International Journal of Innovation Scientific Research and Review
Vol. 03, Issue, 10, pp.1897-1912, October, 2021
Available online at http://www.journalijisr.com
SJIF Impact Factor 4.95

Research Article

ISSN: 2582-6131

NATURAL PLANT GUM EXUDATES AND MUCILAGE : PHARMACEUTICAL UPDATES

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Received 27th August 2021; Accepted 29th September 2021; Published online 31th October 2021

ABSTRACT

This review paper highlights the multiple applications of natural plant gum exudates and mucilages in the field of food, cosmetics, textile, paint, paper making, gelling, thickening, emulsifying, suspending, bio-adhesive, biomedical-drug delivery and pharmaceutical industries. India is the first and leading country in the world which has successfully completed the vaccination of 1 billion people against SARS-CoV-2. Two dose vaccine with Indian traditional Ayurvedic herbal medicine treatment has protected many people and reduced the hospitalization. One such example is Okra gum (Bhindi) (*Abelmoschus esculentus*), Acacia gum *(Acacia nilotica*), Tamrind gum (*Tamarindus indica*), Mango gum (*Mangifera indica*) and Cashew gum (*Anacardium occidentale*) were used as a immunity booster and herbal remedy for throat infections, cough, common cold during the recent outbreak of Covid-19 in India. The use of natural gums as pharmaceutical excipients is very attractive because they are economical, abundant, non-toxic, capable of chemical modifications, potentially bio-degradable and biocompatible. There are many health related issues with synthetic polymers in pharmaceutical industries. Therefore, there is an urgent need to develop other natural plant based sources as the modifying formulation of novel drug and other delivery systems. Hence the use of natural gums and their modifications aimed at the development of better biomedical materials for drug delivery has opened up a new ray of hope in solving the current drug delivery issues. A new type of polymeric material explored for pharmaceutical applications is modified plant-based gums and mucilage's, which have extended the scope of gums in the production of formulations.

Keywords: Gums, drug delivery, plants, India, herbal medicine, mucilage's, vaccine.

INTRODUCTION

Natural plant derived gums are pathological products and are produced when the plant is growing under unfavorable conditions or plant is injured (1-30, 41). Plant injury or damage to the plant particularly breaking the cell wall is the main reason for the exudation of gums (1-31, 41, 51-103). Plant injury might be due to the human activity or plant might be under extreme stress conditions. This in turn form cavities, which exudes transformed carbohydrates known as gums. Secondly it is caused as a result of injury to the bark or stem. Thirdly, some others attribute to fungi and bacterial attack to the plant. Majority of the gums are exuded from the stem. The term gum was probably applied to natural plant exudates that had oozed from tree barks (41). Therefore, gums are the abnormal or pathological products of plant metabolism and the process is known as gummosis (1-41). Only a few gums are obtained from roots, leaves and other parts of the plant. These gums on heating decompose completely without melting.

Gums have several forms, such as mucilage gums, seed gums, exudate gums, etc. Gum exudates are the common characteristics of certain plant families like *Leguminosae, Rosaceae, Combretaceae*, and *Sterculiaceae* (1-39, 41). Gums are present in high quantities in certain plants, animals, seaweeds, fungi, and other microbial sources, where they perform several structural and metabolic functions (41-145). The other important gum yielding families are *Anacardiaceae, Combretaceae, Meliaceae,* and *Rutaceae*. Gums come from different parts of plants. The source of some gums may be the seed epidermis, or they may be extracted from the leaves and bark of plants. *Acacia tragacanth* and Guar gum are samples of gums and gums dissolve easily in water (1-41). Plant gums are one of the most important gums because of their bioavailability (51-125). Herbal gums have been widely used in the pharmaceutical sciences for a variety of applications as stabilizing, binding, suspending, emulsifying, and thickening agents and for the sustained release of drugs (51-145). Plant-derived gums have been used by humans since ancient times for numerous applications (41-103). The natural gums are hydrocolloid in nature and used as a water binder and also act as a good carrier of natural antioxidant and antimicrobial agents (51-125). Mucilage's are generally normal products of metabolism (physiological products), formed within the cell (intracellular formation). Gums readily dissolve in water, whereas, mucilage form slimy masses. Both gums and mucilages are plant hydrocolloids yielding mixture of sugars and uronic acids on hydrolysis (51-145). Various applications of gums and mucilage's have been established in the field of pharmaceuticals *(*51-145*).*

