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ROLE OF NATURAL POLYMERS IN GASTRORETENTIVE DRUG DELIVERY SYSTEM: A REVIEW

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ABSTRACT

Oral route is the most preferred route for administration of different drugs because it is regarded as safest, most convenient and economical route. Controlled and sustained released formulations are widely used in modern era for the delivery of various ingredients. Drugs with narrow absorption window in the gastrointestinal tract have poor absorption therefore gastro retentive drug delivery systems (GRDDs) have been developed which prolong the gastric emptying time. Polymers are macromolecules which are composed of structurally similar repeated units of monomers. Natural polymers are the ones that are obtained from natural origins like plants, animals or micro-organisms. Natural polymers are widely used in pharmaceutical and biomedical industries and their applications are growing at a fast pace as the basic knowledge of polymers helps us to know the function of drug products and also to develop new formulations or better delivery systems. The objective of this review is to provide the overview of the role of natural polymers in gastroretentive drug delivery system (GRDDS), its characteristics, ongoing research, trend of future developments and applications in the field. Natural materials have advantages over synthetic ones since they are chemically inert, non-toxic, cost efficacious, biodegradable, widely available, eco-friendly, devoid of any side effect, renewable, and provide nutritional supplement. Using various natural polymers has been aiding the drug delivery systems for prolongation of time as the drug transporters with the objective of improving bioavailability and therapeutic efficacy. The use of natural polymers in novel drug delivery like GRDDS to possess floating or mucoadhesive in the gastric system for the

benefit of increasing gastric resident time and to improve therapeutic efficacy, particularly those drugs are having narrow therapeutic index. The physical characteristics of natural polymers facilitates sustained, swelling and mucoadhesive nature based on literature reviewed, therefore, natural polymers also suitable to GRDDS as like synthetic or semi-synthetic polymers.

KEYWORDS: Gastro retentive drug delivery systems, Natural polymers, Biodegradable, Therapeutic efficacy, Bioavailability.

INTRODUCTION

The ultimate goal in drug design and development is to optimize a carrier that ensures the delivery of the active pharmaceutical ingredient to the systemic circulation in a safe and stable manner.[1] Patient compliance is a key aspect to consider when designing a new pharmaceutical dosage form.[2] Therefore, the way the drug will be introduced to the body should be optimized to ensure the availability of the drug at its site of action, at levels within the range of its therapeutic window. Despite emerging advances in drug delivery, the oral route remains the predominant route of drug administration. It is the simplest route, non-invasive and provides ~200 m^2 of readily available surface area for drug absorption.[3] Conventional oral dosage forms usually release drugs immediately in the body, via first order release kinetics for both absorption and elimination processes.[4] Since the efficacy of the administered drug is limited to its residence time in plasma, frequent administration is required for active pharmaceutical ingredient which exhibit a short biological half-life. As a result, low patient compliance and high fluctuation of drug levels in plasma is expected.[5,6] In order to counter the foregoing drawbacks of conventional dosage forms, a new term in drug delivery was introduced; modified release dosage forms.[7] Polymers are a large class of high molecular weight compounds consisting of many small molecules (called monomers) that can be linked together to form long chains. Thus, they are known as macromolecules. A typical polymer may include tens of thousands of monomers.[8] In Greek, the word poly means 'many' and meros means 'units or parts'. They consist of different functional groups.[9] Natural polymers and their derivatives widely used for the development of novel drug delivery system for their compatibility with other ingredients and biodegradability, ready availability and ability for chemical modification. Natural polymers are given most preference because synthetic excipients cause unwanted side effects in human. More ever herbal products are safer to use so now patients and researchers looking for the natural herbal constituents instead

