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Review Article

Redefining Drug Delivery: Potency of Floating Drug Delivery System towards Modern Medicine

Diptimayee Jena[1], Asra Jabeen[2], Swetha Vegesna[3], Gowri Sankar Chintapalli[4], Vikash Dash[5], Debasis Patra[1], Kirtimaya Mishra[1,*]

[1]School of Pharmacy and Life Sciences, Centurion University of Technology and Management, Bhubaneswar, Odisha, INDIA.
[2]Department of Pharmacognosy, Bharat Institute of Technology, Mangalpally, Ibrahimpatnam, Telangana, INDIA.
[3]School of Pharmaceutical Sciences and Technologies, Jawaharlal Nehru Technological University (JNTUK), Kakinada, Andhra Pradesh, INDIA.
[4]School of Pharmaceutical Sciences, Centurion University of Technology and Management, Vizianagaram, Andhra Pradesh, INDIA.
[5]School of Pharmacy, ARKA JAIN University, Jharkhand, INDIA.

ABSTRACT

Drug delivery systems are an important part of modern medicine, which aims for maximizing therapeutic efficacy, reduce adverse effects, and increase patient compliance. An important development in this area is the use of Floating Drug Delivery Systems (FDDS), which provide controlled drug release and extended stomach retention to maximise the bioavailability of different medicinal substances. In order to better understand the possibilities of FDDS in modern healthcare, this study looks at their design, workings, and therapeutic advantages. Sustained drug release, tailored distribution, and fewer doses required are important benefits that all lead to better patient outcomes. The study also covers the materials and technological advancements used in the creation of FDDS, as well as the difficulties and potential applications in the future. FDDS have the potential to transform treatment paradigms in a number of therapeutic domains and solve unmet medical needs by redefining conventional drug delivery techniques. The goal of this review is to present a thorough grasp of the function of floating systems in contemporary medicine, emphasising how they could revolutionise therapeutic approaches and medication delivery.

Keywords: Bioavailability, Contemporary medicines, Controlled Drug release, Floating Drug Delivery System, Patient Compliance, Sustained Drug release, Therapeutic Efficacy.

Correspondence:
Dr. Kirtimaya Mishra
Professor, School of Pharmacy & Life Sciences, Centurion University of Technology & Management, Bhubaneswar, Odisha, INDIA.
Email: kirtimaya.mishra@cutm.ac.in

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INTRODUCTION

Overtime, there have been major developments in drug delivery systems with the main objective of improving treatment outcomes through the optimisation of drug release and bioavailability. Poor bioavailability, varying drug levels, and uneven stomach emptying rates are common issues with traditional oral drug delivery techniques, particularly when it comes to medications that are predominantly absorbed in the upper small intestine or stomach. Many controlled-release devices are being developed by solving such problems; floating drug delivery systems; FDDS have drawn lots of concern (Chaudhary, 2022). The capacity to lengthen and adjust the period of emptying interval is a crucial advantage, as dose forms linger in the stomach greater than normal dosage forms. Dosage-type gastric emptying is a very uncertain method. One of the challenges is confining the dose form in the intended location of the gastrointestinal tract. To address this physiological challenge, investigations have been conducted on various pharmaceutical delivery strategies with longer stomach retention durations (Tripathi, 2019; Sharma, 2020; Jena, 2024; Mandal, 2016). Gastroretentive devices, which may persist in the stomach for a prolonged period, might increase the gastrointestinal residence time of medications. Extended stomach retention increases the solubility of drugs that are more difficult to dissolve in high pH settings, reduces drug waste, and boosts bioavailability (Altreuter, 2018). Patients will experience significant benefits and new treatment opportunities with gastric retention. Restricted gastric retention of solid dose forms can be achieved via pharmacological drugs that inhibit stomach emptying, as well as the processes associated with flotation, sedimentation, mucoadhesion, expansion, and modified shape systems (Vinchurkar, 2022). These methods suggest that floating drug delivery devices are the most promising drug delivery method for regulating medication release. FDDS have an impact upon pharmaceuticals which are harder to dissolve and unsteady in digestive contents by retaining them in the stomach. The goal of FDDS is in order to render the dose form thinner than stomach fluids, allowing it to float on them.

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Scope of FDDS

Scopes of FDDS are illustrated in Figure 1.

