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A Review On Natural Plant Based Polymers: A Brilliant Pharmaceutical Excipients

Mahor Seema*[1], Chandra Phool[2], Prasad Neelkant[3], Chadha Hina[1], Meenakshi[4], Siddiqui Tajdar A[5]

[1]School of Pharmaceutical Sciences, IFTM University, Lodhipur Rajput, Delhi Road (NH-24), Moradabad, Uttar Pradesh India 244102.

[2]Teerthanker Mahaveer College of Pharmacy, Teerthanker Mahaveer University Moradabad, Uttar Pradesh India 244101.

[3]SGT College of Pharmacy, SGT University, Gurgaon-Badli Road, Budhera, Gurugram, Haryana, India.

[4]Vishveshwarya College of Pharmacy, GB Nagar Dadri.

[5]Vishveshwarya Group of Institutions GB Nagar Dadri, Greater Noida 203207, U.P. India,

Email addresses of corresponding author
Email: seemamahor@gmail.com

Corresponding author
Seema Mahor
Telephone: 8586849938
Email id: seemamahor@gmail.com
Address; Department of Pharmaceutical Sciences, *School of Pharmaceutical Sciences, IFTM University, Lodhipur Rajput, Delhi Road (NH-24), Moradabad, Uttar Pradesh India.*

ABSTRACT

There are various synthetic and semi synthetic polymers are available in market for pharmaceutical formulation, but these polymers have certain disadvantages such as side effects, high cost, toxicity, poor patient compliance, environmental pollution during synthesis and non-renewable sources. Because of these disadvantages they are avoid to use in pharmaceutical preparation and are replaced by some plant based excipients such as natural gums and mucilage are preferred to semi synthetic and synthetic excipients. A large number of natural plant based pharmaceutical excipients are available today. Gums and mucilages are

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one of them and most commonly available plant ingredients with a wide range of applications and advantages like easily available in nature, cheap, safe, economy benefit and biocompatible. They have been extensively explored as pharmaceutical excipients because of natural ingredients, chemically inert, nontoxic, less expensive, biodegradable and widely available. Recent trend toward the use of plant based and natural products demands the replacement of synthetic additives with natural ones. In this review, we describe the pharmaceutical applications of various natural gums, mucilages and their modified forms for the development of various drug delivery systems.

Keywords: Natural gum, safe, mucilage, biocompatible

INTRODUCTION

In recent years, polymers which are derived from plant origin have evoked tremendous interest in pharmacy because of their effective pharmaceutical applications such as diluents, binder, disintegrant in tablets, thickeners in oral liquids, protective colloids in suspensions, gelling agents in gels, and bases in suppository.[1] These natural gums and mucilage are preferred over the synthetic ones because they are biocompatible, cheap, and easily available. Also the natural excipients are preferred on the synthetic and semi synthetic polymers because of their lack of toxicity, low cost, soothing action, availability, and nonirritant nature of the excipient. [2,3]

Natural gums are abnormal products which are obtained from pathological conditions brought about either by injury or by adverse conditions of growth and usually formed by changes in existing cell wall while mucilage are generally normal products of metabolism that is formed within the cell and are produced without injury to plant.[4]

GUM AND MUCILAGE

Gums are naturally obtained and are considered to be a pathological products, formed by giving injury to the plant or due to unfavourable conditions, such as drought, by breakdown of cell walls (extra cellular formation i.e. gummosis). Mucilages are generally normal products of metabolism also known as physiological products, formed within the cell (intracellular formation). Gums are soluble in water, whereas, mucilage form slimy masses. Both gums and mucilage are plant hydrocolloids yielding mixture of sugars and uronic acids on hydrolysis.[5] Other differences in gum and mucilage is, gums are pathological products, whereas mucilage are physiological products.[6] The plant based polymers have been studied for their various application in different pharmaceutical dosage forms like film coating agents, matrix controlled system, buccal films, microspheres, nanoparticles, viscous liquid formulations such as ophthalmic solutions, suspensions, implants and their applicability and efficacy has also been proven. These have also been utilized as solubilisers, viscosity enhancers, stabilisers, disintegrates, emulsifiers, suspending agents, bio adhesives gelling agents and binders.[7] Acacia, tragacanth, and guar gum are examples of gums.[8]

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ADVANTAGES OF NATURAL GUMS AND MUCILAGES IN PHARMACEUTICAL SCIENCES [9,10]

The advantages of natural plant–based materials are as follows.

