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SYNTHETIC AND NATURAL POLYMERS: IMPORTANCE ON GASTRO RETENTIVE DRUG DELIVERY SYSTEM

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ABSTRACT

Background: Natural polymers in industrial applications such as medicine, agriculture, and other fields quickly increase. The increasing usage of natural biodegradable polymers in the pharmaceutical area has been seen. **Aim:** This paper aims to summarise the function of artificial and biological polymers in drug delivery systems for gastroprotective drugs. **Methodology:** a comprehensive description of all processes, interventions, and comparisons; artificial and natural polymers are being investigated. **Results:** Various natural polymers are utilised longer as drug transporters in drug distribution methods to increase bioavailability and therapeutic efficacy. Natural polymers in gastroprotective drug delivery systems have floating properties in the gastric system to increase gastric resident time and improve therapeutic efficacy. Especially for drugs with narrow therapeutic indexes like carvedilol, itopride, and glipizide. **Conclusion:** Natural polymers promote prolonged swelling, and the mucosal layer binding property makes natural polymers suited for gastroprotective drug delivery systems compared to synthetic polymers.

Keywords: Gastroprotective drug delivery systems, Natural polymer, Synthetic polymer, Formulation, Drug transport

INTRODUCTION

Administration by mouth is the most appropriate and recommended mode of medication transfer to the systemic circulation. The pharmaceutical industry has recently become interested in sustained drug delivery to gain more significant pharmacological benefits such as simplicity of dosage distribution, improved bioavailability, and versatility in the formulation. Drugs have quick half-lives and they are swiftly excreted through the bloodstream after absorption via the GI (Gastrointestinal tract). To oral sustained-release formulations, gently release medicines into the gastrointestinal tract while maintaining a therapeutic agent concentration in the blood circulation that is effective for a longer length of time **[1]**. Following oral delivery, the medication will reach the stomach and be released in a regulated manner, allowing it to continually get its absorption sites in the GI system **[2]**. Gastro retentive drug delivery method is practical for medications with low absorption in the more flawed gastrointestinal system, is unresolved at alkaline pH, has a limited shelf life, and has a modest impact on eliminating Helicobacter pylori upper gastrointestinal tract **[3, 4]**.

The gastro retentive dosage form can be affected by nonionic, cationic, and anionic configurations, viscosity grade, molecular weight, and polymer-drug solubility **[5]**. Drug delivery methods for the gastrointestinal tract the physicochemical qualities of the excipient are essential. For example, in effervescent floating systems, the mass of excipients and the mix of effervescent agents are critical parameters. Swellings like crospovidone and sodium carboxymethylcellulose are needed to create highly porous hydrogel systems **[6, 7]**.

Drug delivery system

For the first time, the phrase "drug carrier" was used to refer to a system capable of incorporating a precise number of molecules to improve their selectivity, bioavailability, and efficiency. The efficiency of a drug carrier during delivery is contingent upon the presence of an adequate protective barrier. This barrier can significantly reduce mass flow and diffusion between the inner core and the exterior bulk. Another critical aspect of the carrier's character is the behaviour of the bulk, which can be water, gel, or even a blood-like medium.

Polymers are required as excipients in all dosage forms. They have an impact on medication release and should be steady, cost-effective and non-toxic. Natural polymers and synthetic polymers are the two primary categories. Because of their potential applications in domains such as

environmental protection and physical health, synthetic and natural-based biodegradable polymers have gotten much attention in recent decades. Agriculture, medical packaging, and other industries use biodegradable materials. There has been a surge in interest in biodegradable polymers in recent years. There are two different types of polymers: artificial and biological polymers. Because artificial polymers may be produced into various shapes, they are commonly employed in biomedical implants and devices. Natural polymers are polysaccharides, which means they're biocompatible and have no adverse side effects.

The oral route is still common way to provide therapeutic medicines. Patient compliance is good because of inexpensive and suitability of drug administration **[8]**. In controlled-release medication delivery systems, drugs are released at a predetermined and predictable rate. For oral controlled-release medication delivery systems to be effective, the medicine must be absorbed efficiently across the whole digestive tract. The standard oral dosing form maintains a consistent medication concentration in the systemic circulation while allowing for significant variation in plasma drug levels.

