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AN OVERVIEW ON OKRA (*ABELMOSCHUS ESCULENTUS)* MUCILAGE AS A BINDER FOR GASTRO RETENTIVE DRUG DELIVERY SYSTEM(GRDDS)

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ABSTRACT

Oral drug delivery is the most commonly used route due to its safety and patient convenience. However, many drugs show reduced bioavailability because of rapid gastric emptying. Gastroretentive drug delivery systems (GRDDS) are designed to remain in the stomach for a longer time and improve drug absorption. This review focuses mainly on floating drug delivery systems and the use of natural polymers in (GRDDS). Okra (Abelmoschus esculentus) mucilage is a natural polysaccharide with good swelling and binding properties. It is extracted from okra pods and shows suitable physicochemical characteristics for pharmaceutical use. Okra mucilage acts as an effective binder and matrix-forming agent in gastroretentive formulations. Being natural, biodegradable, and economical, it offers advantages over synthetic polymers. This review concludes that okra mucilage has good potential use in (GRDDS) formulations.

INTRODUCTION

The most practical and favoured method of distribution to systemic circulation is oral administration. The pharmaceutical industry has recently become more interested in oral controlled release drug delivery in order to promote therapeutic benefits such patient compliance, convenience of dosage administration, and formulation flexibility.[1] Drugs with a short half-life and easy absorption from the gastrointestinal tract (GIT) are rapidly removed from the systemic circulation.[2] To achieve therapeutic effect, the creation of oral sustained controlled release formulations is an effort to circumvent these restrictions by releasing the medication gradually into the gastrointestinal tract and sustaining an efficient drug concentration in the systemic circulation for an extended period of time.[1] Following oral administration, In order for the medication to be constantly given to its absorption site in the gastrointestinal tract, it would be retained in the stomach and released in a regulated manner. The goal of gastroretentive drug delivery is to target site-specific drug release in the upper gastrointestinal tract for both local and systemic effects by.[3] The gastric retention time (GRT) of medications can be considerably extended by using a gastroretentive dose form, which can. Several gastroretentive medication delivery strategies have been created, includes mucoadhesive systems that produce bioadhesion to the stomach mucosa, unfoldable, extensible, or swellable systems that restrict emptying of the stomach, and high density (sinking) systems that are retained in the 2,3,4 (2 dose types) a magnetic system, a super porous hydrogel system, etc.[4],[5] The many gastro-retentive techniques that have lately emerged as in the field of site-specific oral controlled release drug delivery systems are the subject of this review. Dosage forms benefit greatly from the capacity. This stays in the stomach longer than traditional dose types. The inability to limit the dose form in the intended gastrointestinal tract region is one of these challenges. Drug absorption from, It is commonly known that in the gastrointestinal tract.

BASIC PHYSIOLOGY OF GASTROINTESTINAL TRACT

The fundus, body, and antrum (pylorus) are the three anatomical divisions of the stomach. While the antrum is the primary location for mixing motions and serves as a pump from gastric emptying by driving the actions, the proximal portion, which is composed of the fundus and body, acts as a reservoir for undigested materials. Both during feeding and fasting, the stomach empties. However, the patent for motility is unique in two states. An interdigestive sequence of electrical events occurs

during a fast, cycling through the gut and stomach every two to three hours11, this is known as the interdigestive myoelectric cycle or migrating myoelectric cycle (MMC).

- Phase I, or the basal phase, has contractions and lasts between forty and sixty minutes
- Phase II, also known as the pre-burst phase, is characterized by sporadic contractions and action potentials that last for 40 to 60 minutes. Both intensity and frequency gradually rise as the phase progresses.
- Phase III, lasts four to six minutes. It involves frequent, strong contractions for a brief amount of time. This walve is the reason why all the undigested. The stomach's contents are carried to the small intestine.
- Phase IV takes place in between phases III and I of two consecutive cycles, lasting between 0 and 5 minutes. The contraction pattern shifts from a starved to a fed condition following the consumption of a mixed meal. This is also referred to as the digestive motility pattern, and it consists of constant contractions similar to those that occur during phase II of fasting. The delayed start of MMC during the fed state causes the pace of stomach emptying to slow down. Orally administered controlled release dosage forms are essentially vulnerable to two complications: short stomach residence time and unpredictable gastric emptying rate.[6]

FLOATING DRUG DELIVERY SYSTEM (FDDS)

Floating systems are low-density systems that have sufficient buoyancy to remain above the contents of the stomach for an extended period of time. They were first described by Davis in 1968. When the medication is administered gradually and at the appropriate pace while the system floats over the stomach contents, the GRT increases and the plasma drug concentration fluctuates less. These formulations can float in stomach secretions since their bulk density is less than 1.004 g/cm^3.