synthetic or semi-synthetic polymers. Several studies showed that natural polymers containing formulations release activities of drug influenced by the physiochemical properties, morphology and release pattern of polymer, shape of dosage form and particle size.[10] Natural gums have diverse applications as a binders, suspending agents, disintegrant, swelling nature, emulsifying agents and mucoadhesive. They are also useful in the preparation of sustained release and immediate release formulations.[11] Gastroretentive systems are dosage forms having ability to retain itself in the stomach to increase absorption of released drug from acidic medium in a controlled manner.[12] Gastroretentive drug delivery systems (GRDDS) are of many types such as effervescent, non-effervescent, mucoadhesive, raft forming, low-density and high-density system and without effecting on gastric emptying rate such systems remains floating or adhesion into stomach mucous membrane for longer period time because of system consists of density that is less than gastric fluids (1.004 g/cm3).[13] When system floats or adhered in the gastric region, the drug is released from this system and entered only the solution form into duodenum (upper part of small intestine) having larger surface area that's providing more absorption of drugs. The best events of these systems are well-regulated fluctuations in plasma drug concentration, particularly those drugs with narrow therapeutic index and increased gastric resident time.[14]

Advantages of Gastro Retentive Drug Delivery System

GRDDS is suitable for those drugs which are well absorbed through stomach and local action in it, for example, antacids, etc. Poor drug absorption may occur in diarrhea due to vigorous intestinal movement, it can be prevented using this system to retain drug in stomach and its better response. It increases the patient compliance and lowers the dosing frequency. Therapeutic effect can be improved of drugs having short half-life. Minimizing the mucosal irritation due to drugs releasing slowly at controlled rate. In this system, the continuous drug release from the dosage form at constant rate in prolonged manner provides a desired plasma drug concentration their by prevent drug fluctuations. Drugs which are unstable in intestinal pH can also be used. Dose dumping cannot occur. Sustained and uniform release of drug can prevent the gastric irritation. By the administration of prolonged release, gastroretentive dosage forms dissolution in the gastric fluid can be maintained as well as in alkaline pH of small intestine.[15,16]

Disadvantages of Gastro Retentive Drug Delivery System

This system is not suitable for those drug which are acid insoluble or unstable in acidic medium, e.g., phenytoin and erythromycin respectively. It can't be used for those drugs which produces gastric lesions on slow release, e.g., non-steroidal anti-inflammatory drugs. This system is not compatible with those drugs which absorb specifically in colon, e.g., corticosteroids. Drug delivery systems with increased size may contain the high risk of preservation in stomach for long time and may pose a life threatening effect on further use of this system. For bio adhesive system the most difficult for is the high turnover proportion of gastric mucus. For efficient result and effect, this floating system needs high fluid level in stomach so it can float.[17,18]

Applications of Gastro Retentive Drug Delivery

GFDDS stays in stomach for extensive period of time to enhance GRT while sustained drug delivery system shows limited effect due to short retention time in stomach. It can't pass through pylorus because of increased size and low density than their gastric fluids [19]. Those drugs which metabolized in upper GIT, their bioavailability and absorption can be enhanced by using this system.[20] Those drugs that absorbed from the stomach and proximal part of intestine have advantage of this system. It provides sufficient therapeutic level and effect and decreases the systemic exposure to the drug and reduced side effects due to slow delivery of drug from this system. It can also reduce the dosing frequency of certain drugs due to prolonged gastric availability, e.g., Furosemide.[21] This system can decrease the counter action of the body may lead to higher efficiency and productivity of drug.[18] Unwanted actions or activities of drug in colon can be avoided due to retention of drug in GRDF. Beta lactam antibiotics that absorbed from the small intestine and their presence in the colon may cause microorganism's resistance.[22]

Polymers form the core of drug delivery systems. Polymers are utilized in drug delivery to provide weight, consistency and volume for the correct administration of the drug and in addition, they are multi-functional providing stability, drug release, targeting, enhanced bioavailability and patient acceptability.[23] The choice of a polymer due to inherent diversity of structures, necessitates an extensive understanding of the surface and bulk properties of the polymers that can produce the desired functionalities.[24] A polymer is a large molecule (macromolecule) composed of repeating structural units or chains typically connected by covalent chemical bonds. While polymer in popular usage suggests plastic, the term actually

refers to a large class of natural and synthetic materials with a variety of properties and purposes.

