CODEN (USA): IJPB07 ISSN: 2320-9267

Indian Journal of Pharmaceutical and Biological Research (IJPBR)

Journal homepage: www.ijpbr.in

Review Article

A review on gastroretentive drug delivery system

Shailaja Pant*, Ashutosh Badola, Preeti Kothiyal

Division of Pharmaceutical Sciences, S.G.R.R.I.T.S, Patel Nagar Dehradun-248001, Uttarakhand, India.

ARTICLE INFO:

Article history:

Received: 26 May 2016
Received in revised form:
30 May 2016
Accepted: 10 June 2016
Available online: 30 June 2016

Keywords:

Floating system*;*
Non-floating system,
Gastric residence time,
Evaluation parameter

ABSTRACT

Oral controlled release and site specific drug delivery system has been of great interest in pharmaceutical field to achieve improved therapeutic advantage. Concept of novel drug delivery system arose to overcome certain aspect related to physicochemical properties of drug molecule and the related formulations. Gastro retentive drug delivery system is one of such novel approaches to prolong gastric residence time, thereby targeting site specific drug release in the stomach for local or systemic effects. This approach is useful particularly for the drugs which have narrow absorption window in the upper part of gastro intestinal tract. In this review we have been discussed various approaches of gastro retentive drug delivery system, such as floating and non-floating systems.

Introduction

The goal of any delivery system is to provide a therapeutic amount of drug to proper site in the body to achieve promptly and then maintain a desired drug concentration. Oral drug delivery system is the oldest and most preferable route of drug delivery due to the ease of administration, patient compliance and flexibility in formulation. Oral dosage forms are intended for systemic effects resulting from drug absorption through gastro intestinal tract. Therefore, different approaches have been proposed to retain the dosage form in the stomach. These include floating systems, bioadhesive systems, swelling, expanding systems, delayed gastric emptying systems and low density super porous systems. Oral drug delivery system is the most preferable route of drug delivery due to the ease of administration, patient compliance, non-evasive in nature and flexibility formulation. From immediate release to site specific delivery, oral dosage forms have really progressed. Many orally administered drugs display poor bioavailability when administered as a conventional dosage form, i.e. the rate and extent to which the drugs are absorbed is less than desirable. With several drugs, absorption may be as little as 30% or less of orally administered dose. To compensate for this effect, a very large dose is often administered so that absorption of therapeutically required quantity of drug can occur. This technique may prove costly with expensive drugs; and the absorbed drug may also have undesirable side effect within the gastrointestinal tract. In addition, poorly absorb drug often display large inter and intra variability in bioavailability. This problem may overcome by modified release drug delivery system with prolonged residence time in the stomach[1].Gastroretentive drug delivery system (GRDDS) is thus beneficial for such drugs by improving their bioavailability, therapeutic efficacy and by possible reduction of dose. Drug absorption in the gastrointestinal tract is a highly variable procedure and it depends upon the factors such as gastric emptying process, gastrointestinal transit time of dosage forms, drug release from the dosage form, and site of absorption of drugs [2,3] Drugs that are easily absorbed from the gastro intestinal tract (GIT) and have short half-lives are eliminated quickly from the systemic circulation. Frequent dosing of these drugs is required to achieve suitable therapeutic activity. Also, the drugs which have a narrow absorption window (NAW) in the upper part of GIT are not suitable for oral sustained release drug delivery system due to the brief gastric emptying time as tablets have 2.7 ± 1.5 hours (h) stomach transit and 3.1 ± 0.4 h intestinal transit time[4], thus the bioavailability of such drugs having absorption window in stomach is generally limited. Gastro retentive drug delivery is one of those approaches to prolong gastric

***Corresponding Author: Shailaja Pant,** Division Of Pharmaceutical Sciences ,S.G.R.R.I.T.S Dehradun,Uttarakhand, India. **E-Mail:** shailjapant2501@gmail.com

residence time, thereby targeting site specific drug release in the stomach for local or systemic effects. These dosage forms can remain in the gastric region for long periods and hence significantly prolong the gastric retention time of the drugs. It will release the drug in stomach in a controlled manner, so that the drug could be supplied continuously to absorption site in GIT i.e. stomach [5]

Need for GRDDS [6]

• Conventional oral delivery is widely used in pharmaceutical field to treat diseases. However, conventional delivery had many drawbacks and major draw-back is non-site specificity.

• Some drugs are absorbed at specific site only. They require release at specific site or a release such that maximum amount of drug reaches to the specific site.