Floating Mechanism in Drug Delivery System

Certain drug concentrations are delivered in systemic blood circulation by solid oral dose forms like capsules and tablets without causing any control over the drug delivery system and significantly alter the drug concentrations in plasma (Afrosesoha, 2021). Oral administration is the most practicable and recommended route of getting any medicine into the systemic circulation. The pharmaceutical industry has recently demonstrated an increasing curiosity in oral controlled- release drug delivery systems as an approach of providing better therapeutic advantages (Adepu, 2021; Lou, 2023; Mishra, 2023; Alqahtani, 2021; Mishra, 2024). Characteristics as flexibility in medicinal composition, patient compliance with the product, and ease of dose administration, drugs having short half-lives along with easy absorption from Gastrointestinal Tract [GIT] are quickly getting removed from systemic circulation. To overcome this limitation, sustained-controlled delivery oral medications have been created (Devi, 2023; Desai, 1993; Sahoo, 2023; Yang, 1996). The objective is to gradually deliver the medicine into the digestive system while retaining therapeutic levels of medication in the bloodstream for an extended length of time (Soppimath, 2001). To maximise the stomach persistence of solid dose forms, processes such as expansion, flotation, mucoadhesion, sedimentation, transformed shape, or simultaneous delivery of pharmacological agents accompanied by gastric emptying are used.

Low-density systems, frequently referred to as floating systems, provide sufficient obstruction to float on the inside the stomach and maintain buoyant for an extended duration without altering the stomach emptying with respect to time. The medication will progressively flow into the system at the proper concentration while floating inside the stomach (Choi, 2002; Moursy, 2003; Jena, 2023; El-Kamel, 2001; Fabregas, 1994). As a result, the stomach will be free of the residue. These outcomes will therefore lead to an advancement with respect to GRT and also improved flux control with respect to plasma medication concentrations. It is especially useful for local drugs used in the proximal gastrointestinal tract, such as antibiotics against Helicobacter pylori infections, and pharmaceuticals that are difficult to dissolve or unsteady in intestinal fluids.

Classification of FDDS

FDDS is classified pictorially in Figure 2.

Advantages and Limitations of FDDS

Advantages and Limitations are illustrated perfectly in Figure 3.

Application of FDDS in modern Medication

As the upper GIT's floating drug delivery as well as small absorption window period delves a number of applications for drugs that have poor bioavailability (Hilton, 1992). Bioavailability is increased by preserving the dose form where it is absorbed. It can also be used to administer medications directly to the stomach via the first couple of inches of the small intestine (Cheuh, 1995; Mishra, 2024; Menon, 1994; Mishra, 2023; Gibaly, 2002). Drug retention in the stomach is also exacerbated by concurrent drug administration or pharmaceutical additives that slow down motility of GIT (Table 1 and Figure 4).

In vitro Evaluation of FDDS

Bioadhesiveness

The dosage form's capacity to stick to the stomach mucosa is evaluated to make sure it doesn't separate too soon, which could shorten the amount of time it spends there (Watanbe, 1993; Inouye, 1988; Jena, 2024; Niharika, 2018).

Bouyancy Study

This involves evaluating the floating dose form's ability to float over the stomach's fluids (Kamalakkannan, 2011; Jena, 2024; Kumari, 2018). The system is put in a gastric simulation environment, and various parameters, including viscosity and pressure, are used to quantify its buoyancy.

Drug Release Study

Under carefully monitored conditions, the degree and rate of drug release from the floating dosage form are assessed. Typically, an acidic pH 1.2 buffer solution is used to replicate the stomach's environment (Chaudhary, 2019).

In vivo Evaluation of FDDS

Floating Lag Time (FLT)

The time taken by the dosage form to start floating in stomach is also measured. This makes it easier to understand how the dose form first functioned in the gastrointestinal tract (Roshani, 2017).

Orocaecal Transit Time (OCTT)

To determine how the dosage form affects the entire gastrointestinal transit, the total transit time from the mouth to the caecum is evaluated (Jaimini, 2019).

Physiological Parameters

In order to comprehend how the dose form interacts with the gastrointestinal environment, *in vivo* investigations frequently involve monitoring physiological indicators including gastric emptying rates and pressure (Moursy, 2003; Chaudhary, 2022; Zhang, 2012; Sahoo, 2015).