- Polymers may consist of long chains of unbranched or branched monomers or may be cross-linked networks of monomers in two or three dimensions.
- Many important natural materials are organic polymers including cellulose, lignin, rubber, proteins and nucleic acids. Synthetic organic polymers many plastics, including polyethylene, the nylons, polyurethanes, polyesters, vinyl's (e.g., PVC) and synthetic rubbers. The silicone polymers, with an inorganic backbone of silicon and oxygen atoms and organic side groups, are among the most important mixed organic-inorganic compounds.[25,26]

Classification of Polymers

Polymers may be classified as follows, according to the mechanical response at elevated temperatures

1. Thermoplasts
2. Thermosets

a) Thermoplasts

- Thermoplasts polymers soften when heated and harden when cooled. Simultaneous application of heat and pressure is required to fabricate these materials.
- On the molecular level, when the temperature is raised, secondary bonding forces are diminished so that the relative movement of adjacent chains is facilitated when a stress is applied.
- Most linear polymers and those having branched structures with flexible chains are thermoplastics.
- Thermoplastics are very soft and ductile. Example: Polyvinyl Chloride (PVC) and Polystyrene, Polymethyl methacrylate, Polystyrene.[27]

b) Thermosets

- Thermosetting polymers become soft during their first heating and become permanently hard when cooled. They do not soften during subsequent heating. Hence, they cannot be remolded/reshaped by subsequent heating.
- In thermosets, during the initial heating, covalent cross-links are formed between adjacent molecular chains.

These bonds anchor the chains together to resist the vibration and rotational chain motions at high temperatures. Cross linking is usually extensive in that 10 to 15% of the chains per units are cross linked. Only heating to excessive temperatures will cause severance of these crosslink bonds and polymer degradation.

- Thermoset polymers are harder, stronger and more brittle than thermoplastics and have better dimensional stability.
- They are more usable in processes requiring high temperatures.
- Most of the cross linked and network polymers which include: Vulcanized rubbers, Epoxies, Phenolic, Polyester resins.
- Thermosets cannot be recycle, do not melt, are usable at higher temperatures than thermoplastics, and are more chemically inert.[27,28]

Polymers can also be classified as

1. Natural polymers
2. Synthetic polymers
3. Semi-synthetic polymers

Synthetic polymers: The polymers which are prepared in the laboratories are called synthetic polymers. These are also called man made polymers. For example polyethene, PVC nylon, teflon, bakelite terylene, synthetic rubber etc.[27]

Semi synthetic polymers: These polymers are mostly derived from naturally occurring polymers by chemical modifications. For example cellulose is naturally occurring polymers, cellulose on acetylation with acetic anhydride in the presence of sulphuric acid forms cellulose diacetate polymers. It is used in making thread and materials like films glasses etc. Vulcanized rubber is also an example of semi synthetic polymers used in making tyres etc. gun cotton which is cellulose nitrate used in making explosive.[27,29]

Natural Polymers Suitable to GRDDS

Natural polymers are materials of large molecular weights from natural origins such as plants, micro-organisms and animals. In comparison to synthetic, natural polymers are preferable due to low toxicity, renewability, flexibility to modification, biodegradability and low cost.[30] Natural polymers such as polysaccharides are hydrophilic, enzymatically degradable and are able to retain the stability of protein drugs incorporated in them as well as increase their (proteins) therapeutic effects.[31] Polysaccharides exhibit good haemocompatibility and