• Pharmaceutical field is now focusing towards such drugs which require site specificity.

• Gastro-retentive delivery is one of the site specific deliveries for the delivery of drugs either at stomach or at intestine. It is obtained by retaining dosage form into stomach and drug is being released at controlled manner to specific site either in stomach, duodenum and intestine.

Merits [7]

- Delivery of drugs with narrow absorption window in the small intestine region.
- Longer residence time in the stomach could be advantageous for local action in the upper part of the small intestine, for example treatment of peptic ulcer disease.
- Improved bio-availability is expected for drugs that are absorbed readily upon release in the GI tract such as cyclosporine, ciprofloxacin, ranitidine, amoxycillin, captopril, etc.
- Patient compliance by making a once a day therapy.
- Improved therapeutic efficacy.
- Reduces frequency of dosing.
- Targeted therapy for local ailments in the upper GI tract.
- The bioavailability of therapeutic agents can be significantly enhanced especially for those which get metabolized in the upper GIT by this gastroretentive drug delivery approach in comparison to the administration of non gastroretentive drug delivery.
- Gastroretentive drug delivery can produce prolong and sustain release of drugs from dosage forms which avail local therapy in the stomach and small intestine. Hence they are useful in the treatment of disorders related to stomach and small intestine.
- Gastroretentive drug delivery can minimize the counter activity of the body leading to higher drug efficiency.
- Prolongs the residence time of the dosage form at the site of absorption.
- To avoid the first pass metabolism.
- Excellent accessibility.
- Rapid absorption because of enormous blood supply and good blood flow rates.
- Increase in drug bioavailability due to first pass metabolism .
- Site-specific drug delivery.
- Minimizing mucosal irritation by drugs, by drug releasing slowly at a controlled rate.
- Minimizing mucosal irritation by drugs, by drug releasing slowly at a controlled rate.

Demerits [7]

- Floating systems has limitation, that they require high level of fluids in stomach for floating and working efficiently. So more water intake is prescribed with such dosage form.
- In supine posture (like sleeping), floating dosage form may swept away (if not of larger size) by contractile waves. So patient should not take floating dosage form just before going to bed.
- Drugs having stability problem in high acidic environment, having very low solubility in acidic environment and drugs causing irritation to gastric mucosa cannot be incorporated into GRDDS.
- Bio/mucoadhesives systems have problem of high turnover rate of mucus layer, thick mucus layer & soluble mucus related limitations.
- Swellable dosage form must be capable to swell fast before its exit from stomach and achieve size larger than pylorus aperture. It must be capable to resist the housekeeper waves of Phase III of MMC.
- Gastric retention is influenced by many factors such as gastric motility, pH and presence of food. These factors are never constant and hence the buoyancy cannot be predicted.
- The major challenge for a bioadhesive system is the high turnover rate of gastric mucus.
- There is also possibility of esophageal binding with bioadhesive drug delivery systems.
- Drugs which have stability and solubility problems in GI T are not suitable candidates for these types of systems.

Physiology of the stomach [8]

The Gastrointestinal tract is essentially a tube about nine meters long that runs through the middle of the body from the mouth to the anus and includes the throat (pharynx), esophagus, stomach, small intestine (consisting of the duodenum, jejunum and ileum) and large intestine (consisting of the cecum, appendix, colon and rectum). The wall of the gastrointestinal tract has the same general structure throughout most of its length from the esophagus to the anus, with some local variations for each region. The stomach is an organ with a capacity for storage and mixing. The antrum region is responsible for the mixing and grinding of gastric contents. The interdigestive motility pattern is commonly called the 'migrating motor complex' ('MMC') and is organized in cycles of activity and quiescence. Each cycle lasts 90–120 minutes and consists of four phases. The concentration of the hormone motilin in the blood controls the duration of the phases. In the interdigestive or fasted state, an MMC wave migrates from the stomach down the GI tract every 90–120

minutes. A full cycle consists of four phases, beginning in the lower esophageal sphincter/gastric pacemaker, propagating over the whole stomach, the duodenum and jejunum, and finishing at the ileum. Phase III is termed the 'housekeeper wave' as the powerful contractions in this phase tend to empty the Stomach of its fasting contents and indigestible debris. The administration and subsequent ingestion of food rapidly interrupts the MMC cycle, and the digestive phase is allowed to take place. The upper part of the stomach stores the ingested food initially, where it is compressed gradually by the phasic contractions. The digestive or fed state is observed in response to meal ingestion. It resembles the fasting Phase II and is not cyclical, but continuous, provided that the food remains in the stomach. Large objects are retained by the stomach during the fed pattern but are allowed to pass during Phase III of the interdigestive MMC. It is thought that the sieving efficiency (i.e. the ability of the stomach to grind the food into smaller size) of the stomach is enhanced by the fed pattern or by the presence of food (Fig. 1 and 2).

