In this system, the drug is incorporated into a matrix composed mainly of hydrophilic polymers or hydrocolloids. Polymers such as hydroxypropyl methylcellulose (HPMC), hydroxypropyl cellulose, and hydroxyethyl cellulose are widely used due to their excellent swelling and

gel-forming properties. When the dosage form comes into contact with gastric fluid, these polymers rapidly hydrate and form a viscous gel layer around the tablet. The formation of this gel barrier helps maintain the structural integrity of the dosage form and decreases its density, allowing it to remain floating on the gastric contents. Additionally, the gel layer regulates the penetration of gastric fluid and the diffusion of the drug, resulting in controlled and prolonged drug release. In some formulations, matrix-forming polymers such as polycarbophil or polystyrene derivatives are incorporated to enhance mechanical strength and maintain the stability of the gel matrix.

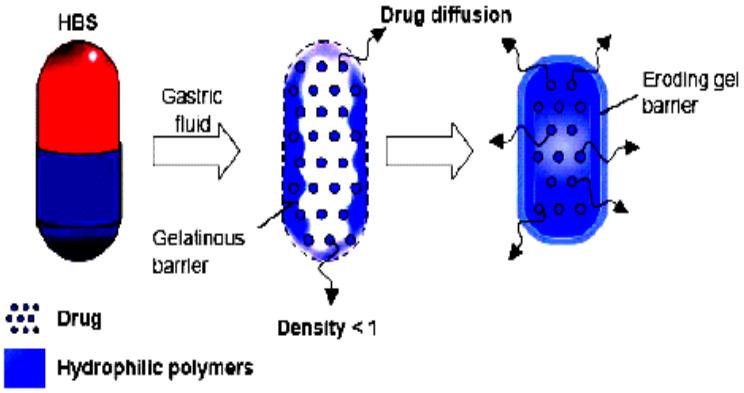

Figure 4: Colloidal Gel Barrier System

2. Bilayer Floating Tablet

Bilayer floating tablets are designed to combine both immediate drug release and sustained drug delivery within a single dosage form. These tablets consist of two distinct layers that perform different functions in the drug delivery process. The first layer acts as an immediate-release layer, which provides a rapid release of a portion of the drug soon after administration to produce an initial therapeutic effect. The second layer is formulated using swellable polymers and functions as a floating sustained-release layer. Upon contact with gastric fluid, this layer absorbs water and swells to form a gel-like structure. The swelling of the polymeric layer reduces the density of the dosage form and helps it remain buoyant in the gastric environment. At the same time, the hydrated polymer matrix controls the diffusion of the drug, allowing gradual drug release over an extended period. Because of this dual-layer design, bilayer floating tablets can provide both rapid onset of action and prolonged therapeutic effect, while also increasing gastric retention.(39).

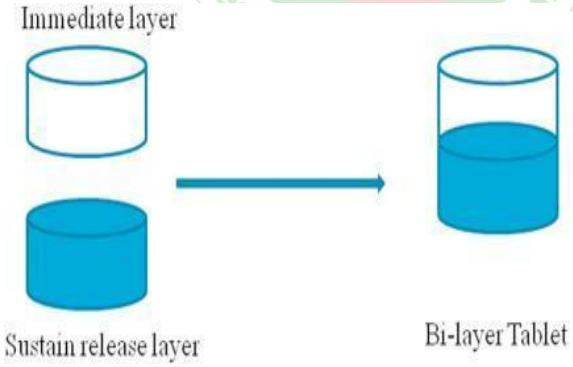

Figure 5: Bilayer Floating Tablet

3. Microporous Compartment System

The microporous compartment system represents another approach for achieving gastro-retentive drug delivery. In this system, the drug is enclosed within a specialized compartment surrounded by a microporous membrane. The lateral sides of the drug reservoir are usually sealed to prevent direct contact between the drug and the gastric mucosal surface.

A floating chamber containing air or an entrapped gas is incorporated into the system, which helps reduce the overall density and allows the dosage form to remain buoyant in gastric fluid. The microporous membrane permits the entry of gastric fluid through numerous tiny pores. Once inside the compartment, the fluid dissolves the drug contained in the reservoir.