A gastro retentive drug delivery targets site-specific medication release in the upper gastrointestinal tract for local or systemic effects by extending stomach residence time. It helps increase a drug's bioavailability and therapeutic efficacy **[9]**. The process of drug absorption in the gastrointestinal tract is highly varied. It is also affected by stomach emptying, dosage form, gastrointestinal transit duration, drug release from the dosage form, and drug absorption location **[10]**. The capacity to manage and prolong the emptying time of dose forms that stay in the stomach for more extended periods than standard dose forms is valuable. Physiological variability, such as gastrointestinal transit and stomach retention duration, is a critical issue that significantly impacts the overall transit of the dose form **[11]**. Not all medication candidates are absorbed uniformly throughout the gastrointestinal tract is a key stumbling block in oral controlled medication delivery. Some medications are only interested in a portion of the gastrointestinal tract, whereas others are interested in numerous gastrointestinal tract segments to varying degrees **[12, 13]**.

Physiology of the Gastrointestinal System

Understanding GI physiology and the related gastric emptying process is critical to the efficacy of the gastro retentive medication delivery system. The fundus, body, and antrum are the three anatomical regions that make up the human stomach **[14]**. The typical volume after a meal is

approximately 1.5, fluctuating between 250 and 500 ml during the inter-digestive stages. The fundus and body serve as storage areas for any undigested matter, while the antrum is the primary mixing location. By a propelling step, the antrum acts as a pump for stomach emptying. Pylorus acts as a barrier between the stomach and the duodenum, allowing ingested materials to spend more time in the stomach **[15]**. The pattern of stomach motility differs depending on whether you're fasting or eating. The pattern of stomach motility is systematised in cycles of activity and inactivity. Each cycle lasts 90–120 minutes and is divided into four phases. The stomach motility pattern is frequently linked to the migrating motor complex **[16]**.

Function of stomach

The fundus is the most important component of the stomach; the body and antrum are the most important parts. The fundus and body are responsible for food storage, while the antrum is responsible for food grinding and sieving. The stomach is made up of mucosa that lacks gastric pits **[17]**.

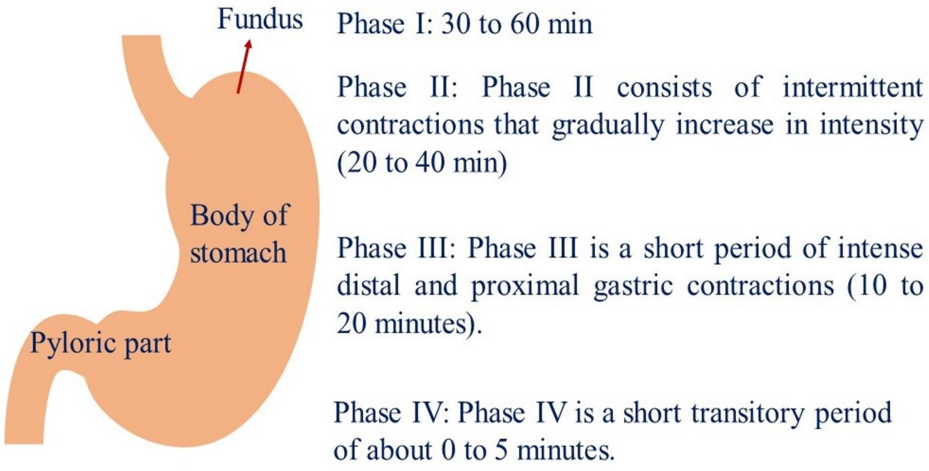

Figure 1: Anatomy of the Stomach in Schematic Form

Polymers

Monomers combine to produce polymers, which have high molecular weights. Poly means 'many,' and meros denotes units in Greek. They are made up of various functional groups. Polymers are widely employed in medications due to their unique features. The novel polymer-based medication release system technology opens up new possibilities for drug administration **[18]**. These polymers are employed in pharmaceuticals as a binder in tablets, as flow-regulating agents in liquids, suspensions, emulsions, and film coating agents to mask the medication's unpleasant taste, improve drug stability, and adjust the

drug's release characteristics. The initial drug concentration and relaxation of polymer chains determine the drug release rate from a matrix product with a controlled delivery characteristic. The purpose of developing a sustained release medication delivery system is to reduce dose frequency while increasing drug effectiveness at the desired place, reducing or eliminating side effects and ensuring consistent medication administration. Because drug delivery is more feasible, sustained-release has gotten the most attention **[19]**.

In a floating system, polymers are utilised to target medicine delivery to a specific region of the Gastrointestinal system. Floating medication delivery uses both synthetic and natural polymers. In the floating method, natural and synthetic polymers are employed **(Table 1)**.