interaction with living cells.[32] making them compatible and suitable biomaterials for long systemic circulation and targeting. Most natural polymers are generally regarded as safe for oral consumption and so find applications in the food and pharmaceutical industries. Extraction and development of polymers from natural sources such as plants utilized as food may reduce regulatory requirement for approval.[33] Some of the challenges are the seasonality of optimum yields, variations based on locations/climate and soils and stability as they lose viscosity or deform on storage. These challenges and the revolution of petrochemicals led to increasing utilization of synthetic polymers with natural polymers gradually nudged to the background. Synthetic polymers became convenient and their physicochemical properties endeared them to drug delivery scientists. However, the growing concern of their bio-incompatibility, possible toxicity and carcinogenicity has propelled the re-visitation of natural polymers. The use of natural polymers has increased in recent times; also due to the advocacy of "green" materials from "green" chemistry and technologies. Natural polymers are biogenic and their biological properties such as cell recognition and interactions, enzymatic degradability, semblance to the extracellular matrix and their chemical flexibility make them materials of choice for drug delivery. Natural polymers have been used for diverse applications in drug delivery such as emulsification,[34] suspension,[35] controlled release,[36] film coating,[37] disintegration,[38] solubilization, bioadhesion, gelling, thickening, viscosity modulation, bulking agent,[39] drug devices, drug modification, encapsulation and mechanical strengthening.[40-42] Natural polysaccharides are increasingly being used for drug targeting for chronic and site-specific diseases. Natural polymers are continually being explored in innovative approaches to drug delivery and personalized medicines. Increasing application of natural polymers in drug delivery implies increase in demand indicating the need for research and development into new natural polymers for subsequent commercialization. Polymers utilized in pharmaceuticals require regulatory approval.

Advantages of Natural Polymers

The various advantages of natural plant based materials include the following.

1. ***Biodegradable:*** Biodegradable as they are naturally available and they are produced by all living organisms.
2. ***Biocompatible and non-toxic:*** Basically, all of these plant materials are reiterating sugar polysaccharides.

3. ***Low cost:*** They are cheaper to utilize as natural sources. The production cost is less compared with the synthetic material. India and many other developing countries are dependent on agriculture, and there are substantial amounts of money investment on gricultures.
4. ***Environmental-friendly processing:*** There are many types of natural compounds obtained from different plant sources which are widely utilized in pharmaceutical industry and collected in immensely large quantities due to the simple production processes involved.
5. ***Local availability (especially in developing countries):*** In India and homogeneous developing countries, there is promotion for the production of plants as pharmaceutical excipients being done by government, and it withal provides the facilities for bulk production, like gum and mucilage's because of their wide applications in industries.
6. ***Patient tolerance as well as public acceptance:*** There is less chance of side and adverse effects with natural materials compared with synthetic one.[43]

Disadvantages of natural polymer

1. Microbial contamination during production due to their natural sources.
2. Batch to batch variation- as result to difference of resources and resource regions.
3. Slow Process-as the production rate is depends upon the environment and many other factors, it can't be changed.
4. Potential impurities-may also result in unwanted immune reactions.
5. Heavy metal contamination- that often associated with herbal polymeric excipients.[44]

1. ***Guar gum***

Guar gum belongs to family Leguminosae and derived from cyamopsis tetragonolobus kernels. It is also known as Guaran, Cluster bean, Cyamopsis, Calcutta-lucerne, and Guarina.[45] It is a whitish-yellow powder and has taste or odor. It is water soluble and is not soluble in organic solvents. Guar gum has ability to increase viscosity and used in solid dosage forms as a disintegrant and binder in pharmaceutical industries.[46]

2. ***Gum Karaya***

Gum karaya is a vegetable gum produced as an exudate by trees of the genus *Sterculia*. Chemically, gum karaya is an acid polysaccharide composed of the sugars galactose, rhamnose, and galacturonic acid. The high viscosity nature of gumlimits its uses as binder and disintegrant in the development of conventional dosage form. Gum karaya has been

investigated for its potential as a tablet disintegrant. Different results showed that modified gum karaya produces rapid disintegration of tablets. Gum karaya can be utilized as an alternative superdisintegrant to commonly available synthetic and semisynthetic superdisintegrants due to its low cost, biocompatibility as well as facile availability.[47]

