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Floating Drug Delivery System – Novel Tool for Delivering H_2 Antagonist

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ABSTRACT

Floating drug delivery systems (FDDS) or hydrodynamically controlled systems are low-density systems that have sufficient buoyancy to float over the gastric contents and remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time. Advantages of FDDS are gastro retention, prolong release, enhanced absorption, improved patient compliance, increased bioavailability etc. There are also some disadvantages like not suitable for drug insoluble in GIT, irritation in gastric mucosa etc. FDDS is classified into single unit floating systems, multiple unit floating systems and raft forming systems. There are many factors which affect FDDS are density, size and shape, fed or unfed state, nature of the meal, caloric content, frequency of feed, gender, age, posture and concomitant drug administration. There is variety of natural and synthetic polymer used in FDDS. Evaluation parameters for FDDS are buoyancy capability, floating time and dissolution, drug release etc. FDDS is applicable in sustained drug delivery, site-specific drug delivery and absorption enhancement.

INTRODUCTION[1-3]

Floating systems, first described by Davis in 1968, have bulk density lower than that of the gastric fluid and thus remain buoyant in stomach for prolong period. Floating drug delivery systems (FDDS) or hydrodynamically controlled systems are low-density systems that have sufficient buoyancy to float over the gastric contents and remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time. While the system is floating on the gastric contents, the drug is released slowly at desired rate from the system. After release of drug, the residual system is emptied from the stomach. This results in an increased Gastric retention time and a better control of the fluctuations in plasma drug concentration. However, besides a minimal gastric content needed to allow the proper achievement of the buoyancy retention principle, a minimal level of floating force (F) is also required to keep the dosage form reliably buoyant on the surface of the meal. Many buoyant systems have been developed based on granules, powders, capsules, tablets, laminated films and hollow microspheres. The gastric emptying of dosage forms is an extremely variable process and ability to prolong and control the emptying time is a valuable asset for dosage forms that reside in the stomach for a longer period of time than conventional dosage forms. There are many difficulties faced in designing controlled release systems for better absorption and enhanced bioavailability.

One of such difficulties is the inability to confine the dosage form in the desired area of the gastrointestinal tract. Gastro retentive systems can remain in the gastric region for several hours and hence significantly prolong the gastric residence time of drugs. Prolonged gastric retention improves bioavailability, reduces drug waste, and improves solubility for drugs that are less soluble in a high pH environment. It has applications also for local drug delivery to the stomach and proximal small intestines. Gastro retention helps to provide better availability of new products with new therapeutic possibilities and substantial benefits for patients. FDDS have been developed for drugs that act either locally in the stomach or absorbed from it, for those drugs that are either poorly soluble at alkaline pH or unstable in the intestinal or colonic environment. These systems help in completely releasing the drug in the vicinity of the absorption window to enhance bioavailability. Several approaches that are currently made to prolong gastric retention time include floating drug delivery systems, swelling and expanding systems, bioadhesive systems, high-density systems and other delayed gastric emptying devices. The oral route is considered to be the most common route

of drug delivery and especially oral controlled drug delivery offers numerous advantages. Effectiveness of the controlled drug delivery system depends upon the factors like gastrointestinal transit time of the dosage form, gastric residence time, gastric emptying, and pH variability in gastrointestinal (GI) tract segments, drug release and the site of absorption of drugs. These physiological limitations may result improper absorption profiles, partial drug release and shorter gastric residence time of the dosage form in the stomach; these may lead to incomplete absorption of drugs, which are having absorption windows in the upper parts of the small intestine.