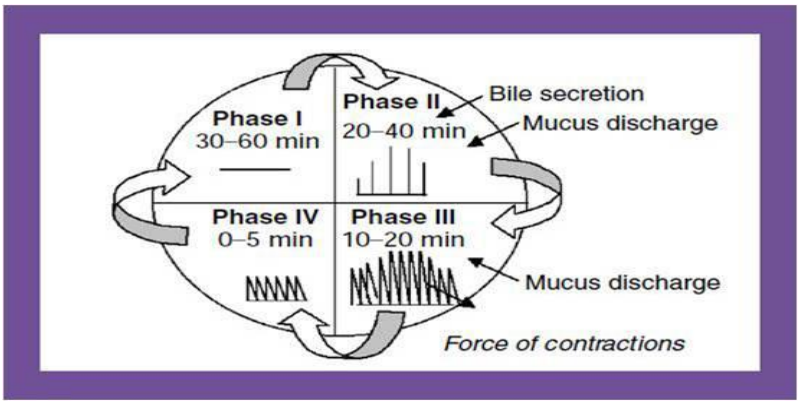

Figure 1: Phase of gastric cycle

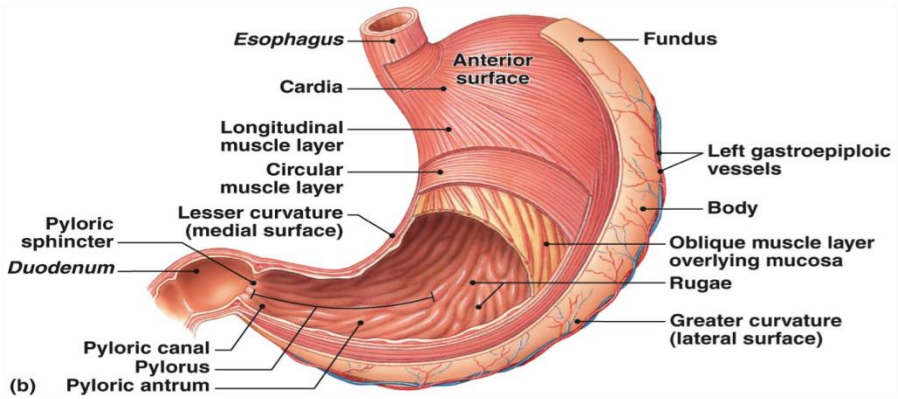

Figure 2: physiology of stomach

Different features of stomach

Gastric pH: Fasted healthy subject 1.1 ± 0.15
Fed healthy subject 3.6 ± 0.4

Volume: Resting volume is about 25-50 ml

Gastric secretion: Acid, pepsin, gastrin, mucus and some enzymes about 60 ml with approximately 4 mm of hydrogen ions per hour.

Effect of food on Gastric secretion: About 3 liters of secretions are added to the food. Gastro intestinal transit time.

Factors influencing gastric residence time [9]

- Density of dosage form: Dosage forms having density lower than that of gastric fluids experience floating behavior and greater gastric residence time.
- Size of dosage form: In most cases larger the size greater the gastric residence time because larger size will not allow dosage form to quickly pass through pyloric spincter to intestine.
- Food intake and nature of food: Usually presence of food in stomach increases the GRT of the dosage form and increases drug absorption by allowing it to stay at absorption site for longer time.
- Affect of age, gender, posture and disease state: Elderly persons and females has slow gastric emptying rate. It was found that gastric emptying in women is slower than in men regardless of height, weight, body surface area.

- When individual rests on left side floating of dosage form will be towards pyloric antrum. If rests on right side it will be in opposite direction.

- Shape of dosage form: Tetrahedrons (each leg 2 cm long), rings (36 cm diameter) exhibited nearly 100% retention at 24 hrs. Whereas on other hand cloverleaves (2.2-3.3 cms) exhibit (40- 67%) retention.