The dissolved drug then diffuses slowly out of the system through the micropores and becomes available for absorption in the gastrointestinal tract. Due to the controlled diffusion process, the system is capable of providing sustained drug release for an extended period, while the floating chamber ensures prolonged gastric residence.(40)

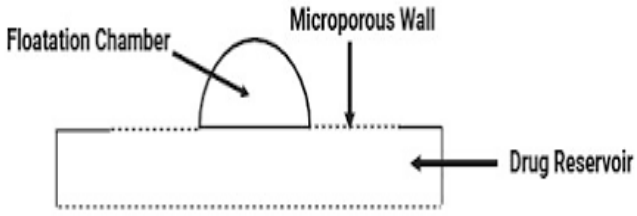

Figure 6: Microporous Compartment System

4. Floating Beads / Alginate Beads

Floating beads, particularly alginate beads, are widely used in multi-particulate gastro-retentive drug delivery systems. These dosage forms consist of numerous small, discrete particles that are administered orally and disperse throughout the stomach after ingestion. Alginate beads are usually prepared using sodium alginate, which forms gel beads in the presence of multivalent cations through an ionotropic gelation process. To impart floating characteristics, gas-generating agents such as sodium bicarbonate or calcium carbonate may be incorporated into the formulation. When these beads come into contact with gastric fluid, carbon dioxide is generated and trapped within the polymeric matrix, which decreases the density of the beads and enables them to float on gastric contents. Due to their low density and multi-particulate nature, floating alginate beads remain in the stomach for an extended period and provide sustained drug release.(41)

5. Microballoons and Hollow Microspheres

Microballoons, also known as hollow microspheres, are another type of gastro-retentive floating drug delivery system designed to prolong gastric residence time. These systems are characterized by a hollow internal cavity surrounded by a polymeric shell. Due to the presence of this hollow structure, microballoons possess low density, which allows them to remain buoyant in gastric fluid for a prolonged period.

Hollow microspheres are generally prepared using techniques such as solvent evaporation or emulsion solvent diffusion methods. In these processes, the drug and polymer are dissolved in a suitable organic solvent and emulsified in an aqueous phase. As the solvent evaporates, a hollow cavity is formed within the microsphere, resulting in a lightweight structure capable of floating on gastric fluid.