A gastric floating drug delivery system (GFDDS) may be an alternative for drugs that are absorbed in the upper parts of the small intestine. The GFDDS can prolong the gastric residence time of the dosage form, thereby enhancing the drug bioavailability. GFDDS are most regularly used technique for gastric retention of the dosage form. In order to attain floating, an intimate balance required between the mass and volume of the drug delivery system. To obtain floating, the drug delivery system should have an original density of less than 1gm/cc. One of the major advantages of developing a floating drug delivery system is the capability to attain an increase in GRT without varying the gastric emptying rate. GFDDS can be further divided into hydrodynamically balanced systems, low-density systems, hot melt extrusion systems and effervescent systems. Gastric retention is beneficial for the drugs, which are less soluble in alkaline pH (e.g. verapamil, chlordiazepoxide, propranolol HCl and cinnarizine) or those that degrade in alkaline pH (e.g. captopril). Floating drug delivery systems are among the several approaches that have been developed in order to increase the gastric residence time of the dosage forms. The multiple unit systems have been developed to identify the merit over a single unit dosage form because the single unit floating systems are more popular but have a disadvantage owing to their “all-or-nothing” emptying process, leading to high variability of the gastrointestinal transit time. Still, the multiple unit dosage forms may be better suited because they are claimed to reduce the inter subject variability in absorption and lower the probability of dose dumping. Such a dosage form can be widely distributed throughout the gastrointestinal tract (GIT), which afforded the possibility of a longer-lasting retention and more reliable release of the drug from the dosage form. The synthetic polymers have been used to prepare floating microspheres. Kawashima et al. prepared hollow microspheres or micro balloons of ibuprofen by the emulsion–solvent diffusion method using acrylic polymers.

These microspheres exhibited good *in-vitro* floatability but showed drastically decreased drug release with increasing polymer concentration. Floating microspheres of cellulose acetate loaded with three different model drugs were prepared by the solvent diffusion–evaporation method. Those prepared microspheres remained buoyant for more than 12 h, but methylcellulose and chitosan micro pellets loaded with lansoprazole as a model drug have a lower density than gastric contents and exhibited better encapsulation efficiencies. Other polymer solution systems have been used to prepare floating microspheres of famotidine such as polycarbonate/dichloromethane, cellulose acetate butyrate/eudragit RL100 mixture in acetone and eudragit S100/i-propanol. Famotidine is a histaminic drug that has been widely used in treating gastric and duodenal ulceration and also in Zollinger-Ellison syndrome and reflux esophagitis. It is poorly absorbed from the lower GIT and has a short elimination half-life (3 h). Present review summarizes mechanism and types of FDDS, factors affecting and polymers used in FDDS, Dosage forms and evaluation of FDDS.

Advantages of Floating Drug Delivery System[4-5]

1. The gastro-retentive systems are advantageous for drugs absorbed through the stomach, e.g. ferrous salts, antacids. Acidic substances like aspirin cause irritation on the stomach wall when come in contact with it. Hence, HBS formulation may be useful for the administration of aspirin and other similar drugs.

2. Administration of prolongs release floating dosage forms, tablet or capsules, will result in dissolution of the drug in the gastric fluid. They dissolve in the gastric fluid would be available for absorption in the small intestine after emptying of the stomach contents. It is therefore expected that a drug will be fully absorbed from floating dosage forms if it remains in the solution form even at the alkaline pH of the intestine.

3. The gastro retentive systems are advantageous for drugs meant for local action in the stomach. E.g. antacids.

4. When there is a vigorous intestinal movement and a short transit time as might occur in certain type of diarrhea, poor absorption is expected. Under such circumstances, it may be advantageous to keep the drug in floating condition in stomach to get a relatively better response.

5. FDDS improves patient compliance by decreasing dosing frequency. Bioavailability enhances despite first pass effect because fluctuations in plasma drug concentration are avoided; a desirable plasma drug concentration is maintained by continuous drug release.

6. Better therapeutic effect of short half-life drugs can be achieved. Gastric retention time is increased because of buoyancy. Enhanced absorption of drugs which solubilize only in stomach.

7. Superior to single unit floating dosage forms as such microspheres releases drug uniformly and there is no risk of dose dumping.

8. Avoidance of gastric irritation, because of sustained release effect, floatability and uniform release of drug through multi-particulate system.

Disadvantages[4-5]

1. Floating system is not feasible for those drugs that have solubility or stability problem in G.I. tract. These systems require a high level of fluid in the stomach for drug delivery to float and work efficiently-coat, water.

2. The drugs that are significantly absorbed throughout gastrointestinal tract, which undergo significant first-pass metabolism, are only desirable candidate. Some drugs present in the floating system causes irritation to gastric mucosa.