Ideal drug characteristics for gastrointestinal drug delivery system [10]

- Drug acting locally in the stomach antacids and drug for H.Pylori via Misoprostol.
- Drugs that are primary absorbed in the stomach and upper part of GIT. E.g. Amoxicillin and calcium supplement, Cinnarazine, Chlordiazopoxide.
- Drug that is poorly soluble at alkaline pH e.g. Furosemide, Diazepam , Verapamil HCl
- Drug which are absorbed rapidly from GI. E.g. Riboflavin,PABA, Cyclosporine, Methotrexate, Levodopa, Captopril, Ranitidine HCl, Metronidazole, Metformin HCl.
- Drug that degrade or unstable in colon. E.g. Captopril, ranitidine HCl, metronidazole ,metformin HCl.
- Drug that disturb normal colonic microbes, e.g. Amoxicillin Trihydrate, Antibiotic against Helicobacter Pylori.

Different approaches of gastrointestinal drug delivery system

Different approaches have been pursued to increase the retention of oral dosage forms in the stomach. Some are formulated as single component whereas others are formulated as multi- component dosage forms. GRDDS can be broadly categorized into floating and non-floating system.

- **Floating system**
- **Non-floating system:**
  Bioadhesive system
  Swelling system
  High density system
  Expendable system
- **Floating drug delivery system (FDDS)[11]**

The floating system is intended to float in and over the gastric content resulting in prolonged gastric retention time (GRT). It is a low density approach which has a bulk density lower than gastric fluids and hence remains buoyant in the stomach, releasing the drug slowly without affecting the gastric emptying rate for a prolonged period of time. After the drug is released from the stomach, the delivery system is expelled.

Mechanism of floating drug delivery system:

Floating systems are low density systems that have sufficient buoyancy to float over the gastric contents and remain in the stomach for a prolonged period. While the system floats over the gastric contents, the drug is released slowly at the desired rate, which results in increased gastro-retention time and reduces fluctuation. 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 as shown in fig. 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 [12]

F = F buoyancy – F gravity = (DF – Ds) gv--- (1)

Where, **F**= total vertical force, **DF** = fluid density, **Ds**= object density, **v** = volume and **g** = acceleration due to gravity.

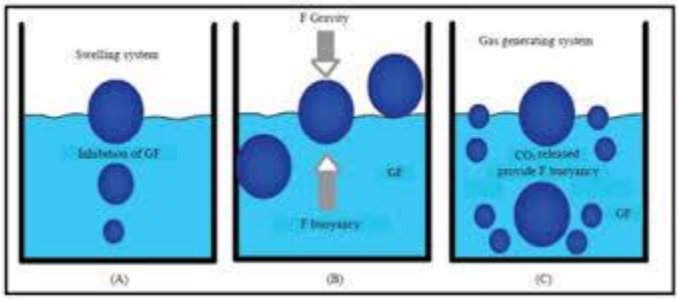

Figure 3:Mechanism of floating system

Classification of floating drug delivery system

Based on the byouncy mechanism, floating system are classified as fellows:

(A) **Effervescent system:**

1. Gas generating system

2. Volatile liquid containing system.

(B) **Non- effervescent system:**

1. Colloidal gel barrier system
2. Microporous compartment system
3. Floating microspheres
4. Alginate floating beads
5. Raft forming system

Effervescent system

These are matrix type of system. Prepared with the help of swellable polymer such as methylcellulose and Chitosan and various effervescent compounds.

Ex: sodium bicarbonate, tartaric acid, citric acid. These are formulated in such a way that when they come in contact with gastric content, CO_2 is liberated and gets entrapped in swollen hydrocolloid which provides Buoyancy to dosage form. The design of delivery system was based on swellable asymmetric triple layer tablet approach [13]

These systems are further classified as below:

1. Gas generating system

The main mechanism is involved in this system is the production of CO_2 gas due to reaction between sodium bi carbonate, citric acid and tartaric acid. The gas produced result in the reduction of density of system thereby making it to float on the gastric fluids. Salts and citric/tartaric acid release CO_2 , which entrapped in the jellified hydrocolloid layer of the system which decrease its specific gravity and making it float over chime. The system consist of a sustain release pill as seed surrounded by double layers. The inner layer is an effervescent layer containing sodium bi carbonate and tartaric acid. The outer layer is of a swellable membrane layer containing PVA shellac etc [14-16].it is further divided as:

Floating capsule: these are prepared by formulating mixture of sodium bi carbonate and sodium alginate. On exposure to acidic environment, CO_2 gas is generated which is trapped in the hydrating gel network and makes the system to float.