1. Biodegradable: Gums and mucilages are biodegradable in nature. Naturally available biodegradable polymers are produced by living organisms and they represent truly renewable source and also have no adverse effect on humans or environmental health (e.g., skin or any type of eye irritation).

2. Non-toxic: Chemically, nearly all of these plant materials are carbohydrates in nature and composed of repeating sugar (monosaccharide) units. Hence, they are non- toxic in nature.

3. Low cost: They are always cheaper to use natural sources. The production cost is also much lower as compared to synthetic material. It has been seen that India and many developing countries are dependent on agriculture for economic purpose.

4. Environmental friendly processing: Gums and mucilages from different sources are easily collected in different seasons in a large quantities due to the simple production processes in a large area.

5. Local availability: In developing countries, governments also have promote the production of plant like guar gum and tragacanth because of the wide applications of these excipients in a variety of industries.

6. Better patient tolerance as well as public acceptance: There is less chances of side effects or adverse affects with natural materials compared with synthetic one. For example, PMMA, povidone.

7. Edible sources: Most of the gums and mucilages are obtained from edible sources.

DISADVANTAGES OF NATURAL GUMS AND MUCILAGES[9,10]

1. Microbial contamination: The equilibrium moisture content present in the gums and mucilages is around 10% or more and structurally they are carbohydrates in nature. During production, they are exposed to the external environment so that there is a chance of microbial contamination. However this problem can be prevented by proper handling and by using preservatives.

2. Batch to batch variation: Synthetic manufacturing is a controlled procedure with fixed quantities of ingredients, while the production of gums and mucilage is tottaly depend on environmental conditions and seasonal factors.

3. Uncontrolled rate of hydration: Due to differences in the collection of natural materials at different times, also differences in region, species, and climate conditions the percentage of chemical constituents present in a given material may be vary so there is a need to develop suitable monographs on available gums and mucilages.

4. Reduced viscosity on storage: Generally when gums and mucilages come into contact with water, there is an increase in the viscosity of the formulations. Due to the complex nature of gums and mucilage (formation of monosaccharide to polysaccharides and their derivatives), it has been found that after storage there is reduced in viscosity.

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CLASSIFICATION OF GUMS AND MUCILAGES[11,12,13]

Gums and mucilages can be obtained in a very high quantities from varieties of plants, animals, sea weeds, fungi and other microbial sources, where they perform a number of structural and metabolic functions but plant sources provide the largest amounts of these ingredients. The different available gums and mucilages can be classified as follows:

1. According to the charge:

A. Non-ionic seed gums: guar gum, locust bean, tamarind seed gum, xanthan, amylose, arabinans, cellulose, galactomannans.

B. Anionic gums: arabic, karaya gum, tragacant, gellan, agar, algin, carrageenans, pectic acid.

2. According to the source:

A. Marine origin/algal (seaweed) gums: agar, carrageenans, alginic acid, laminarin.

B. Plant origin:

- **Shrubs/tree exudates** gum arabica, gum ghatti, gum karaya, gum tragacanth, khaya and albizia gums.
- **Seed gums** guar gum, locust bean gum, starch, amylose, cellulose.
- **Extracts** pectin, larch gum
- **Tuber and roots** potato starch.

C. Animal origin: chitin and chitosan, chondroitin sulfate, hyaluronic acid.

D. Microbial origin (bacterial and fungal): xanthan gum, dextran, curdian, pullulan, zanflo, emulsan, Baker's yeast glycan, schizophyllan, lentinan, krestin, scleroglucan.

3. Semi-synthetic

A. Starch derivatives starch acetate, starch phosphates.

B. Cellulose derivatives carboxy methyl cellulose (CMC), hydroxy ethylcellulose, hydroxypropyl methylcellulose (HPMC), methylcellulose (MC), microcrystalline cellulose (MCC).