Mechanism of Floating Systems[6]

Various attempts have been made to retain the dosage form in the stomach as a way of increasing the retention time. These attempts include introducing floating dosage forms

- Gas-generating systems
- Swelling or expanding
- Mucoadhesive systems
- High-density systems
- Low density system

Floating drug delivery systems (FDDS) have a bulk density less than gastric fluids and so remain buoyant in the stomach without affecting the gastric emptying rate for a prolonged period of time. The drug is released slowly at the desired rate from the system. After release of drug, the residual system is emptied from the stomach. This results in an increased GRT and a better control of the fluctuations in plasma drug concentration. However, besides a minimal gastric content needed to allow the proper achievement of the buoyancy retention principle, a minimal level of floating force (F) is also required to keep the dosage form reliably buoyant on the surface of the meal. To measure the floating force kinetics, a novel apparatus for determination of resultant weight has been reported in the literature. The apparatus operates by measuring continuously the force equivalent to F (as a function of time) that is required to maintain the submerged object. The object floats better if F is on the higher positive side. This apparatus helps in optimizing FDDS with respect to stability and durability of floating forces produced in order to prevent the drawbacks of unforeseeable intragastric buoyancy capability variations.

$$F = F\,(\text{buoyancy}) - F\,(\text{gravity}) = (DF - Ds)\,gv \text{--- (1)}$$

Where,

F= total vertical force

DF = fluid density

Ds = object density

V = volume of GI fluid

g = acceleration due to gravity

Types of FDDS on The Basis of Mechanism[7-8]

A. Single Unit Floating Dosage Systems: In single unit systems, such as capsules or tablets, effervescent substances are incorporated in the hydrophilic polymer and CO_2 bubbles are trapped in the swollen matrix e.g.; Bilayer system.

Single unit formulations are associated with problems such as sticking to one another or obstruction to gastrointestinal tract, which may result in local irritation. The main drawback

of such systems is the "all or none" phenomenon. In such cases, a danger of the dosage form passing into intestine when of housekeeper waves are produced.

Multiple unit dosage forms have been designed to overcome this problem.

a) ***Effervescent Systems (Gas-generating Systems):*** These buoyant systems utilized matrices prepared with swellable polymers like HPMC, polysaccharides like chitosan, effervescent components like sodium bicarbonate, citric acid and tartaric acid or chambers containing a liquid that gasifies at body temperature. The optimal stoichiometric ratio of citric acid and sodium bicarbonate for gas generation is reported to be 0.76:1. The common approach for preparing these systems involves resin beads loaded with bicarbonate and coated with ethyl cellulose. The coating, which is insoluble but permeable, allows permeation of water. Thus, carbon dioxide is released, causing the beads to float in the stomach. Excipients used most commonly in these systems include HPMC, polyacrylate polymers, polyvinyl acetate, Carbopol®, agar, sodium alginate, calcium chloride, polyethylene oxide and polycarbonates.

b) Non-effervescent Systems: This type of system, after swallowing, swells unrestrained via imbibitions of gastric fluid to an extent that it prevents their exit from the stomach. These systems may be referred to as the "plug-type systems" since they have a tendency to remain lodged near the pyloric sphincter. One of the formulation methods of such dosage forms involves the mixing of drug with a gel, which swells in contact with gastric fluid after oral administration and maintains a relative integrity of shape and a bulk density of less than one within the outer gelatinous barrier. The air trapped by the swollen polymer confers buoyancy to these dosage forms.

Examples of this type of FDDS include,

Colloidal gel barrier: First designated this hydrodynamically balanced system. These types of system contain drug with gel forming hydrocolloids which allow them to remain buoyant on the stomach content. This prolongs to GRT and maximizes the amount of drug at its absorption site in solution form for ready absorption. Suitable hydrocolloids are synthetics, anionic or non-ionic like hydrophilic gums, modified cellulose derivatives. e. g. Acacia, pectin, agar, alginates, gelatin, casein, bentonite, veegum, MC, HPC, HEC, and Na, CMC can be used. The hydrocolloids must hydrate in acidic medium i.e. gastric fluid is having pH 1.2.

Although the bulk density of the formulation may initially be more than one, but when gastric fluid enters in the system

B. Multiple Unit Floating Systems: Multiple unit floating systems lowers the probability of dose-dumping. It involves development of both non-effervescent and effervescent multiple unit systems. Much research has been focused and the scientists are still exploring the field of hollow microspheres, capable of floating on the gastric fluid and having improved gastric retention properties. Multiple unit floating system is subdivided into non-effervescent and effervescent system.

a) Non-effervescent Systems: A multiple unit HBS containing indomethacin as a model drug prepared by extrusion process is reported. A mixture of drug, chitosan and acetic acid is extruded through a needle, and the extrudate is cut and dried. Chitosan hydrates and floats in the acidic media and the required drug release could be obtained by modifying the drug polymer ratio.