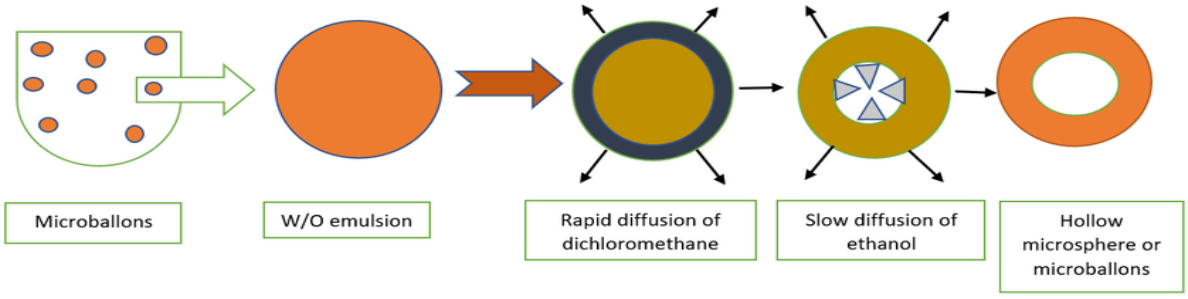

Figure 7: Microballoons and Hollow Microspheres

C. Raft-Forming Systems

Raft-forming systems represent a specialized type of gastro-retentive drug delivery approach commonly used in the management of gastroesophageal reflux disease (GERD) and for the delivery of antacid formulations. These systems are designed to form a viscous gel layer, commonly referred to as a "raft," when the formulation comes into contact with gastric fluid. The formation of this raft creates a floating barrier that remains on the surface of the stomach contents. The mechanism of raft formation generally involves the presence of gel-forming polymers, such as sodium alginate or other hydrocolloids. When the formulation reaches the stomach, these polymers interact with gastric fluid and undergo rapid gelation, resulting in the formation of a cohesive and viscous gel structure. At the same time, the formulation usually contains gas-generating agents, such as sodium bicarbonate or calcium carbonate. These compounds react with gastric acid and produce carbon dioxide gas. The generated carbon dioxide becomes trapped within the gel structure, reducing the density of the system and enabling it to float on the gastric contents. The floating gel layer acts as a mechanical barrier, which helps prevent the reflux of gastric acid into the esophagus. In addition to providing relief from acid reflux, raft-forming systems can also deliver drugs in a controlled manner while remaining in the stomach for an extended period. Because of these characteristics, raft-forming formulations are widely used in the treatment of acid reflux and other gastrointestinal disorders.(42)

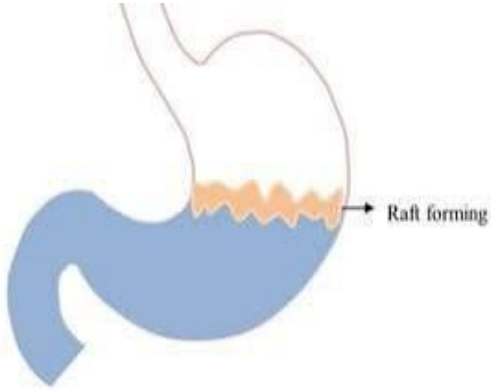

Figure 8: Raft-forming System26

APPLICATIONS OF FLOATING DRUG DELIVERY SYSTEM (43-46)

Floating drug delivery systems (FDDS) are widely investigated in pharmaceutical research because of their ability to remain in the stomach for a prolonged period. By increasing gastric residence time, these systems can improve drug absorption, enhance therapeutic efficacy, and provide controlled drug release. The major applications of floating drug delivery systems are discussed below.

1. Sustained Drug Delivery

One of the most important applications of floating drug delivery systems is their ability to provide sustained and controlled drug release. Because the dosage form remains buoyant in the gastric environment for an extended period, the drug is released gradually from the formulation. This controlled release helps maintain therapeutic drug levels for a longer duration and reduces the frequency of dosing. For example, sustained-release floating capsules of nicardipine have demonstrated improved in vivo performance and prolonged drug action compared to conventional dosage forms.

2. Site-Specific Drug Delivery

Floating drug delivery systems are particularly useful for drugs that are primarily absorbed in the stomach or upper part of the small intestine. By prolonging gastric residence time, the dosage form remains near the optimal absorption site, which improves drug bioavailability. This approach is beneficial for drugs such as riboflavin (vitamin B_2) and certain diuretics, whose absorption is limited to the upper gastrointestinal tract. Maintaining the dosage form in this region enhances therapeutic effectiveness.

3. Enhancement of Drug Absorption

Another important application of FDDS is the improvement of drug absorption. Many drugs exhibit site-specific absorption in the upper gastrointestinal tract, and rapid gastric emptying may reduce their bioavailability. Floating systems help retain the drug in the stomach and upper intestine for a longer duration, thereby providing sufficient time for drug absorption. As a result, floating formulations often demonstrate higher bioavailability and improved absorption profiles compared with conventional oral dosage forms.

4. Maintenance of Constant Plasma Drug Levels

Floating drug delivery systems are capable of maintaining relatively constant plasma drug concentrations for an extended period. The gradual release of the drug from the floating dosage form minimizes fluctuations in drug levels within the bloodstream. This steady drug release helps maintain therapeutic concentrations while avoiding sudden peaks or rapid declines in plasma drug levels. Consequently, FDDS can improve therapeutic efficacy and enhance patient compliance by reducing dosing frequency.