Table 1: List of various natural polymers and synthetic polymers used for formulations

S. No.	Natural polymers	Synthetic polymers
1	Gum Karaya	HPMC
2	Guar gum	Eudragit
3	Carrageenan	ethyl cellulose
4	Pectin	Hydroxypropyl methylcellulose
5	Locust Bean Gum	
6	Chitosan	
7	Tamarind Gum	
8	Xanthan gum	
9	Gellan gum	
10	Sodium alginate	
11	Tara Gum	
12	Colocasia esculenta gum	

Gum Karaya

Sterculia gum is derived from Sterculiaurens Roxburgh and is known as Gum Karaya. Gum Karaya usually yields D-galactose, D-galacturonic acid, L-rhamnose, and minor amounts of D-glucuronic acid after acid hydrolysis. Water is sparingly soluble; 0.1N HCl and simulated gastric juice are weakly soluble; 95 per cent ethanol is mildly insoluble. Because gum karaya swells in water, it is employed as a release rate regulating polymer in many formulations. It had a high rate of erosion and a low hydration capacity. It had a high rate of erosion and a low hydration capacity. Zero-order drug release is being investigated, as well as matrices erosion **[20]**.

Guar gum

Guar gum is made from the kernels of Cyamopsis tetragonolobus and belongs to the Leguminosae family. It's a yellowish-white powder with a distinct flavour. It is soluble in water but not in organic solvents. Guar gum can improve viscosity and is utilised in pharmaceutical companies as a disintegrant and binder in solid oral dosage forms **[21]**.

Carrageenan

Carrageenans are high molecular weight anionic gel-forming polysaccharides isolated from red seaweed species such as

Euchema, Chondrus crispus, and Iridaea. Carrageenans are commonly used in the food industry for their excellent physical functional qualities, such as bulking, thickening, stabilising, and gelling. It showed to be beneficial as a tablet excipient agent due to its high durability, good compatibility, and persistent viscoelasticity during granulation and compression. As a result, carrageenans are a good excipient for long-acting formulations. Carrageenans are commonly used in the food industry for their excellent physical functional qualities, such as bulking, thickening, stabilising, and gelling. It showed to be beneficial as a tablet excipient agent due to its high durability, good compatibility, and persistent viscoelasticity during granulation and compression. Carrageenans are thus appropriate excipients for formulations with a long release time **[22, 23]**.

Pectin

Pectin is a non-toxic and cost-effective polysaccharide found in apple pomaces and citrus peels. A complex structure underpins both the extraction procedure and the source pectin. Pectin's capacity to form gel based on the degree of esterification and molecular size, it's an attractive pharmaceutical application, such as a drug transporter for controlled release applications **[24]**.

Locust Bean Gum

Locust bean gum is a neutral galactomannan polymer obtained from the seeds of the leguminous plant Ceratonia siliqua Linn. It is made up of 1, 4-linked D-mannopyranosyl units with every fourth or fifth chain unit replaced on C6 with a D-glucopyranosyl unit. The use of locust bean gum as a gelling, stabilising, and thickening agent is more successful, and it has a wide range of applications in preparation and development **[25]**.

Chitosan

It is a linear cationic polysaccharide made up of glucosamine and N-acetylglucosamine. Deacetylation of chitin derived from crab shells is used to make chitosan. Chitosan is non-toxic, biodegradable, and biocompatible, and It's utilised as a viscosity improver, mucoadhesive, film-forming agent, tablet binder, coating agent, and disintegrant **[26]**.

Tamarind Gum

Tamarind is a kind of xyloglucan that comes from the seeds of the tamarind tree, which belongs to the Tamarindus indica family. Tamarind gum is a polysaccharide with a 1:2:3 ratio of galactosyl, xylosyl, and glucosyl. In the pharmaceutical and food sectors, xyloglucan, a key structural polysaccharide found in higher plant main cell walls, is employed as a binder, gel-forming agent, stabiliser, and thickening. The wet granulation technique is used to test the drug release characteristics of

tamarind gums utilised in the formulation of matrix tablets. In the production of tablets, several polymer concentrations are used. Increased polymer content leads to a decrease in medication release **[27]**.

Xanthan gum

Xanthomonas campestris is a bacterium that naturally produces xanthum gum. This gum appears as an odourless, fine powder that flows freely. This gum is a stable polymer with a D-glucose backbone similar to that of cellulose. It's utilised in medicine and pharmaceutical goods and topical and oral pharmaceutical formulations and preparations because it's non-toxic and non-irritating. It's also utilised as a thickener, a stabilising agent, a gelling agent, a viscosity-increasing agent, a suspending agent, and an emulsifier.

Gellan gum

Gellan gum is the linear deacetylated extracellular high-molecular anionic polysaccharide. All qualities of this gum are flavour release, gel strength, stability, flexibility of the process, excellent clarity, powerful film-shaping, and thermally reversible gel. Gellan gum is a fermentation product manufactured by Spingomonas elodea **[28]**.