3. *Xanthan gum*

Bacterium *Xanthomonas campestris* produced xanthan gum naturally. This gum appears as odorless, free-flowing fine powder or cream. Polysaccharide B-1459, Keltrol, Rhodigel, Merezan, and Corn sugar gum are soluble in warm or cold water and are insoluble in ethanol and ether. This gum is stable material and is polysaccharide in nature with D-glucose backbone like cellulose. Their aqueous solutions are durable in existence of enzymes, bases, salts, acids, and stable at pH range 3–12 and temperature between 10–60°C. It is non-toxic and non-irritant and used in cosmetics and food products, in topical and oral pharmaceutical formulations and preparations. It is also used as stabilizing agent, gelling agent, viscosity-increasing agent, suspending agent, emulsifying agent, and thickening agent.[46]

4. *Okra gum*

Okra gum obtained from the pods of *Hibiscus esculentus*, yields high viscosity mucilage at low concentrations. It is polysaccharides having hydrophilic nature, currently used in pharmaceutical industry as a swelling polymer in dosage forms. Okra gum contains different coil polysaccharides consisting of rhamnose, galactose, and galacturonic acid are used as a tablet binding agent and to produce tablets with good friability, hardness and drug release profiles. Due to its chemically inert, safe, biodegradable, non-irritant, eco-friendly, and biocompatible properties, it has advantage over most commercial synthetic polymers because it is widely harvested and do not require toxicology studies. Okra gum is beneficial as a retarding polymer in the formulation of sustained release tablets as extraction in water give highly viscous solution with slimy appearance.[48]

5. *Locust bean gum (LBG)*

LBG also known as Carob bean gum and it is derived from the seeds of the leguminous plant *Ceratonia siliqua* Linn., consists basically of neutral galactomannan polymer made up of 1, 4-linked D-mannopyranosyl units with every fourth or fifth chain unit is substituted on C6 with a D-galactopyranosyl unit. There is variation in ratio of D-galactose to D-mannose based on varying origins of the gum source materials and growth effecting conditions of the plant during production. LBG is more effective to use as a gelling, stabilizer, and thickening agent

and shows a wide variety of application in preparation and development of various novel drug delivery systems.[49,50]

6. *Psyllium husk*

Psyllium obtained from the plant Plantago psyllium, the husk and seed of Plantago ovata is referred to as psyllium. Psyllium is classified as a mucilaginous fiber due to its powerful gel forming ability in water. Psyllium husk is biocompatible, inert, swellable, biodegradable, inexpensive, and easily available. The seed contains sterols, unsaturated fatty acids ranging 5–10% lipids, traces of cyclopentano pyridine-type alkaloids, proteins (15–18%), aucubi, and trisaccharide, carbohydrates-planteose, and 10–12% mucilage of the heteroxylan type. Psyllium husk serves as reliable means for GRDDS as it shows release retardant properties. Researchers have also focused on prolonged retention of dosage form use in the GIT; stomach.[51]

7. *Tamarind gum*

Tamarind is xyloglucan also called as Tamarind Kernel Powder is collected from seed of the tamarind tree under the family of *Tamarindus indica*. Tamarind gum; a polysaccharide composed of galactosyl: xylosyl: glucosyl in the ratio of 1:2:3. Higher plant primary cell walls has major structural polysaccharide called xyloglucan and used as binder, gel-forming agent, stabilizer, and thickener in pharmaceutical and food industries. Tamarind gums used in formulating matrix tablets are evaluated for its drug release characteristics by wet granulation technique. Different concentrations of polymers are used in tablets preparation. Decrease in drug release is observed with increase in polymer content.[52]