4. According to shape

A. Linear: algins, amylose, cellulose, pectins.

***B. Branched*:** xanthan, xylan, galactomanan, amylopectin, gum arabic, tragacanth

5. According to manomeric units in chemical structure

A. Homoglycans amylose, arabinanas, cellulose;

B. Diheteroglycans algins, carragennans, galactomannans;

C. Tri-heteroglycans arabinoxylans, gellan, xanthan;

D. Tetra-heteroglycans gum arabic, psyllium seed gum;

E. Penta-heteroglycans ghatti gum, tragacanth.

ISOLATION AND PURIFICATION OF GUM AND MUCILAGES

Mucilage can be extracted from parts of plants by various methods like heating, solvent precipitation, and microwave assisted extraction methods. The easiest and popular method is

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solvent precipitation. In this method the part of the plant containing gum or mucilage is selected followed by drying, grinding, and sieving of that plant part. This is then stirred in distilled water and heated for complete dispersion then kept for 6–8 hours at room temperature. The supernatant is obtained by centrifugation. The residue is then washed with water and the washings are added to the separated supernatant. Solvent for precipitation is selected and, finally, the supernatant is mixed with twice the volume of precipitating solvent by continuous stirring. The precipitated material is washed with distilled water and dried at 50–60°C under vacuum. Plant material must be treated with petroleum ether and chloroform (to remove pigments and chlorophyll) and finally with distilled water. [14,15]

SOME RECENTLY INVESTIGATED NATURAL GUMS AND MUCILAGES

Aloe mucilage:

Aloe mucilage is obtained from the leaves of Aloe barbadensis. Aloe vera leaves and the exudates arising from the cells adjacent to the vascular bundles are used. The bitter yellow exudates contains 1, 8 dihydroxy anthraquinone derivatives and their glycosides.[16] Researchers studied a controlled delivery system of glibenclamide using aloe mucilage. Various formulations of glibenclamide with *Aloe barbadensis* Miller leaves mucilage were prepared by direct compression method. Matrix tablets with aloe mucilage were found to have better uniformity of weight and drug content with low statistical deviation. The swelling behaviour and *in vitro* release rate characteristics were also found good. The dissolution study proved that the dried *Aloe barbadensis* Miller leaves mucilage can be used for making controlled release glibenclamide matrix tablets.[17]

Almond gum:

Almond gum is water soluble gum and obtained from the tree *Prunus communis*. Main constituents of almond gum are aldobionic acid, L-arabinose, L-galactose, D-mannose etc. Almond gum used as emulsifier, thickener, suspending pharmaceutical, adhesive, glazing agent and stabilizer. Gum obtained from Almond as a binder in tablet formulations was also studied.[18] The drug release increased with almond gum when compared to synthetic gum concentration and the release mechanism was found to be non-Fickian diffusion. The almond gum was found to be useful for the preparation of uncoated tablet.[19]

Albizia gum:

Albizia gum is obtained from the incised trunk of the tree *Albizia zygia,* (family: *Leguminosae*). Gum has a shape like round elongated tears of variable colour ranging from yellow to dark brown. Main chemical constituents are β-1– 3-linked D-galactose units with some ß1-6-linked D-galactose units.[20] This gum has been investigated as a possible substitute for gum arabic as a natural emulsifier for food and pharmaceuticals.[21] Albizia gum is evaluated as a binding agent in tablet formulations in comparison with gelatin BP.[22] It has

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been also evaluated as a suspending agent in Sulphadimidine suspension as compared to the relatively common natural agents as Acacia, Tragacanth and Gelatin.[23]

Bhara gum:

Bhara gum is a yellowish colour natural gum extracted from the bark of *Terminalia bellerica* (family: *Combretaceae*). Main chemical constituents of this gum are tannins which mainly include gallic acid, ß-sitosterol, ellagic acid, ethyl gallate, galloyl glucose, and chebulaginic acid. Recently, microcapsules were formulated by ionic gelation technique using famotidine as the model drug and the effect of different drug and bhara gum ratio, drug release profile was examined and compared with guar gum. It was studied that microcapsules containing bhara gum exhibited slow release of Famotidine over 10 hour. [24, 25]

Cashew gum:

Cashew gum is the exudates from the stem bark of a plant *Anacardium occidentale (*family: *Anacardiaceae*). Chemical constituents of Cashew gum are glucose, galactose, arabinose, rhamnose, glucuronic acid, and sugar residues Upon hydrolysis this gum yields L-arabinose, L-rhamnose, D-galactose, and glucuronic acid.[26] Cashew gum was also studied for its binding property and was compared with acacia. It was also observed that the disintegration time of the tablet increased with increase in concentration of cashew gum. Controlled release property has also studied which showed that increase in the polymer ratio retarded the drug release.[27,28]

Cassia Tara mucilage:

This gum is also known as Tara gum which is obtained from the endosperm of seed of *Caesalpinia spinosa*. It is a small tree of the (family: *Leguminosae*). The gum mainly contains galactomannans.[29] Tara gum studied as a controlled release carrier in the formulation of gastroretentive dosage forms due to swelling of the gum and using tara gum increases floating time of the dosage form thus showing good gastro retentive property.[30]

Cordia mucilage:

Cordia mucilage is obtained from raw fruits of a tree *Cordia obliqua* (family: *Boraginaceae*). Cordia mucilage can be used as an expectorant and is effective in treating lung disease. Raw gum can be used to treat gonorrhoea. Cordia mucilage also used as binding and emulsifying properties.[31]

Cocculus mucilage: This mucilage is obtained from leaves of the tree *Cocculus hirsute* (family: *Menispermaceae*). Main chemical cocculus of *Coccus mucilage* are polysaccharides and a gelatinous type of material. Leaves are used topically as emollient and demulcent. It has been observed nontoxic to human skin.[32] Gelling property of this mucilage was also studied on Flurbiprofen an anti-inflammatory drug for the formulation of gel. Marketed

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flurbiprofen gel and gel prepared from *Cocculus hirsute* leaf powder were compared and both the gels were evaluated for anti-inflammatory property. It was also observed that the quantity of drug released from prepared test gel and its anti-inflammatory activity was found to be more than that of marketed gel.[33]

Fenugreek mucilage:

Trigonella foenum-graceum, commonly known as Fenugreek, is an herbaceous plant of the (Family: *Leguminous)*. Fenugreek seeds contain a high percentage of mucilage and this mucilage forms a viscous tacky mass when exposed to fluids.[34] Mucilage derived from the seeds of fenugreek evaluated as a matrix formulation containing Propranolol hydrochloride and methocel K4M was used as a standard controlled release polymer for comparison.[35]

Gum dammar:

Gum damar is a whitish to yellowish colour gum produced by tapping trees of *Shorea wiesneri* (Family: *Dipterocarpaceae)*. This contains about 40% alpha-resin (alcohol soluble resin), 22% beta-resin, 23% dammarol acid, and 2.5% water. Gum damar was studied for its sustained release matrix forming property that showed sustained drug delivery beyond 10 hour.[36] Microencapsulating property of the gum was also evaluated and it was observed that the increase in gum : drug ratio also increases the particle size, encapsulation efficiency and decrease in drug release rate.[37]

Gum copal: Gum copal is a resin containing material obtained from the plants of *Araucariaceae* and *Caesalpinaceae* a subfamily of *Leguminoaceae*. Gum copal contains agathic acid, a diterpenoid and related lobdane compounds along with cis-communic acid, trans-communic acid, polycommunic acid, and sandaracopimaric acid, monomethyl ester of agathalic acid, agatholic acid and acetoxy agatholic acid.[38] Copal gum has been evaluated as matrix-forming material for sustaining drug delivery and copal resin studied as a film forming agent. Films showed good swelling property. It was proved that it can be used as a coating material for sustained release and colon targeted drug delivery.[39]

Hibiscus mucilage:

Mucilage is obtained from fresh leaves of *Hibiscus rosa-sinensis (*family: *Malvaceae)*. Mucilage of *Hibiscus rosa-sinensis* mainly contains L-rhamnose, D-galactose, D-galacturonic acid, and D-glucuronic acid.[40] Mucilage of Hibiscus also subjected to toxicity studies for its safety and preformulation studies for its suitability as a disintegrating agent.[41]

Honey locust gum:

The gum is obtained from the seeds of the plant *Gleditsia triacanthos* (family: *Leguminosae)*. The seed contains proteins, fats, carbohydrates and fibres. Honey locust gum was used to

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formulate matrix tablets at different concentrations (5% and 10%) by wet granulation method using theophylline as a model drug.[42]

Hakea gum:

Hakea gum is a dried exudate obtained from the plant *Hakea gibbosa* (family: *Proteaceae)*. Gum contains galactose, glucuronic acid, arabinose, mannose, xylose. The exuded is partly soluble in water. Gum was studied as a sustained release and mucoadhesive component in buccal tablets as a polymer. In this study, It was also observed that formulation which did not contain hakea gum showed 90% release of the drug in about 14 minutes. While when hakea gum was used in concentration of 32 mg per tablet, it was seen that 90% release of the drug took place in around 165 minutes. Also when tablets were directly compressed using hakea gum, for 32 mg gum per tablet, 90% release took place in 405 minutes.[43]

Kondagogu gum:

Kondagogu gum also known as hupu gum is a naturally occurring polysaccharide derived as an exudate from the tree *Cochlospermum religiosum* (family: *Bixaceae*). Gum contains rhamnose, galactose, galacturonic acid, glucuronic acid, b-D galactopyranose, a-D-glucose, b-D-glucose, arabinose, mannose, and fructose. Studies were performed on kondagogu gum for its gastro retentive property. Drug release rate decreased as the concentration of hupu gum increased 46. Hupu gum was also evaluated for its mucoadhesive property in the formulations of microspheres, all microspheres showed good mucoadhesive property in *in vitro* wash of test. Drug release from the microspheres was found to be slow and following zero order release kinetics with non-Fickian release mechanism.[44]

Mango gum: Mango gum is a dried gummy exudate polysaccharide obtained from the bark of a tree *Mangifera indica* (family: Anacardiaceae). Gum of *Mangifera indica* was studied as a binder in a tablet which contains Paracetamol as a model drug. Mango gum also studied as a drug release retardant polymer in the formulation development of sustained release Diclofenac sodium tablet. Mouth dissolving tablets were also studied using this gum.[45]

Mimosa mucilage:

Mimosa pudica generally known as sensitive plant belongs to (family: Mimosaceae). Mucilage of *Mimosa pudica* is obtained from seeds. Chemical components of mucilage are d-xylose and D-glucuronic acid. Mimosa seed mucilage hydrates and swells rapidly when it comes in contact with water. A controlled delivery system of Mimosa seed mucilage was studied with Diclofenac sodium as a model drug . In this study different batches of tablets were formulated and their drug releases were checked and it was observed that as the concentration of *Mimosa pudica* seed mucilage increases, there is a decrease in release of drug. Studies showed that as the concentration of the mucilage increased, there was a corresponding increase in percent swelling and decrease in percent erosion of the tablets.[46]

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Tamarind seed gum:

Tamarind seed polysaccharide obtained from the seed kernel of *Tamarinds indica*, it has properties of high viscosity, broad pH tolerance, no carcinogenicity, mucoadhesive nature, and biocompatibility. Tamarind seed gum was used in the formulation of matrix tablets containing Diclofenac sodium as a model drug by wet granulation method and was evaluated for its drug release characteristics. Tablets were prepared by using different concentration of the polymer and it was observed that upon increasing polymer content there is decrease in drug release. Other study done on Pilocarpine in-situ gelling solution based on alginate along with novel bio adhesive tamarind gum. Effects of tamarind seed polysaccharide as a biodegradable carrier for colon specific drug delivery was also studied by researchers. It was seen that the matrix tablets prepared by using tamarind gum were able to carry most of the drug to the colon and restrict the release in upper GIT.[47]

Neem gum:

Neem gum is obtained from the trees of *Azadirachta indica (*family: *Meliaceae*). Neem gum contains mannose, glucosamine, arabinose, galactose, fucose, xylose, and glucose and used as a binder in various pharmaceutical dosage forms.[48]

Ocimum mucilage:

Ociimum mucilage is obtained from the seeds of the plant *Ocimum americanum* commonly called *Ocimum canum* (family: *Lamiaceae*). Mucilage contains xylose, arabinose, rhamnose, and galacturonic acids.[49] The mucilage was studied to have disintegrating property and the disintegration time for tablet formulations prepared using ocimum mucilage was less than those tablets that were prepared by using starch as a disintegrating agent.[50]

Conclusion: The present review of the literature shows the release behaviour of natural polymers, gums and mucilage's therefore they can be easily used in the pharmaceutical formulations. The use of natural gums for pharmaceutical applications is attractive because they are economical, biocompatible, readily available, nontoxic, capable of chemical modifications, potentially biodegradable. Now-a-days natural polymers play a very important role almost in all kind of formulations. The pharmaceutical scientists have achieved a great success in developing the most therapeutic systems with suitable natural polymers. Majority of investigations on natural polymers in drug delivery systems centre around polysaccharides. Natural gums can also be modified to have tailor-made products for drug delivery systems and thus can compete with the synthetic excipients available in the market. Though the use of traditional gums has continued, newer gums have been used, some of them with exceptional qualities. There is huge scope for research on newer gums and mucilages obtained from plants and could be further exploited in future as a novel natural polymer for development of different drug delivery systems in pharma industry.

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CONFLICT OF INTEREST The author declare no conflict of interest.

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