b) Effervescent Systems (Gas-generating Systems): Sustained release floating granules containing tetracycline hydrochloride. The granules are a mixture of drug granulates of two stages A and B, of which A contains 60 parts of HPMC, 40 parts of polyacrylic acid and 20 parts of drug and B contains 70 parts of sodium bicarbonate and 30 parts of tartaric acid. 60 parts by weight of granules of stage A and 30 parts by weight of granules of stage B are mixed along with a lubricant and filled into capsule. In dissolution media, the capsule shell dissolves and liberates the granules, which showed a floating time of more than 8 h and sustained drug release of 80% in about 6.5 h. Eg pepstain – floating mini capsules, Sustained release pills.

c) Hollow Microspheres: Hollow microspheres are considered as one of the most promising buoyant systems, as they possess the unique advantages of multiple unit systems as well as better floating properties, because of central hollow space inside the microsphere. Polymers such as polycarbonate, Eudragit® S and cellulose acetate were used in the preparation of hollow microspheres. e. g. The research group of kawashima prepared hollow microspheres based on blends of Eudragit S and HPMC.

C. Raft Forming Systems: Raft forming systems have received much attention for the delivery of antacids and drug delivery for gastrointestinal infections and disorders. The mechanism involved in the raft formation includes the formation of viscous cohesive gel in

contact with gastric fluids, wherein each portion of the liquid swells forming a continuous layer called a raft. This raft floats on gastric fluids because of low bulk density created by the formation of carbon dioxide. Usually, the system contains a gel forming agent and alkaline bicarbonates or carbonates responsible for the formation of Carbon dioxide to make the system less dense and float on the gastric fluids, Jorgen et al. described an antacid raft forming floating system. The system contains a gel forming agent (e.g. alginic acid), sodium bicarbonate and acid neutralizer, which forms a foaming sodium alginate gel (raft) when in contact with gastric fluids. The raft thus formed floats on the gastric fluids and prevents the reflux of the gastric contents (i.e. gastric acid) into the esophagus by acting as a barrier between the stomach and esophagus. e.g.; Alginate raft forming floating system, Antacid raft forming floating system.

Factors Affecting Floating Drug Delivery Systems[9]

There are numerous factors that affect FDDS, some of the important factors are given below:

a. Density: Density of the dosage form should be less than the gastric contents (1.004gm/ml) and so remain buoyant in the stomach without affecting the gastric emptying rate for prolonged period of time. While the system is floating on the gastric contents, the drug is released slowly at desired rate from the system.

b. Size and Shape: Dosage form unit with a diameter of more than 7.5 mm are reported to have an increased Gastric residence time competed to with those with a diameter of 9.9 mm. The dosage form with a shape tetrahedron and ring shape devices with a flexural modulus of 48 and 22 kilopond's per square inch (KSI) are reported to have better GIT for 90 to 100 % retention at 24 hours compared with other shapes.

c. Fed or Unfed State: Under fasting conditions, the GI motility is characterized by periods of strong motor activity or the migrating myloelectric complexes (MMC) that occur every 1.5 to 2 hours. The MMC sweeps undigested material from the stomach and if the timing of administration of the formulation coincides with that of the MMC, the GRT of the unit can be expected to be very short. However, in the fed state, MMC is delayed and GRT is considerably longer.

d. Nature of the meal: Feeding of indigestible polymers of fatty acid salts can change the motility pattern of the stomach to a fed state, thus decreasing the gastric emptying rate and prolonging the drug release.

e. Caloric Content: GRT can be increased between 4 to 10 hours with a meal that is high in proteins and fats.

f. Frequency of feed: The GRT can increase by over 400 minutes when successive meals are given compared with a single meal due to the low frequency of MMC.

g. Gender: Mean ambulatory GRT in meals (3.4±0.4 hours) is less compared with their age and race-matched female counterparts (4.6±1.2 hours), regardless of the weight, height and body surface.

h. Age: Elderly people, especially those over 70 years have a significantly longer GRT.

i. Posture: GRT can vary between supine and upright ambulatory states of the patients.

j. Concomitant drug administration: Anticholinergic like atropine and propantheline, opiates like codeine and prokinetic agents like metoclopramide and cisapride, affect the gastric emptying and hence gastric residence time of an oral dosage form.