5. Reduction of Colonic Side Effects

In some cases, drugs may cause undesirable effects when they reach the colon. Floating drug delivery systems help retain the drug within the stomach for a longer duration, which reduces the amount of drug that reaches the lower gastrointestinal tract. This can help minimize local irritation or adverse reactions in the colon. Hydrodynamically balanced systems (HBS), for example, are designed to remain in the gastric region and limit drug exposure to the colonic environment.

6. Reduction in Variability of Drug Concentration

Floating drug delivery systems can also help reduce fluctuations in drug concentration in the bloodstream. Continuous and controlled drug release from controlled-release gastro-retentive formulations (CR-GRDF) results in a more stable drug input into systemic circulation. Compared to conventional immediate-release formulations, this leads to less variation in plasma drug levels, which improves therapeutic consistency and reduces the risk of sub-therapeutic or toxic concentrations.

7. Drugs with Narrow Absorption Window

Floating drug delivery systems are highly suitable for drugs that possess a narrow absorption window in the upper gastrointestinal tract. Such drugs are absorbed mainly in the stomach or the proximal part of the small intestine. If these drugs pass quickly into the distal intestine, their absorption decreases significantly. By prolonging gastric residence time, floating systems allow the drug to remain within the optimal absorption region for a longer duration, thereby improving therapeutic efficiency.

8. Local Drug Delivery in the Stomach

Floating drug delivery systems can also be used for the local treatment of gastric disorders. Since these systems remain in the stomach for an extended period, they allow localized delivery of drugs directly to the gastric mucosa. This approach is beneficial in the treatment of conditions such as gastric ulcers, gastritis, and Helicobacter pylori infections. The prolonged residence of the dosage form enhances drug contact with the affected area, thereby improving therapeutic outcomes.

9. Improved Therapeutic Efficiency of Drugs with Short Half-Life

Drugs that have a short biological half-life often require frequent dosing to maintain therapeutic levels. Floating drug delivery systems can provide sustained drug release and maintain drug concentration in the systemic circulation for a longer duration. This reduces the need for frequent administration and improves overall therapeutic effectiveness.

10. Reduced Drug Wastage

Floating drug delivery systems help retain the drug in the stomach and upper gastrointestinal tract, where maximum absorption occurs. As a result, less drug passes unabsorbed into the lower part of the

gastrointestinal tract. This reduces drug wastage and enhances the overall bioavailability of the medication.

11. Improved Patient Compliance

By providing prolonged drug release and reducing dosing frequency, floating drug delivery systems contribute to better patient compliance. Patients are not required to take medication repeatedly throughout the day, which improves adherence to the prescribed therapy.

12. Controlled Delivery of Drugs with Poor Solubility

Floating systems can also be beneficial for drugs that exhibit poor solubility in intestinal fluid but better solubility in acidic gastric fluid. By retaining the dosage form in the stomach for a longer period, the drug remains in an environment where its solubility is higher, which enhances drug dissolution and absorption.

CONCLUSION

In pharmaceutical science, floating drug delivery systems in particular, floating tablets represent a promising strategy for increasing the bioavailability of medications with limited therapeutic windows or those impacted by gastric emptying delays. Longer stomach retention, targeted medication release, and enhanced patient compliance are just a few of the many benefits that these systems provide. Numerous elements, including the selection of excipients, polymers, and preparation technique, affect the design and formulation of floating tablets and can have a major impact on their functionality. Even with the advancements in this area, there are still issues to be resolved, such as the fluctuation of stomach conditions, the requirement for exact control over drug release, and the dosage form's stability over time.

Future studies should concentrate on improving formulation techniques, investigating novel materials for improved floating qualities, and carrying out clinical trials to confirm the effectiveness of floating tablets in a range of therapeutic domains. All things considered, floating tablets continue to present intriguing opportunities for developing oral medication delivery systems and enhancing patient outcomes.

FUTURE PROSPECT

Gastro-retentive floating drug delivery systems (GRFDDS) continue to attract significant research attention due to their potential to improve the bioavailability and therapeutic efficacy of drugs with a narrow absorption window in the upper gastrointestinal tract. Future developments in this field are likely to focus on novel polymers, advanced formulation technologies, and smart delivery approaches.