Floating pills: these are a type of sustained release formulations which are basically multiple types of unit dosage forms. The sustained release pill is surrounded by two layers. Outer layer consists of swellable membrane and the inner layer consists of effervescent agents. The systems swell due to swellable membrane and then sink. Due to presence of effervescent agent, CO_2 is released and the system floats.

Floating system with ion exchange resin: The most common approach for formulating these systems involves resin beads loaded with bi carbonates. This is then coated with ethyl cellulose which is usually insoluble but permeable to water .this causes carbon di oxide to release and the system to float.

2. Volatile liquid containing system:

These have an inflatable chamber which contain a liquid e.g. ether, cyclopentane, that gasify at body temperature to cause the inflation of the chamber in the stomach. These systems are osmotically controlled floating system containing a hollow deformable unit. These are two chambers in the system first contain the drug and the second chamber containing the volatile system.

These are classified as:

a. Intra gastric floating gastrointestinal drug delivery system: this system contains a floatation chamber which contains vacuum or an inert, harmless gas and a micro porous compartment enclosing drug reservoir.

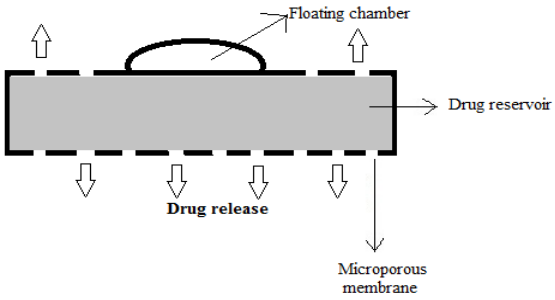

Figure 4: Intra gastric floating gastrointestinal drug delivery system

b. Inflatable gastrointestinal drug delivery system: These systems possess inflatable chamber containing liquid ether which gasifiers at body temperature to inflate the stomach. Inflatable chamber contains bio erodible polymer filament (e.g. Copolymer of poly vinyl alcohol and poly ethylene) that gradually dissolves in gastric fluid and finally cause inflatable chamber to release gas and collapse.

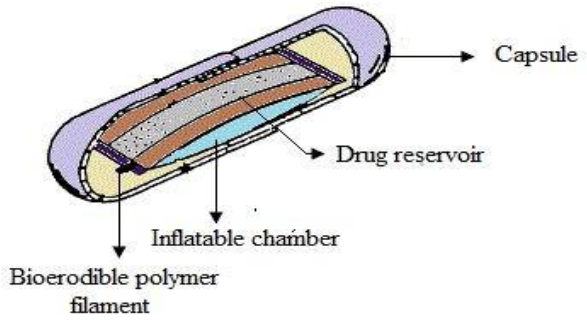

Figure 5: Inflatable gastrointestinal drug delivery system

c. Intra-gastric osmotically controlled drug delivery system: It is composed of osmotic pressure controlled drug delivery device and an inflatable floating capsule. In the stomach, inflatable capsule disintegrates and release the osmotically controlled drug delivery system which contains two components: drug reservoir compartment and osmotically active compartment[17-19]

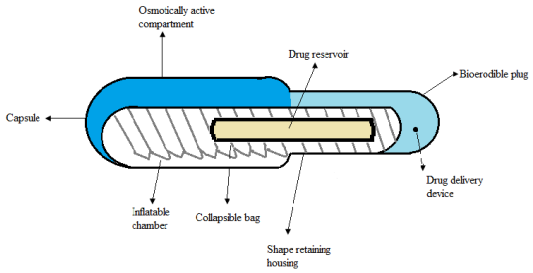

Figure 6: Intra-gastric osmotically controlled drug delivery system

Non effervescent system: These are a type of floating gastro retentive drug delivery system in which gel forming hydrocolloids, polysaccharides and matrix forming polymers like polycarbonate, polystyrene, polymethacrylate etc. are used. These are further classified as follows:

a. Colloid gel based system: Hydrodynamically balanced system (HBS), which contains drugs with gel forming hydrocolloids, was first designed by Sheath and Tossounian in 1975. These systems incorporate a high level (20- 75%w/w) of one or more gel forming, highly swellable, cellulose type hydrocolloids, polysaccharides and matrix forming polymers. On coming in contact with gastric fluid, the hydrocolloids in the system hydrate and form a colloidal gel barrier around its surface. This gel barrier controls the rate of fluid penetration into the device and consequent release of the drug[21]

b. Microporous compartment system: This technology is based on the encapsulation of a drug reservoir inside a micro porous compartment with apertures along its top and bottom walls. The peripheral walls of the drug reservoir compartment are completely sealed to prevent any direct contact of the gastric mucosal surface with the undissolved drug[21]