Gastric Retention Time (GRT)

In vivo studies investigate the length of time the dosage form remains in the stomach (Durgapal, 2017; Harshal, 2018; Degen, 2001). It's critical for ensuring that the medicine gets released and absorbed over a long period.

Techniques Referred

Alternating Current Biosusceptometry (ACB)

This method is used to track the behaviour of *in vivo* and *in vitro* magnetic floating dose forms (Manjunath, 2017; Prajapati, 2013; Bajpai, 2007; Arunachalam, 2011). It continuously monitors and records the dose forms, offering insightful information on how well they function in various scenarios.

Pharmacokinetic and Pharmacodynamic Studies

To make sure the dosage form is delivering the medication safely and effectively, these tests measure the drug's levels in the body as well as its effects.

Emerging Technologies

Foam Power-Based Microcapsules

The creation of floating microcapsules using low-density foam powder is one of the latest developments in FDDS. The benefits of these foam powder-based microcapsules include a zero to very slight lag time before they begin to float (Ibrahim, 2009; Kerdsakundee, 2015; Mishra, 2008). The ratio of polymer with respect to foam powder, the tablet geometry, the initial drug loading, including the kind or blend of matrix-forming polymers are some of the variables that can be changed to modify how rapidly pharmaceuticals emerge from these microcapsules.

Magnetic Floating Dosage Forms

An innovative method called Alternating Current Biosusceptometry (ACB) is used to track the behaviour of magnetic floating dosage forms *in vivo* and *in vitro* in real time (Perri, 2005; Sato, 2004; Zhang, 2017). The magnetic floating dosage forms can be tracked and imaged with ACB, which offers important insights regarding how well they function in various scenarios.

Combination Approaches

An emerging concept to enhance gastric retention is combining FDDS with other gastroretentive strategies like bioadhesion or swelling/expanding systems (Kaushik, 2011). The combined effects of these systems are intended to improve the dosage form's floating ability and stomach residence time.

Marketed Products and Patented Technologies

A number of marketed goods and patented FDDS technologies are figured out. Microballoons, floating tablets, capsules, and laminated formulations with controlled drug release and good floating behaviour are a few examples.

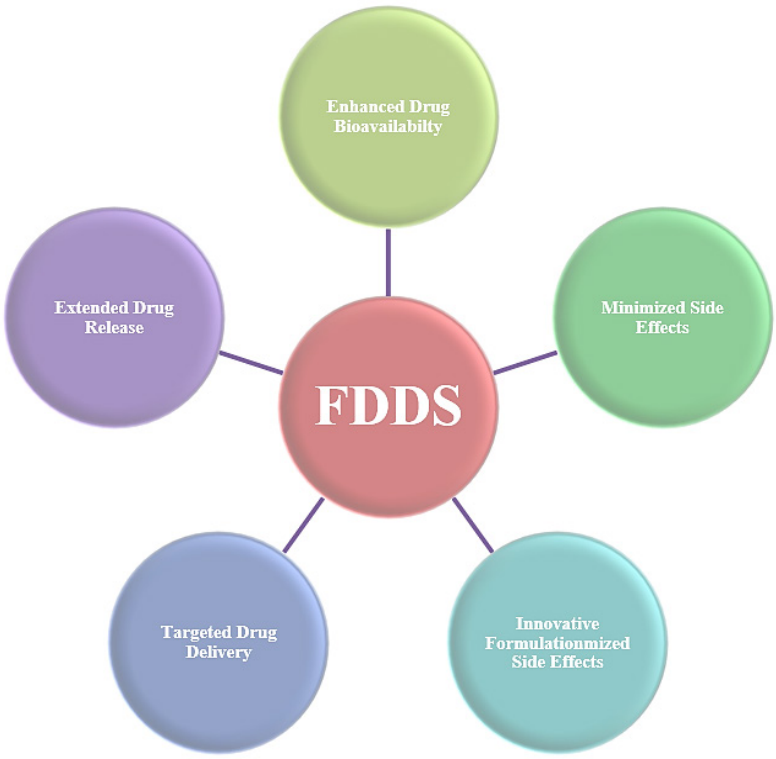

Figure 1: Scope of FDDS.