Recent advances in biodegradable and stimuli-responsive polymers offer promising opportunities to design floating systems that can respond to physiological triggers such as pH, temperature, or enzymatic activity. The integration of nanotechnology with gastro-retentive systems may enable controlled release at the molecular level, leading to enhanced drug solubility, reduced dose frequency, and improved patient compliance.

Furthermore, the use of 3D printing and computer-aided formulation design can allow precise customization of floating tablets with tailored buoyancy and release kinetics. Future studies may also explore in vivo imaging and pharmacokinetic modeling to better understand gastric retention behavior and optimize formulation parameters.

Regulatory and industrial advancements are expected to push these systems toward commercial viability, particularly for drugs used in chronic conditions like hypertension, diabetes, and peptic ulcer disease. Ultimately, the combination of innovative materials, advanced manufacturing techniques, and mechanistic understanding will drive the next generation of gastro-retentive drug delivery systems with superior therapeutic outcomes.

REFERENCES

1. Gupta P and Gnanarajan PK. Floating Drug Delivery System: A Review. Int. J Pharm Res Rev. 2015; 4(8): 37-44.
2. Shyama SK and Sivakumar R. Floating Drug Delivery System: An Updated Review. Int J Curr Pharm Clinical Res. 2014; 4(3):150-53.
3. Parmar PD, Pande S, Shah HS, Sonara SN and Patel GH. Floating Drug Delivery System: A Novel Approach to Prolong Gastric Retention. World J Pharma Pharma Sci. 2014; 3(4): 418-44.
4. Veerareddy PR, Bajjuri S, Sanka K, Jukanti R, Bandari S and Ajmeru RK. Formulation and Evaluation of Gastroretentive Dosage Form of Ofloxacin. Stamford J Pharma Sci. 2011; 4(1): 09-18.
5. Singh BN, Kim KH, Floating drug delivery systems: an approach to oral controlled drug delivery via gastric retention, Journal of Controlled Release, 2000; 63(3):235–259. DOI: https://doi.org/10.1016/S0168-3659(99)00204-7
6. Gadge AR, Lamkhade GJ, Vishe SU, Varpe MM, et al., Floating drug delivery systems: A review, World Journal of Biology Pharmacy and Health Sciences, 2024;18(2):065-073. DOI:https://doi.org/10.30574/wjbphs.2024.18.2.0249
7. Dixit N. Floating Drug Delivery System. J Curr Pharm Res. 2011; 7(1): 6-20.
8. Banker GS, Rhodes CT, Modern Pharmaceutics, Marcel Dekker, New York 1996; 3(1):125-128. DOI: https://doi.org/10.1201/9780824744694.
9. Hoffman A, Pharmacodynamic aspects of sustained release preparations, Advanced drug delivery reviews, 1998; 33(3):185-199. DOI: https://doi.org/10.1016/s0169-409x(98)00027-1.
10. Kothule S, Aher S, BachhavR. Gastro-retentive Drug Delivery System: A Review. International Journal in Pharmaceutical Science. 2023; 2(1):75-85.
11. Dixit N. Floating Drug Delivery System. J Curr Pharm Res. 2011; 7(1): 6-20.
12. Chawla G, Gupta P, Vishal K and Bansal AK. Gastroretention a Means to Address Regional Variability in Intestinal Drug Absorption. Pharm Technol. 2002; 27(7): 50-68.
13. Meka, V. S., Dharmanlingam, S. R., & Kolapalli, V. R. M. Formulation of gastroretentive floating drug delivery system using hydrophilic polymers and its in vitro characterization. Brazilian Journal of Pharmaceutical Sciences, 2014 50(2), 431–439. https://doi.org/10.1590/S1984-82502014000200023.
14. Srebro J, Brniak W, Mendyk A. Formulation of Dosage Forms with Proton Pump Inhibitors: State of the Art, Challenges and Future Perspectives. Pharmaceutics. 2022; 14(10):2043. https://doi.org/10.3390/pharmaceutics14102043
15. Mohanty, D.; Zafar, A.; Jafar, M.; Upadhyay, A.K.; Haque, M.A.; Gupta, J.K.; Bakshi, V.; Ghoneim, M.M.; Alshehri, S.; Jahangir, M.A.; et al. Development, in-vitro characterization and preclinical

evaluation of esomeprazole-encapsulated proniosomal formulation for the enhancement of anti-ulcer activity. Molecules 2022, 27, 2748.