Polymers used in floating drug delivery system[9]

Use of polymeric material particularly of biodegradable type has gained lot of importance during the last two decades in drug delivery research. The most of the commercial biodegradable polymers investigated for use in controlled drug delivery come under the class.

- Lactides/glycolides
- Polyanhydrides
- Polycaprolactones
- Polyorthoesters
- Polyphosphothiazines
- Polypseudoaminoacids

Polymers Employed FDDS[9]

Synthetic	Natural
HPMC K4M	Sodium alginate
HPMC K15M	Pectin
HPMCK100M	Tragacanth
Carbopol 934 p	Gelatin
Polyvinyl alcohol	Carrageenan
Polyamides	Guar gum
Polycarbonates	Chitosan
Polymethacrylic acid	Okra gum
Polymethyl methacrylic acid	Gellan gum

Floating Dosage Forms

Floating Tablets[10-11]: Floating tablet is the new era for the successful development of controlled release formulation. It is also beneficial to active gastric retention by forming floating tablets with active pharmaceutical ingredient and also to increase the life cycle of drug product.

Floating tablets of H_2 antagonist (Ranitidine) can be developed with the help of some reagents such as methocel K100, methocel K15M, magnesium stearate, hydrochloric acid, sodium bicarbonate, citric acid anhydrous, lactose, purified talc and PVP K-30.

Floating Granules[12]: This is a multiple-unit floating system. It is beneficial for gastric retention.

Floating granules of H_2 antagonist (Ranitidine HCL) can be developed with the help of some reagents such as Gelucire 43/01, EC, MC, HPMC & conc. HCL.

Floating Microspheres[13]: A controlled release system designed to increase its residence time in the stomach without contact with the mucosa was achieved through the preparation of floating microspheres. Techniques involved in their preparation include simple solvent evaporation, and solvent diffusion and evaporation. The drug release and better-floating properties mainly depend on the type of polymer, plasticizer and the solvents employed for the preparation.

Floating microspheres of H_2 antagonist (Famotidine) can be developed with the help of some reagents such as cellulose acetate, acrycoat S100, polyvinyl alcohol, HCL, tween 80, dichloromethane, ethanol, etc.

Evaluation Parameters of Stomach Specific FDDS[14]

1. Measurement of buoyancy capabilities of the FDDS: The floating behavior can be evaluated with resultant weight measurements. The experiment was carried out in two different media, deionized water in order to monitor possible difference. The apparatus and its mechanism are explained earlier in this article. Studies showed that higher molecular weight polymers with slower rate of hydration had enhanced floating behavior and it was observed more in simulated meal medium compared to deionized water.

2. Floating time and dissolution: The test for floating time measurement is usually performed in simulated gastric fluid or 0.1 moles/lit HCl maintained at 37°C. It is determined by using USP dissolution apparatus containing 900 ml of 0.1mole/lit HCl as the dissolution medium at 37°C. The time taken by the dosage form to float is termed as floating lag time and the time for which the dosage form floats is termed as the floating or flotation time. A more relevant *in-vitro* dissolution method proposed to evaluate a floating drug delivery system (for tablet dosage form). A 100 ml glass beaker was modified by adding a side arm at the bottom of the beaker so that the beaker can hold 70 ml of 0.1 mol/lit HCl dissolution medium and allow collection of samples. A burette was mounted above the beaker to deliver the dissolution medium at a flow rate of 2 ml/min to mimic gastric acid secretion rate. The performance of the modified dissolution apparatus was compared with USP dissolution. Apparatus 2 (Paddle): The problem of adherence of the tablet to the shaft of the paddle was observed with the USP dissolution apparatus. The tablet did not stick to the agitating device in the proposed dissolution method. The drug release followed zero-order kinetics in the proposed method. Similarity of dissolution curves was observed between the USP method and the proposed method at 10% difference level (f2=57). The proposed test may show good *in-vitro-in-vivo* correlation since an attempt is made to mimic the *in-vivo* conditions such as gastric volume, gastric emptying, and gastric acid secretion rate.

3. Drug release: Dissolution tests are performed using the dissolution apparatus. Samples are withdrawn periodically from the dissolution medium with replacement and then analyzed for their drug content after an appropriate dilution.

4. Content uniformity, hardness, friability (for tablets)

Content uniformity is carried out as per procedure specified on respective pharmacopoeia. Hardness and friability are determined by following procedure same as for conventional tablet dosage form.