8. *Tara gum*

Tara gum is obtained from family Leguminosae from the endosperm of seed of Caesalpinia spinosa. Tara gum is odorless and white powder. Like, guar and LBGs, major component is galactomannan polymers consist of a linear main chain of (1-4)-β-D-mannopyranosyl units with α-D-galactopyranose units attached by (1-6) linkages. The ratio of galactose to mannose is 1:3, produce highly viscous thick solutions, at 1% concentration. Tara gum is used in formulation of gastroretentive controlled release tablets and emulsions for drugs in pharmaceutical industries such as glipizide, metformin hydrochloride, carvedilol, clozapine and ciprofloxacin hydrochloride, and itopride has been claimed in patents. Good gastroretentive property is observed using Tara gum in combination increases floating time of the dosage form. Tara gum also used in formulation of emulsions.[52]

9. *Chitosan*

It is composed of glucosamine and N-acetylglucosamine and is linear cationic polysaccharide. Chitosan is prepared by the deacetylation of chitin that is obtained from crustacean shells. It is biodegradable, biocompatible, and non-toxic. It is odorless creamy or white flakes or powder and partially insoluble in 95% ethanol and soluble in water. It is used as viscosity enhancer, mucoadhesive, film-forming agent, tablet binder, coating agent, and disintegrant.[53]

10. *Pectin*

Pectin is non-toxic and economic polysaccharide extracted from apple pomaces and citrus peels. On the base of both extraction process and source pectin is a complex structure. Actually, it is a D-galacturonic acid with 1–4 linkages. It is used as a bulking agent, food additive, and a gelling agent due to the pectin ability to form gel based on degree of esterification and molecular size, it is an alluring candidate for pharmaceutical care, for example, as drug carrier for controlled released applications.[54]

11. *Carrageenan*

Carrageenan, naturally occurring repeating units of galactose and 3, 6-anhydrogalactose high molecular weight anionic gel-forming polysaccharides, extracted from red seaweeds species such as *Euchema*, *Chondrus crispus*, *Iridaea*, and *Gigartina stellate*. Depending on degree of sulfation, are classified into different types: λ-carrageenan (three-sulfate), κ- carrageenan (di-sulfate), and ι- carrageenan (monosulfate). Highly sulfated λ-carrageenan is a thickener agent and does not form gel while κ- and ι-carrageenan forms gel, which influences their release kinetics.[11] Carrageenans are mostly utilized because of their superb physical functional properties in food industries, such as bulking agent, thickening, stabilizing abilities, and gelling. Because of the high robustness, good compatibility, and persistent viscoelasticity of the tablet during granulation and compression, it proved to be useful as tablet excipient agents. Hence, for sustained release formulations, carrageenans are suitable excipients.[55]

12. *Mimosa pudica gum*

Mimosa pudica (Mimosaceae), commonly known as sensitive plant, is a diffuse undershrub found widely in the tropical and subtropical parts of India. Seeds of gum mucilage containing olysaccharides, which is composed of d-xylose and d-glucuronic acid. Mimosa seed mucilage hydrates and swells rapidly on coming in contact with water. The isolated seed mucilage

having sustained release properties employing diclofenac sodium as a model drug and mucilage suitable for various GRDDS as a swelling and mucoadhesive polymer.[56]

13. *Limonia acidissima gum*

Limonia acidissima gum (Rutaceae), commonly known as wood apple and elephant apple, found widely in the tropical and subtropical parts of India. Mucilage obtained from trunk of trees composed of carbohydrates. Mucilage hydrates and swells rapidly on coming in contact with water. The isolated stem mucilage having sustained release properties and mucilage suitable for various GRDDS as a swelling polymer.[57]

14. *Colocasia esculenta gum*

Colocasia esculenta is a plant of Araceae family widely cultivated in tropical areas of Southeast Asia. Underground tubers (corns and cormels) containing rich in carbohydrates. Colocasia tubers mucilage hydrates and swells rapidly on coming in contact with water. The isolated tubers mucilage having sustained release properties and mucilage suitable for various GRDDS as a swelling polymer.[58]