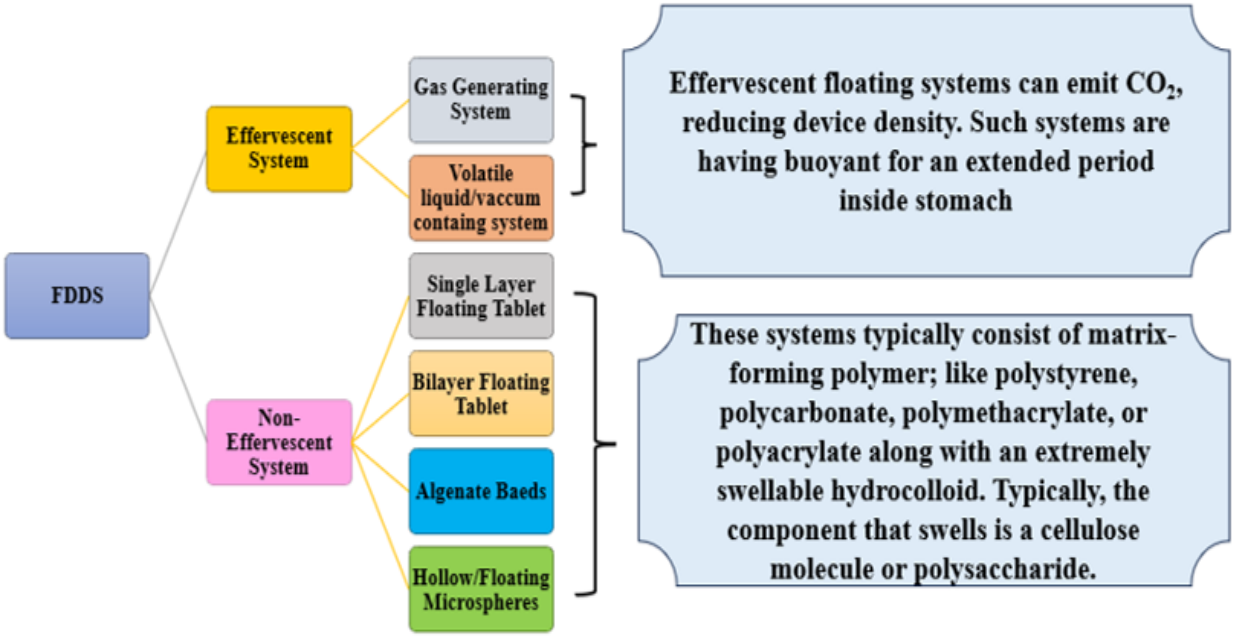

Figure 2: Categorization of FDDS.