c. Floating microspheres: Hallow microspheres are considers as most promising buoyant system as they are more advantageous because of central hallow space inside the microsphere. Hallow microsphere is loaded with drug in their outer polymer shelf were prepared by a novel emulsion solvent Diffusion method[22]

d. Alginate floating beads: Multi-unit floating dosage forms have been developed from freeze calcium alginate [23]. Spherical beads of approximately 2.5 mm in diameter can be prepared by dropping sodium alginate solution into aqueous solution of calcium chloride. Causing the precipitation of calcium alginate. The beads are than separated, snap-frozen in liquid nitrogen and freeze-dried at 400C for 24 h, leading to the formation of a porous system, this can maintain a floating force for over 12 h. these floating beads gave a prolonged residence time of more than 5.5 h.

e. Raft forming system: Raft forming system has received much attention for the delivery of antacid and drug Delivery for gastro infection and disorders on contact with gastric fluid a gel forming Solution swells and forms a viscous cohesive gel containing entrapped co2 bubbles. Which Forms raft layer on top of gastric fluid which releases drug slowly in stomach. (Often used for gastro oesophageal reflux treatment[24]

- **Non-floating system:** These gastro retentive drug delivery systems do not float in the stomach however they remain retained there by different mechanism.

Bioadhesive system: These types of systems adhere to the biological membrane (mucosa) of the stomach and maintain intimate contact with the membrane for a

longer time and hence retains in stomach for its prolonged release. These systems are formulated using bio adhesive polymers.

Figure 7: Bioadhesive system

Swelling system: These are a type of non-floating gastro retentive drug delivery system which when enters to stomach , swells (due to presence of swell able polymers) to an extent that cannot pass through the pyloric sphincter leading to its retention in the stomach

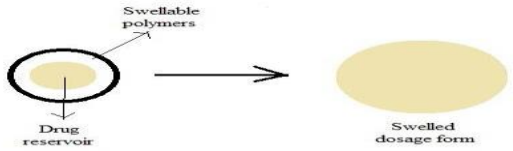

Figure 8: Swelling system

High density system: These systems possess density greater than the gastric fluids due to which the system sinks to the bottom and remains in the stomach. These are formulated by coating drug on heavy inert materials like zinc oxide, titanium dioxide, iron powder, etc.

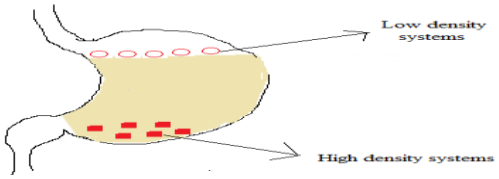

Figure 9: High and low density systems

Expandable system: These systems are capable of expanding and retain in the stomach for longer periods. These are usually formulated as a capsule containing dosage form folded and compact form. After being exposed to stomach environment, capsule shell disintegrates and dosage form expands preventing its exit through the stomach. By using a suitable polymer, sustained and controlled drug delivery can be achieved.

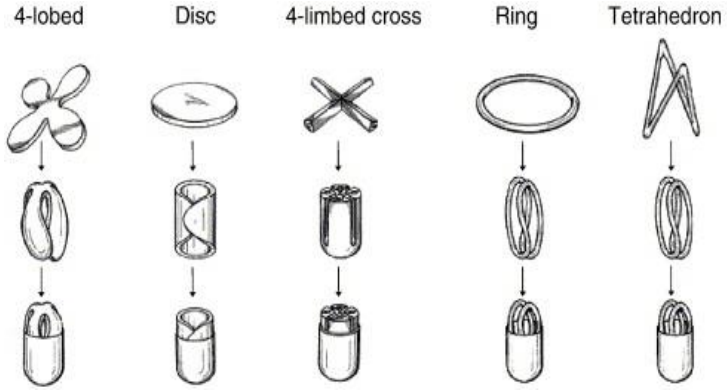

Figure 10: Expandable systems

Marketed products of Gastroretentive drug delivery system [24]

Following are some gastroretentive products which are available in market

BRAND NAME	ACTIVE INGREDIENTS
Cifran OD®	Ciprofloxacin
Madopar®	LDopa and Benserazide
Valrelease®	Diazepam
Topalkan®	Aluminium-magnesium antacid
AlmagateFlatCoat®	Aluminium-magnesium antacid
Liquid Gavision®	Aluminium hydroxide
Conviron®	Ferrous sulfate
cytotec®	Misoprostal

Evaluation parameter of gastroretentive drug delivery system

Floating system: 6 stage dissolution test apparatus is used. 0.1N, 900 ml HCl is used as dissolution media. The time required to emerge on surface of medium (Floating lag time) and Total duration of floating time is measured. *In-vitro* studies are done at temperature of 37 ^{0}C for duration as specified (approx. 8 hours).