15. *Rosin*

From pinupal ustrismiller and other species such as pinuslinnae rosin is obtained a natural non-volatile resinous mass. Some rosin biopolymers are reported to have excellent biocompatibility and biodegradation features. It primarily contains resin tricyclic diterpene carboxylic acids (abietic and pimaric) figure-2 and a few amounts of nonacidic components. Rosin contains approximately 90% rosin acids. The rosin acids are monocarboxylic acids and have a typical molecular formula C20H30O2.[59]

16. *Gelatin*

From the collagen inside animals skin and bones Gelatin is obtained it is a translucent, colorless, brittle (when dry), flavorless solid substance. It is commonly used as a gelling agent in food and pharmaceuticals. Gelatin is produced by partial hydrolysis of collagen extracted from the boiled bones, connective tissues, organs and some intestines of animals such as domesticated cattle and pigs. The approximate amino acid composition of gelatin is glycine 21%, proline 12%, hydroxyproline 12%, glutamic acid 10%, alanine 9%, arginine 8%, aspartic acid 6%, lysine 4%, serine 4%, leucine 3%, valine 2%, phenylalanine 2%, threonine 2%, isoleucine 1%, hydroxylysine 1%, methionine and histidine<1%and tyrosine<0.5%. Gelatin is used in nanoparticles as drug carrier system for uptake in

lymphocytes, agar modified gelatin A and gelatin B,thiolmodified gelatin nanoparticles for intracellular DNA delivery , hydrophobic hexanoyl anhydrides grafting to the amino groups of primitive gelatin ,cationiced gelatin ,DNA-loaded gelatin nanoparticles ,modified gelatin microspheres impregnated collagen scaffold.[60]

17. *Hemicellulose*

A hemicellulose is a heteropolymer (matrixpolysaccharides), such as arabinoxylans, present along with cellulose in almost all plant cell walls.While cellulose is crystalline, strong, and resistant to hydrolysis, hemicellulose has a random, amorphous structure with little strength.Unlike cellulose, hemicellulose (also apolysaccharide) consists of shorter chains - 500-3,000 sugar units. In addition, hemicellulose is a branched polymer, while cellulose is unbranched. Hemicellulose polysaccharides consist of xyloglucans, xylans and mannans that can be extracted from the plant cell wall with a strong alkali. They have backbones made up of β-1,4-linked Dglycans. Xyloglucan has a similar backbone as cellulose, but contains xylose branches on 3 out of every 4 glucose monomers. The β- 1,4-linked DXylan backbone of arabinoxylan contains arabinose.[61]

18. *Bhara Gum*

From the plant of Terminalia *bellerica* roxb gum Bhara is obtained it is a yellowish natural gum belonging to family Combretaceae. Bahera gum, extracted from the bark of Terminalia bellerica. Main chemical constitutents are tannins which mainly include ß- sitosterol, gallic acid, ellagic acid,ethyl gallate, galloylglucose and chebulaginic acid It has been mainly used as a demulcent and purgative. It is also used as an emulgent in cosmetic industries. Wide applications of bhara gum indicate their hydrophilic nature, and compatibility with the physiologic environment. A new sustained release microencapsulated drug delivery system employing bhara gum has been proposed, were formulated by ionic gelation technique using famotidine as the model drug. The effect of different drug: bhara gum ratio on *in vitro* drug release profile was examined and compared with guar gum. Remaining all parameters was constant. Microcapsules employing bhara gum exhibited slow release of famotidine over 10 hr. Fickian release was observed from most of the formulations with bhara gum. It was concluded that this gum possesses substantial release controlling properties that could be used for sustained drug delivery.[62]

CONCLUSION

The objective of this review is to provide the overview of role of natural polymers in gastro retentive drug delivery systems, its characteristic effects, ongoing research and trend of future developments and applications in the field. The physical characteristics of natural polymers facilitate them to be brilliant drug carriers for such type of drug delivery systems.

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