16. Galmiche, J.P.; Bruley Des Varannes, S.; Ducrotté, P.; Sacher-Huvelin, S.; Vavasseur, F.; Taccoen, A.; Fiorentini, P.; Homerin, M. Tenatoprazole, a novel proton pump inhibitor with a prolonged plasma half-life: Effects on intragastric pH and comparison with esomeprazole in healthy volunteers. Aliment. Pharmacol. Ther. 2004, 19, 655–662.
17. Bera H, Kumar S, Maiti S. Facile synthesis and characterization of tailor-made pectin-gellan gum-bionanofiller composites as intragastric drug delivery shuttles. Int J Biol Macromol 2018;118:149-59.
18. Desai N, Purohit R. Development of novel high density gastroretentive multiparticulate pulsatile tablet of clopidogrel bisulfate using quality by design approach. AAPS PharmSciTech 2017;18:3208-18.
19. Mahmoud D, Shukr MH, ElMeshad AN. Gastroretentive microsponge as a promising tool for prolonging the release of mitiglinide calcium in Type-2 diabetes mellitus: Optimization
20. and pharmacokinetics study. AAPS PharmSciTech 2018.
21. Neumann M, Schneider F, Koziolek M, Garbacz G, Weitschies W. A novel mechanical antrum model for the prediction of the gastroretentive potential of dosage forms. Int J Pharm 2017;530:63-70.
22. Zhang Y, Zhang L, Zhang Q, Zhang X, Zhang T, Wang B. Enhanced gastric therapeutic effects of Brucea javanica oil and its gastroretentive drug delivery system compared to commercial products in pharmacokinetics study. Drug Des Dev Ther 2018;12:535-44.
23. Shin JM, Kim N. Pharmacokinetics and pharmacodynamics of the proton pump inhibitors. J Neurogastroenterol Motil. 2013 Jan;19(1):25-35. doi: 10.5056/jnm.2013.19.1.25. Epub 2013 Jan 8. PMID: 23350044; PMCID: PMC354812212. Gupta P and Gnanarajan PK. Floating Drug Delivery System: A Review. Int. J Pharm Res Rev. 2015; 4(8): 37-44.
24. Pandey SK, Pudasaini J, Parajuli N, Singh RE, et al., Formulation and evaluation of floating tablet of Nimesulide by direct compression method, Magna Scientia Advanced Research and Reviews, 2024; 10(1): 153-161. DOI:https://doi.org/10.30574/msarr.2024.10.1.0008.
25. Tripathi J, Thapa P, Maharjan R and Jeong SH. Current State and Future Perspectives on Gastroretentive Drug Delivery Systems. Pharmaceutics. 2019; 11(4): 1-22.
26. Prajapati ST, Patel L, Patel C, Floating matrix tablets of domperidone: formulation and optimization using simplex lattice design, Iranian journal of pharmaceutical research, 2011; 10(3):447-455. DOI:2011;61(4):567-585. 10.22037/IJPR.2010.892
27. Mandal UK, Chatterjee B and Faria GS. Gastro-retentive drug delivery systems and their in vivo success: A recent update. Asian J Pharm Sci. 2016; 11(5): 575-84.
28. Kumar R, Patil S, Design and in vitro evaluation of sustained release floating tablets of metformin HCl, Asian Journal of Pharmaceutics, 2009; 3(3):240-245.
29. Singh BN, Kim KH, Floating drug delivery systems: an approach to oral controlled drug delivery via gastric retention, Journal of Controlled release, 2000; 63(3):235-259. DOI:https://doi.org/10.1016/S0168-3659(99)00204-7
30. Repka MA, Majumdar S, Kumar Battu S, Srirangam R, et al., Applications of hot-melt extrusion for drug delivery, Expert opinion on drug delivery, 2007;4(2):135-151.