Mucoadhesive system: Bio-adhesive strength is measured. Cellophane membrane is used, similar to mucosa of stomach or intact mucosa from rabbit is taken. When mucosa is there bio adhesive polymer sticks to it and force required to separate is measured. Force required to separate gives measure of strength of the polymer.

Swellable system: We check the water uptake. Water uptake gives idea of swelling index. We also check Weight, diameter and increase in thickness. Dissolution test is done using 0.1N HCl as dissolution fluid.

Swelling index (S.I) = $(W_t - W_0 / W_0)$ X 100

W_t = Final weight after water uptake, W_o = Initial weight.

Micro balloons:

Fourier transform infra-red spectroscopy (FTIR) analysis: The FTIR analysis was done for the analysis of drug polymer interaction. FT-IR spectra of Pure Drug, Eudragit RS 100, HPMC and floating micro balloons were recorded using Shimadzu 8700 FTIR spectrophotometer.

Micromeritics: The prepared micro balloons were characterized for micromeritics properties, such as particle size, bulk density, tapped density, compressibility index and flow properties

Morphology: The dried micro balloons were coated with gold film under vacuum using a sputter coater. The surface part of micro balloons was observed under scanning electron microscopy (Joel JSM-1600, Tokyo, Japan)

Floating behavior: Fifty milligrams of the floating micro balloons were placed in simulated gastric fluid (pH 1.2, 100 ml) containing 0.02 w/v% Tween 20. The mixture was stirred at 100 rpm in a magnetic stirrer. After 6h, the floating and the settled portion of micro balloons were recovered separately by filtration. The micro balloons were dried and weighed. Both the fractions of microspheres were weighed and buoyancy was determined by the weight ratio of floating particles to the sum of floating and sinking particles.

Buoyancy (%) = $W_f / (W_f + W_s) \times 100$

Where W_f and W_s are the weights of floating and settled micro particles respectively

***In-vitro* release study:** The drug release rate from micro balloons was determined using USP XXIII basket type dissolution apparatus. A weighed amount of hollow microspheres equivalent to 20 mg drug was filled into a capsule (# 3) and placed in the basket. Simulated gastric fluid (SGF, pH-1.2) (900 ml) containing Tween 20 (0.02 w/v %) was used as the dissolution medium and maintained at 37± 0.5° C at a rotation speed of 100 rpm. Perfect sink conditions prevailed during the drug release studies. 5ml sample was withdrawn at each 1h interval, passed through a 0.5µm membrane filter (Millipore) and analysed spectrophotometrically at 296 nm to determine the concentration of drug present in the dissolution medium. The initial volume of the dissolution fluid was maintained by adding 5 ml of fresh dissolution fluid after each withdrawal. All experiments were conducted in triplicate.

Stability study: The prepared floating micro balloons, best formulation was selected on basis of buoyancy and the percentage drug released. The selected formulation was placed in borosilicate screw capped glass containers and stored at different temperatures (27±2°C), oven temperature (40±2°C) and in the refrigerator (5-8°C) for a period of 90 days. The samples were assayed for drug content (drug entrapment) at regular intervals.

Polymer and other material used in the formulation of GRDDS

CATEGORY	MATERIALS
Polymers	HPMC K4M, HPMC K100, calcium alginate, CMC, Eudragit RL, Eudragit S100, Eudragit RS, polyethylene glycol, B cyclodextrin.
Inert fatty material (5-75%)	Edible inert materials having a specific gravity less than 1 can be used to decrease hydrophilic property of formulation and hence increase buoyancy e.g. bees wax, fatty acid.
Effervescent	Sodium bi carbonate, citric acid, tartaric acid
Release rate accelerants (5-65%)	Lactose, mannitol
Release rate retard (5-60%)	Talc, magnesium stearate, di calcium phosphate,
Buoyancy increasing agent (up to 80%)	Ethyl cellulose
Low density material	Propylene foam powder

Conclusion

Gastro retentive drug delivery technologies have been extensively explored in recent years. gastro retentive drug delivery systems are the most preferable systems in order to deliver the drugs which have a narrow absorption window near the gastric region. Now a day's numbers of drug delivery devices are being developed which aim at releasing the drug at gastric region. Even though these drug delivery systems have several advantages. They also have disadvantages like their *in-vitro in-vivo* correlation is very less. It is necessary to take into consideration the physiological event in the GIT, selection of correct combinations of drugs and excipients and design appropriate formulation strategies.