5. Drug loading, drug entrapment efficiency, particle size analysis, surface characterization (for floating microspheres and beads): Drug loading is assessed by crushing accurately weighed sample of beads or microspheres in a mortar and added to the appropriate dissolution medium which is then centrifuged, filtered and analyzed by various analytical methods like spectrophotometry. The percentage drug loading is calculated by dividing the amount of drug in the sample by weight and simulated meal, total beads or microspheres. The particle size and the size distribution of beads or microspheres are determined in the dry state using the optical microscopy method. The external and cross-sectional morphology (surface characterization) is done by scanning electron microscope (SEM).

6. X-Ray/Gamma scintigraphy: X-Ray/Gamma scintigraphy is a very popular evaluation parameter for floating dosage form now a day. It helps to locate dosage form in the GIT and by which one can predict and correlate the gastric emptying time and the passage of dosage form in the GIT. Here the inclusion of a radio-opaque material into a solid dosage form enables it to be visualized by X-rays. Similarly, the inclusion of a γ-emitting radionuclide in a formulation allows indirect external observation using a γ-camera or scintiscanner (Harries and Sharma, 1990). In case of γ-scintigraphy, the γ-rays emitted by the radionuclide are focused on a camera, which helps to monitor the location of the dosage form in the GI tract.

7. Pharmacokinetic studies: Pharmacokinetic studies are the integral part of the *in-vivo* studies and several works have been on that. The pharmacokinetics studies of verapamil, from the loading pellets containing drug, filled into a capsule, and compared with the conventional verapamil tablets of similar dose (40mg). The tmax and AUC (0-infinity) values (3.75h and 364.65ng/mlh, respectively) for floating pellets were comparatively higher than those obtained for the conventional verapamil tablets (tmax value 1.21h, and AUC value 224.22ng/mlh). No much difference was found between the Cmax values of both the formulations, suggesting the improved bioavailability of the floating pellets compared to the conventional tablets. An improvement in bioavailability has also been observed with

piroxicam in hollow polycarbonate microspheres administered in rabbits. The microspheres showed about 1.4 times more bioavailability, and the elimination half-life was increased by about three times than the free drug.

8. Resultant weight determination: Bulk density and floating duration have been the main parameters to describe the adequacy of a dosage form's buoyancy. Although single density determination does not predict the floating force evolution of the dosage form because the dry material of it is made progressively reacts or interacts within the gastric fluid to release its drug contents.

Application of FDDS[15]

Floating drug delivery offers several applications for drugs having poor bioavailability because of the narrow absorption window in the upper part of the gastrointestinal tract. It retains the dosage form at the site of absorption and thus enhances the bioavailability. These are summarized as follows:

Sustained Drug Delivery: HBS systems can remain in the stomach for long periods and hence can release the drug over a prolonged period of time. The problem of short gastric residence time encountered with an oral controlled release formulation hence can be overcome with these systems. These systems have a bulk density of <1 as a result of which they can float on the gastric contents. These systems are relatively large in size and passing from the pyloric opening is prohibited.

Site-Specific Drug Delivery: These systems are particularly advantageous for drugs that are specifically absorbed from stomach or the proximal part of the small intestine, e.g., riboflavin and furosemide. Furosemide is primarily absorbed from the stomach followed by the duodenum. It has been reported that a monolithic floating dosage form with prolonged gastric residence time was developed and the bioavailability was increased. AUC obtained with the floating tablets was approximately 1.8 times those of conventional furosemide tablets.

Absorption Enhancement: Drugs that have poor bioavailability because of site specific absorption from the upper part of the gastrointestinal tract are potential candidates to be formulated as floating drug delivery systems, thereby maximizing their absorption. e.g. A significantly increase in the bioavailability of floating dosage forms (42.9%) could be

achieved as compared with commercially available LASIX tablets (33.4%) and enteric coated LASIX-long product (29.5%).

CONCLUSION:

FDDS can be helpful for delivering H_2 antagonists such as ranitidine, famotidine etc. for the treatment of hyperacidity and peptic ulcer disease. The drug delivering approaches are floating granules, floating tablets and floating microspheres and can be evaluated by buoyancy capability, floating time, drug release, weight determination, x-ray/gamma scintigraphy, pharmacokinetic studies, hardness and friability. Ultimately FDDS is useful in sustained drug release, site specific drug delivery, absorption enhancement.

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