Sodium alginate

The primary element of sodium alginate is the sodium salt of alginic acid, a combination of polyuronic acids comprised of D-mannuronic acid and L-guluronic acid residue. The sodium alginate samples were examined for their molecular weight and block structure **[29]**.

Tara Gum

It is made from the endosperm of Caesalpinia spinosa seeds and comes from the Leguminosae or Fabaceae family. Tara gum is a white powder with no odour. Like guar and locust bean gums, Galactomannan polymers have a main linear chain of (1-4)—D-mannopyranose units with (D-galactopyranose units linked by (1-6) links. At a concentration of 1 per cent, the ratio of galactose to mannose is 1:3, resulting in very dense thick solutions. Tara gum is used to prepare controlled release gastro-retentive tablets and pharmaceutical emulsions such as nifedipine, hydrochloride metformin, carvedilol, clozapine and ciprofloxacin. The combination of tara gum with additional substances boosts the dose form's floating time. Emulsions are also made with Tara Gum.

Colocasia esculenta gum

Colocasia esculenta is a plant in the Araceae family that is frequently cultivated in Southeast Asia's tropical climates. Underground tubers with a high carbohydrate content. When water comes into touch with the mucilage of Colocasia tubers, it quickly hydrates and expands. Mucilage from isolated tubers has long-term release qualities and can be used as a

swelling polymer in various Gastro-retentive drug delivery systems **[30]**.

Synthetic Polymers

Pharmaceuticals are increasingly relying on synthetic polymers. Polymers are massive macromolecules that cover a range of useful groups. Artificial polymers can be wholly artificial or semi-synthetic, which is a modification of a natural polymer. A synthetic polymer is used as a binder, film coating agent, and other applications.

Hydroxypropyl methylcellulose (HPMC)

HPMC is a polymer that binds, retains water, thickens, forms films, and lubricates. They are white to off-white, odourless, and water-soluble. It's a semi-synthetic, inert, viscoelastic polymer found in various commercial products as an excipient and controlled-delivery component in oral medicaments.[31] Methoxy and hydropropoxy groups are found in HPMC. When it dissolves in water, it forms a colloidal solution. Specific grades are acetone used as a solvent. They are commonly employed as a bioadhesive, coating action, controlled-release capacity, emulsifying agent and a thickness agent for oral, ocular, nasal and topical formulations **[32]**. They are employed to extend the tablet as a tablet binder with a coating solution and a high grade of viscosity to release reverse action **[33]**.

Eudragit

Eudragit is a spherical substance. Eudragit, which is made by polymerising acrylic and methacrylic acids, is primarily utilised in spray atomisation procedures for coating materials and flavour masking agents in oral dosage forms. The glass transition temperature of these materials is 90-150°C. Its two polymers, L and S, are non-biodegradable, non-absorbent, and non-toxic. A pH of 6 is employed for coating grade L, while for colon targeting systems, seven is used **[34]**. The quaternary amino groups in RS and RL are utilised for sustained release. Eudragit E cannot dissolve at pH five and hence prevents the administration of medicines through the salivary glands. Eudragit is available in various forms, including dispersion, organic solution, granular, and powder. We've reviewed their solubility, description, and applicability based on grade **[35]**.

Ethylcellulose

Cellulose, which contains hydroxyl groups and is used for microencapsulation, is cellulose. It has a melting point of 240-255 °C and is white, odourless and tasteless. It is not biodegradable, not poisonous, does not cause irritation, and is available in three grades: K, N, and T. The kind of K has a group of ethoxy 44,47,9%, N a group of 4 8% to 49% and T a group of ethoxy 49,6% to 51% **[36]**.

CONCLUSION

Natural polymers are promising biodegradable properties and are also less expensive compared to synthetic polymers. Gums and mucilages offer several advantages over synthetic materials. In the realm of medicines, gums and mucilages have a variety of applications. Other natural sources and changing current natural materials must be developed to formulate novel drug delivery systems. Because of gums' ubiquity, low cost, and biodegradability, formulation scientists have had to devise methods to make them acceptable for changing the drug release of dosage forms.

Site-specific techniques have been developed in these delivery systems for a variety of purposes. Molecules' disease-specific action in this technology is achieved by using several polymeric situations that, depending on the site-specificity, have been implemented in these delivery systems for localization and disease-specific molecular action in such technologies, using the many polymeric conditions. The polymer selection and concentration will vary depending on the type of system and the dosage forms used in the study. If a high-density polymer is employed, the GRDDS technology and techniques will alter. Many formulations are available based on the systems and dosage forms, including tablets, beads, gel, and capsule forms.

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