Benefits of FDDS

- Reduces the frequency of dosages to improve patient adherence.
- The therapeutic benefits of drugs with short half-lives may be enhanced.
- The stomach retention duration is extended due to buoyancy.
- The medicine is released gradually and under control over a long period of time.
- Enhanced absorption of medications that are only absorbed in the stomach

Drawbacks of FDDS

- The stomach needs to contain a lot of fluid in order for the dosage form to float and stay buoyant.
- Not possible with medications that have issues with stability or solubility in stomach fluid.
- Drugs like nifedipine, which is widely absorbed across the entire GIT and undergoes substantial first-pass metabolism, may not be the best candidates for FDDS since prolonged stomach emptying may lead to lower systemic bioavailability.
- Limitations on the use of FDDS for medications that cause stomach mucosal irritation.

SUITABLE DRUG SELECTION FOR GASTRIC RETENTION

- Generally speaking, applicable candidate Control Release Gastric Retentive Drug Factors are compounds with low colonic absorption but superior absorption characteristics at the upper GIT.
- Riboflavin and levodopa have a narrow absorption window in the gastrointestinal tract. mostly absorbed from the stomach and upper gastrointestinal tract, such as calcium supplements, chlordiazepoxide, and cinnarizine.
- Medications that are localized in the stomach.
- Example such as misoprostol and antacids. Medications that break down in the colon, such as metronidazole and ranitidine HCl. Medications that disrupt healthy colonic bacteria, such as amoxicillin trihydrate.[7]

MATERIALS TO BE INCORPORATED TO FORM STABLE GASTRO RETENTIVE DRUG DELIVERY SYSTEM

Formulating a swelling system of Gastroretentive Drug Delivery Systems (GRDDS) primarily requires the use of highly swellable, hydrophilic polymers. These polymers absorb gastric fluid and expand significantly to a size that prevents passage through the pyloric sphincter, thus ensuring prolonged gastric retention. The key materials and their functions are:[11]

1. Swellable, Gel-Forming Polymers

These are the primary components responsible for the expansion of the dosage form in the stomach.

- Hydroxypropyl methylcellulose (HPMC): A widely used semi-synthetic polymer available in various viscosity grades (e.g., K4M, K15M, K100M) that forms a gel-like matrix upon hydration. The specific grade and concentration determine the swelling properties and the rate of drug release.
- Polyethylene oxide (PEO): A high-molecular-weight synthetic polymer that exhibits a high swelling index and is effective in controlling drug release.
- Carbopol (Polyacrylic acid derivatives): These cross-linked polymers swell significantly in gastric fluid and are often used for their strong gel-forming and mucoadhesive properties.
- Sodium alginate: A natural polysaccharide that forms a stable gel in the acidic gastric environment, contributing to swelling and sometimes buoyancy.
- Sodium carboxymethyl cellulose (NaCMC): A semi-synthetic polymer with strong swelling capabilities, often used in combination with HPMC or hydroxyethyl cellulose (HEC).
- Other natural gums: Okra Gum, Xanthan gum, guar gum, and karaya gum are also used due to their gel-

forming and swelling characteristics.

2. Active Pharmaceutical Ingredient (API)

The drug to be delivered must be suitable for this system (e.g., stable in the acidic gastric environment, with a narrow absorption window in the upper GI tract).

3. Additional Excipients

Various other materials are used to optimize the formulation:

- Binders: Help hold the tablet ingredients together (e.g., microcrystalline cellulose).
- Diluents/Fillers: Provide bulk to the formulation (e.g., lactose).
- Lubricants and Glidants: Ensure smooth manufacturing processes (e.g., magnesium stearate, talc).
- Release Rate Modifiers: Hydrophobic polymers like ethyl cellulose or inert fatty materials (e.g., hydrogenated vegetable oil, mineral oils, beeswax) can be incorporated to further control and retard the drug release rate from the swollen matrix.
- Cross-linking agents: For certain hydrogel systems, agents like N', N'-methylene bisacrylamide are used to create a stable three-dimensional polymer network.
- The materials and principles described are widely discussed in pharmaceutical research and reviews on GRDDS, with specific examples found in sources such as Gastroretentive Technologies in Tandem with Controlled-Release Strategies, Features and Facts of a Gastroretentive Drug Delivery System, and Development of swelling/floating gastroretentive drug delivery systems.

4. Gas-generating or floating system (for floating GRDDS)

Tartaric acid or citric acid plus sodium bicarbonate (CO_2 production). Povidone foam and low-density polymers are examples of low-density excipients that can help with buoyancy.

PMC. Enhancers for mucoadhesive GRDDS. To improve gastric adhesion, use thiolated okra derivatives or bio adhesive polymers (chitosan, Carbopol, and thiolation).