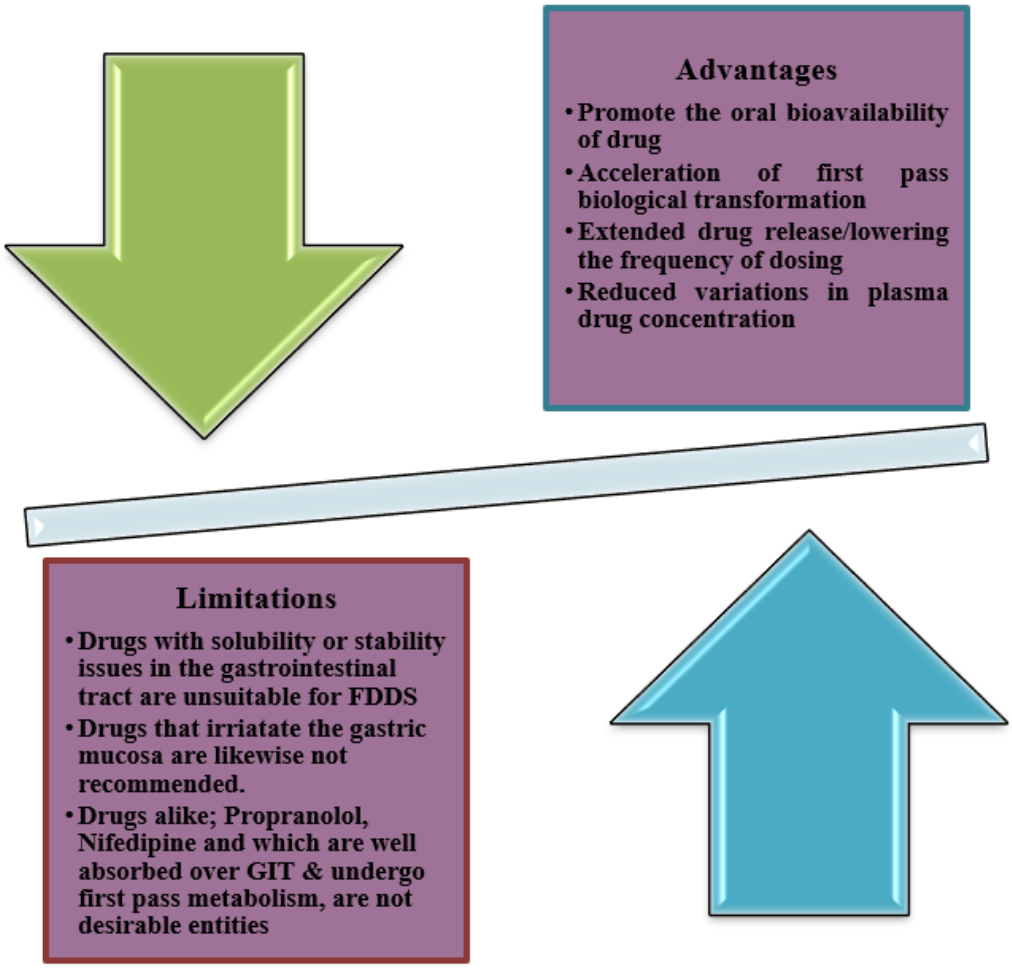

Figure 3: Interpreting Advantages and Disadvantages of FDDS.

Table 1: List of medicines investigated for different floating dose forms.

Drugs	Limitation for Bioavailability	Therapeutics
Captopril	Unstable in the intestinal environment	Treatment of Congestive Heart Failure & Hypertension.
Atenolol	Poor bioavailability from the lower GIT	Antihypertensive
Furosemide	Limited absorption windows in upper GIT.	Treatment of hepatic cirrhosis, Chronic renal failure, Congestive Heart Failure.
Verapamil	Poor solubility at alkaline pH	Antihypertensive and tachycardia distrubances.
Metoprolol Succinate	Half-life: Short Absorption window in upper GIT: Narrow	Antihypertensive Treatment of Angina, Congestive Heart Failure, Arrhythmias.
Amoxicillin	Local Action	Eradication of Helicobacter pylori.
Famotidine	Short half-life Local activity	Therapy for Reflux Esophagitis & Peptic Ulcer.

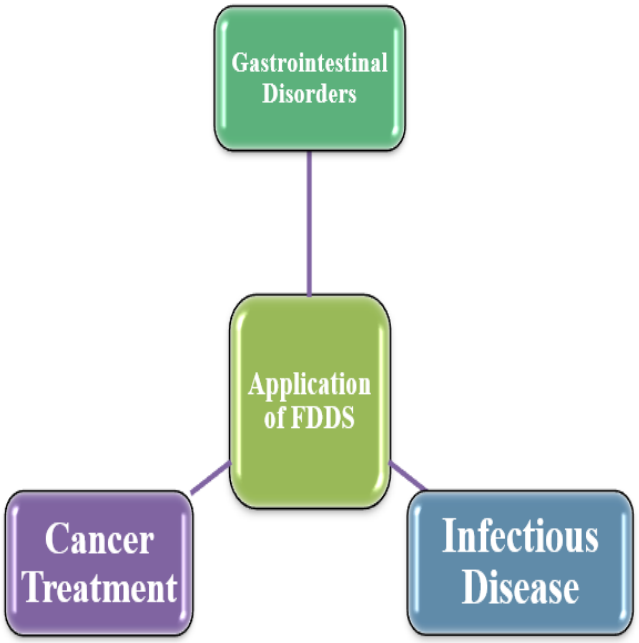

Figure 4: Pictorial Interpretation of FDDS Application.

CONCLUSION

It is quite difficult to develop an effective FDDS, because the drug delivery mechanism needs to stay in the stomach long enough. FDDS is one of the most potential gastro-retentive drug delivery systems, having been created utilising a range of methodologies and strategies. We are in the strongest position yet to see a substantial shift in the manufacture and commercialisation of gastric retention devices, beginning with research and development.

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ABBREVIATIONS

FDDS: Floating Drug Delivery System; **GIT:** Gastro Intestinal Tract; **GRT:** Gastric Retention Time; **FLT:** Floating Lag Time; **OCTT:** Orocaecal Transit Time; **ACB:** Alternating Current Biosusceptometry.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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Nil.

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