31. Kaushik AY, Tiwari AK and Gaur A. Role of Excipients and polymeric advancements in preparation of floating drug delivery systems. Int J Pharm Investig. 2015; 5(1): 1-12.
32. Bhuyar SR, Auti MM, Bhise SA, Innovations and advancements in floating tablet drug delivery systems: a comprehensive review, Pharm Pharmacol Int J, 2024;12(5):195-200. DOI: https://doi.org/10.15406/ppij.2024.12.00452.
33. Vasave VS, A Review on: Floating Drug Delivery System, World Journal of Pharmaceutical Research, 2023; 12(2):641-669. DOI: https://doi.org/10.20959/wjpr20232-26983.
34. Thakur S, Ramya K, Shah DK, Raj K, Floating Drug Delivery System, Journal of Drug Delivery and Therapeutics, 2021; 11(3-S):125-130. DOI: http://dx.doi.org/10.22270/jddt.v11i3-S.4828.
35. Singh LP, Rajesh KS, Umalkar DG, Chauhan VK, et al., Floating effervescent tablet: A review, Journal of pharmaceutical and biomedical sciences, 2011;5(11):1-6.
36. Pawar VK, Kansal S, Garg G, Awasthi R, et al., Gastroretentive dosage forms: A review with special emphasis on floating drug delivery systems, Drug delivery, 2011; 18(2):97-110. DOI:https://doi.org/10.3109/10717544.2010.520354
37. Padhan A, Nanda BK, Behera BC, Floating oral in-situ gel, a comprehensive approach of gastro-retentive drug delivery system: a review, International journal of pharmaceutical sciences and research, 2019;10(9):4026-4039. DOI: https://doi.org/10.13040/IJPSR.0975-8232.10(9).4026-39
38. Chowdary KP, Teeda V, Floating drug delivery systems: a review of recent research, International Research Journal of Pharmaceutical and Applied Sciences, 2014; 4(4):14-24.
39. Grover I, Marwah M, Devgan M, Floating Drug Delivery Systems: A Novel Approach, Research Journal of Pharmacy and Technology, 2015; 8(4):490-495. DOI: https://doi.org/10.5958/0974-360X.2015.00082.7
40. Tomar P, Shukla V, Kharia AA and Chatterjee DP. Floating drug delivery system: an updated review. J Med Pharm Allied Sci. 2013; 04: 31-42.
41. Sharma N, Agarwal D, Gupta MK and Khinchi MP. A Comprehensive Review on Floating Drug Delivery System. Int J Res Pharm Biomed Sci. 2011; 2(2): 428-41.
42. Gadhve MV, Lende LK, Tajane TS and Gaikwad DD. Formulation and Development of Bilayer Floating Tablet of Nifedipine using surface solid dispersion technique. Int J Adv Pharm. 2016; 5(5): 117-26.
43. Reddy RS, Ramachandra CT, Hiregoudar S, Nidoni UK, Kammar M, and Ram J. Influence of processing conditions on functional and reconstitution properties of milk powder made from Osmanabadi goat milk by spray drying. Small Ruminant Res. 2014; 119: 130–137.
44. Mathur P, Verma N, Floating drug delivery system, An innovative acceptable approach in gastro retentive drug delivery, Scholars Research Library, 2010; 2(2):257-270.
45. Hardenia SS, Jain A, Patel R, Kaushal A, Floating Drug Delivery Systems: A Review, Asian Journal of Pharmacy and Life Science, 2011; 1(3):284-293.
46. Chandel A, Chauhan K, Parashar B, Kumar H, et al., Floating drug delivery systems: A better approach, International Current Pharmaceutical Journal, 2012; 1(5):110-118.
47. Shah SH, Patel JK, Patel NV, Stomach specific floating drug delivery system: A review, International Journal of Pharmaceutical Technology and Research, 2009; 1(3):623-633.