INTRODUCTION TO OKRA

Okra is a significant crop in tropical nations and is believed to be native to Africa. Being one of the few vegetables that continues to be prolific throughout the long summer in the Southeast, it is also a crucial component of Southern cuisine. Light frost kills this annual plant. Like snap beans, okra is produced for its seed pod, which is picked before it reaches maturity. It frequently reaches a height of two meters, which is exceptionally high for a vegetable crop. Production numbers are rare since, from a national standpoint, it is a relatively modest vegetable crop. throughout the US, commercial production takes place throughout the Southeast, extending from South Carolina to Texas. The most harmful pests that attack the pods include the southern green stink bug, Nezara viridula (Linnaeus), red imported fire ant, Solenopsis invicta Buren, and Leaf-footed bug (Leptoglossus spp.)[6] Okra mucilage used as pharmaceutical excipient and which has excellent buoyancy time in gastro retentive formulations. Consequently, the okra mucilage may utilize as an in-situ gel forming agent in antacids, because okra mucilage has an anti-ulcer activity, so which can prevent the gastric acidity in stomach. In current era, natural polymers play a vital role almost in all kind of industries especially in pharmaceutical field. The formulation scientists have achieved a great success in developing the most adorable drug delivery systems with suitable natural polymers to overcome the patient compliance.

Synonym: Hibiscus esculentus, okra, okra plant, gumbo.

Biological name: The lady's finger, sometimes referred to as Okra, has the botanical name *Abelmoschus esculentus*.[10]

Family: Malvaceae.[11]

GEOGRAPHIC DISTRIBUTION AND ORIGIN

The genus Hibiscus used to contain the lady's finger. It was later assigned to Abelmoschus, which differs from the genus Hibiscus due to its spatulate calyx, five small teeth, connate to the corolla, and caduceus following flowering. Around the world, okra is farmed, particularly in tropical and subtropical nations. Many nations, including India, Japan, Turkey, Iran, Western Africa, Yugoslavia, Bangladesh, Afghanistan, Pakistan, Myanmar, Malaysia, Thailand, India, Brazil, Ethiopia, Cyprus, and the Southern United States, grow the plants commercially.

HISTORY

The (Abelmoschus esculentus) has botanical roots in East Africa. Okra's journey from its East African origins is still complicated, even if its nomenclature originated in West Africa. It may have been brought to India by the Bantu people who migrated from Egypt circa 2000 BCE, carrying seeds from the Eritrean plateau. Evidence points to its cultivation in Egypt long before it reached India. However, there is no archeological evidence that connects okra, or "bhindi" as it is known locally, to the Harappan civilization, indicating a later introduction. Okra probably extended to the Arabian Peninsula and then to the Mediterranean and South Asia by the seventh century CE thanks to the dominance of Muslim East Africans in Egypt. the Western Chalukya monarch of India, wrote about "bhindi" in his Manasollasa, which has the first known recipe for bhindi masala. This illustrates how okra was incorporated into Indian cooking customs by the Middle Ages.

CULTIVATION

Abelmoschus esculentus is grown for its fibrous fruits or pods that contain spherical, white seeds in both tropical

and warm temperate parts of the world. It can withstand thick clay soils and sporadic precipitation, making it one of the world's most heat- and drought-tolerant vegetable species. However, cold can harm the pods. Before being planted, the seeds are soaked overnight to a depth of 1-2 cm (3-8–13-16 in). For germination, which takes place between six days (for soaked seeds) to three weeks, the soil must be at least 20 °C (68 °F). It needs a lot of sunlight because it is a tropical plant, and it should be grown in soil with a pH of 5.8 to 7, preferably on the acidic side. Seedlings need a lot of water. About two months after planting, the first harvest is usually ready

HARVESTANDAFTER CARE

Harvest the pods 50–60 days after sowing, when they are delicate and 3–5 inches long. Instead of tugging, cut pods with a clean knife or pair of scissors to prevent harming plants. Harvest often, every two to three days, to stimulate the plant to produce more pods.

METHOD OF EXTRACTION

We purchased okra (Abelmoschus esculentus) from local market. The collected okra was thoroughly cleaned, sun-dried for 24 to 48 hours, and then dried at 30 to 40 degrees Celsius until all moisture had been removed. A grinder was used to minimize the size. Fruit powder was put through sieve mess no#22 and kept in a dry, airtight container for further usage. Mucilage extraction is followed by the next two processes.