Reference

1. Timmermans J, MoesAJ. How Well Floating Dosage F orm Float?. Int J Pharm 1990; 62:207-16.
2. Strebeul A, Siepmann J &Bodmeier R, Gastro retentive drug delivery system, Expert Opin Drug Deliv,2006;3(2): 217.
3. Bardonnet PL, Faivre V, Pugh WJ, Piffaretti JC &Falson F, Gastroretentive dosage forms: overview and special case of Helicobacter pylori, J Control Release2006;111:1.
4. Pawar VK, Kansal S, Garg G, Awasthi R, Singodia D & Kulkarni GT, Gastroretentive dosage forms: A review with special emphasis on floating drug delivery systems, Drug Delivery, 2011 ;18: 97.
5. Nayak AK, Maji R & Das B, Gastroretentive drug delivery system: A review, Asian Journal of Pharmaceutical and clinical research, 2010 ;3(2):1.
6. W. Chien Yie, Concepts and System Design for Rate Controlled Drug Delivery in Novel Drug Delivery System, 2nd Edn., New york, Marcell Dekker Inc. (1992).
7. Joseph R. Robinson and Vincent H. L. Lee, Controlled Drug Delivery, Fundamentals and Applications, 2nd Edition, Revised and Expanded, Marcell. Dekker Inc., New York (2009).
8. Y. Madhusudan Rao, A. V. Jithan, Advances in Drug Delivery, Vol. II, Pharma. Med. Press, Hyderabad (2011).
9. S. P. Vyas and Roop K. Khar, Controlled Drug Delivery, Concepts & Advances, Vallabh Prakashan, Delhi (2012).
10. International journal of research in pharmaceutical and Biomedical sciences , Review Article.
11. Novel drug delivery system- Y.W.Chien. Pg no. 1-42
12. Wilson CG, Washington N, The Stomach: its role in the oral drug delivery. In: Rubinstein MH, ed, Physiological Pharmaceutical: biological barriers to drug absorption, chic ester, UK: EllisHorwood; 1989; 47Y70.
13. Roop K khar, controlled drug delivery, gastroretentive system 4th edition, 202-203.
14. Khan F.N, Dehghan H.G, Int J Health Res 2009; 2(1): 23
15. Kamalakkannan V, puratchikody A, Prasanth VV and masilamani K: Enhancement of drugs bioavailability by floating drug delivery system – A Review, international journal of drug delivery 2011; 1; 558-70
16. Suryawanshi A and Hiremath SP: floating drug delivery system- a review, American journal of pharmatech research 2011; 2(1): 138-53
17. Jain N.K, "Advances in Controlled & Novel Drug Delivery", CBS Publishers & Distributers , New Delhi ,Pg-76-95
18. Brahmankar D.M., "Bio pharmaceutics and pharmacokinetics'', vallabh prakashan, New Delhi , pg – 335-370.
19. Narang N: an updated review on: floating drug delivery system (FDDS). International Journal of Applied pharmaceutics 2011; 3(1): 1-7.

20. Chandiran S, kumar BP and nayaran V; formulation an *in vitro* evaluation of floating drug delivery system for salbutamol sulphate, international journal of pharma biomed sciences 2010; 1(1): 12-15.

21. Satinder kakar, Ramandeep Singh, Shallu sandhan, Gastroretentive drug delivery systems: A review,AJPP.2015;.9(12):405-417

22. Geetha A, Rajendra K Mohan CHK, Sateesh V and Raju PN: A review on floating drug delivery systems, international journal of pharmaceutical research and biomedical analysis 2012; 1(1) :1-13.

23. Wu, W, Zhou Q Zhang HB, Ma, G, D, Fu, CD, Studies on mimodipine sustained release tablet capable of floating on gastriv fluids with prolonged gastric residence time, Yao, Xue, Xue, Bao, 1997; 32; 786Y790.

Cite this article as: **Shailaja Pant, Ashutosh Badola, Preeti Kothiyal.** A review on gastroretentive drug delivery system. **Indian J. Pharm. Biol. Res.2016; 4(2):1-10.**