Step 1: Mucilage extraction 500 milliliters of distilled water including powdered fruit. For around three to four hours, the mixture was continuously heated and stirred at 60°C. The concentrated solution was filtered through muslin cloth and refrigerated between 4 and 6 degrees Celsius

Step2: Isolation of Mucilage: Extracted gum has isolated in acetone and allows for filtration through muslin cloth. Washed with acetone and the mucilage filtrated through muslin cloth. Pressed mucilage was further dried to constant weight at 35–45°c in hot air oven. Hard mucilage cake was grinded and sieved through sieve # 22, stored in desiccators for further used. Acetone is recovered by distillation and reused for next batch of extraction.[12]

PHYTOCHEMICAL SCREENING OF OKRA[9]

Class of Components	Common Test Used	Biological Significance
Carbohydrates	Molish's test	Energy source, visocity
Polysaccharides	Phenolic sulfuric test	Prebiotichypoglycemic
Flavanoids	Shinoda test	Antioxidant
Phenolic Compounds	Ferric chloride test	Antioxidant, anti-inflammatory
Tannins	Frothing test	Cholestrol – lowering
Glycosides	Keller-kelliani test	Cardio protective potential
Proteins	Biuret test	Nutritional value

ROLE OF OKRA MUCLIAGE AS A PHARMACEUTICAL AID

Okra mucilage for drug delivery

Okra Inherent features in okra mucilage as their ability to produce a gel forming, coating agent, and controlled-release matrix, okra mucilage frequently employed as drug-delivery carrier in various ways. Furthermore, they promote tissue permeability to improve medicine oral bioavailability and can substitute synthetic polymers for improved mucoadhesive nature.[10]

Okra mucilage matrix tablets

In blood pressure for treat early-morning variations, okra mucilage assisted as a controlled release matrix for propranolol HCl for colon-targeted medication administration. They investigated the propranolol's bioavailability in different natural polymers and compressed as a tablets using direct compression. The findings of this investigation supported the stated theory of sustained release for longer periods of time.[13]

Okra mucilage-based microspheres

Drug rapid absorption and metabolization can be inhibited in the body by developing as polymeric microspheres of oxcarbazepine using okra mucilage, because that may cause adverse effects such as insomnia, headache, dizziness, vomiting, weakness, and skin inflammation. The drug has short half-life, necessitating regular dosing to maintain bioavailability in the body. This investigation proves that, drug-dosing frequency and adverse effects were reduced by developing as okra and alginate microspheres to manage its release.[14]

Okra as a mucoadhesive gels

Mucoadhesive gels containing Rizatriptan benzoate were developed utilizing okra mucilage. A comprehensive examination of all variables revealed that okra gel has formulation qualities and allows the medication to enter the goat nasal mucosa. As a result, okra mucilage can be utilized instead of synthetic polymers and also act as cholesterol- reducing agent.

Okra Mucilage as a binder

Okra mucilage was used as a binder and its binding efficiency in tablet form was investigated in this study. The in- vitro drug-release investigation demonstrated that okra mucilage performed similarly to starch as a binder. The integrated medication displayed a delayed and prolonged release profile at increased concentration of mucilage; hence, this system might be employed as a natural pharmaceutical excipient in dosage forms.

Okra as a beads

Glibenclamide has short plasma half-life, so repeated drug administration necessary to maintain the therapeutic dose in the systemic circulation. Drug was incorporated in okra mucilage-alginate beads (made with CaCl2 as crosslinking agent) developed through ionic gelation to minimise dosing frequency while preserving drug for longer time period.

Okra as buccal patches

Verapamil HCl has a low plasma half-life, narrow absorption window in GIT and less bioavailability. So, buccal patches were created via solvent casting and tested in vitro and ex vivo. The formulations showed significant swelling and ex vivo muco-adhesion strength, with overall findings indicating that okra mucilage and chitosan acetate had superior physical qualities to the buccal patch and significant control release from the matrix film.[14]

Okra as nano-composite film

The nanoparticle was prepared by inclusion of CMC and okra mucilages at the proper level in the films to improve their tensile strength and decrease elongation at break. So, CMC inclusion boosted the film's water vapour permeability and solubility.[18]

CONCLUSION

Gastro-retentive drug delivery systems (GRDDS) improve the bioavailability of drugs absorbed in the upper gastrointestinal tract. The effectiveness of GRDDS depends on suitable drug candidates and functional excipients. Okra mucilage (*Abelmoschus esculentus*) is a natural polysaccharide with excellent binding and matrix-forming ability. Its high swelling index and viscosity supports floating and sustained drug release. Okra mucilage shows pH-independent behavior, aiding prolonged gastric retention. It is biodegradable, biocompatible, non-toxic, and cost-effective. Phytochemical screening confirms the presence of polysaccharides and phenolic compounds. These metabolites contribute to antioxidant and anti-inflammatory activities. Okra mucilage also exhibits gastroprotective properties beneficial for GRDDS. Thus, okra mucilage is a promising natural binder for gastro-retentive formulation.

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