Gums are the carbohydrate biomolecules that have the potential to bind water and form gels (41-125). The main chemical constituents of gum yield arabinose, galactose, mannose and glucuronic acid (41-135). Gums are regularly linked with protein and minerals in their construction. Gums are translucent and amorphous substances produced by plants (1-32, 41). Gums are soluble or partly soluble in water (3-37, 41). They are insoluble in alcohol and most of the organic solvent (1-10, 41). They form viscous adhesive solutions with water either by swelling or due to absorption (1-9, 41). An aqueous solution of gum is usually levorotary, they are plant hydrocolloids and may be anionic or non- ionic polysaccharides (1-41, 51-103). Natural gums obtained from plants have diverse applications in drug delivery as a disintegrant, emulsifying agent, suspending agents and as binders (51-145). Gums are the potent candidates to be used in various pharmaceutical formulations as a potential candidate for novel drug delivery system. Gums in general, are used primarily as adhesives or thickening agents in printing, textiles, paper,

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paint, candy, food, and pharmaceutical industries. They are used as tablet binding agents, suspending agents, emulsifiers, stabilizers, and thickening agents (1-41, 51-103). Gums are the potent candidates to be used in various pharmaceutical formulations as a potential candidate for novel drug delivery system (51-135). These natural gum materials have advantages over synthetic ones since they are chemically inert, nontoxic, less expensive, biodegradable and widely available (1-41). Plant products are therefore, attractive alternatives to synthetic products because of biocompatibility, low toxicity, environmental friendliness and low price compared to synthetic products. Natural gums are polysaccharides of natural origin, capable of causing a large viscosity increase in solution (51-103). Most often these gums are found as exudates from woody elements of plants or in seed coatings (51-103). In the food industry these are used as thickening, gelling and emulsifying agents and stabilizers (51-125). These are also used as adhesives, binding agents, crystal inhibitors, clarifying agents, encapsulating agents, flocculating, foam stabilizers, swelling agents, etc (51-135).

Natural gums can be classified according to their origin (51). Firstly, originated from non-marine botanical resources *e.g.* Gum *arabic*, Gum *ghatti*, Gum *tragacanth*, Gum *karaya*, *Guar* gum, Locust bean gum, *Chicle* gum, *Dammar* gum, *Mastic* gum, Psyllium seed husks and Spruce gum. Secondly, originated from seaweeds *e.g.* agar and *carrageenan* and thirdly, produced by bacterial fermentation *e.g. Gellan* gum and *Xanthun* gum (51). They can also be classified as uncharged or ionic polymers (polyelectrolyte) (51). The demand for hydrocolloids is attributed to the increased utilization in food, and pharmaceutical industry (51-135).

India is one of the largest producers of natural resins, gums, and gum-resins (NRGs) along with China, Indonesia, Russia, and Brazil. India is the world leader in production of Guar, Mango, Acacia, Karaya and Psyllium gums as well as Tamrind gum (1-41). 90% of the Guar gum is produced and exported by India. Therefore, ICAR-Indian Institute of Natural Resins and Gums continuously making efforts to strengthen the sector in the country. Indian subcontinent is a major hub of biodiversity of fauna and flora. Several forest products have significant importance in social and economic life in tropical areas (51-125).

India holds monopoly in world trade over some of the Natural resins and gums (NRGs) such as lac (*Kerria lacca* Ker), Gum Karaya and Guar gum (51). In India, mainly Gum Karaya, Guar gum, Karaya gum (*Sterculia urens*), Dhawada gum (*Anogeissum latifolia*), Babool/Babul gum (*Acacia nilotica*), Prosopis gum or Mesquite gum (*Prosopis juliflora*), Khair gum (*Acasia catechu*), Jhingan gum (*Lannea coromandelica*), Palas gum (*Butea monosperma*), Char gum (*Buchanania lanzan Spreng*) and Guggul gum (*Commiphora wightii*) are produced (51). Further *Shorea robusta*, *Anogeissus latifolia*, *Terminalia tomentosa*, *Boswellia serrata, Acacia catechu*, *Holarrhena antidysenterica and Lannea coromandelica* etc. are reported and listed as the commercially important gum producing tree species in India (51-125). The production of gums in important Indian States, *viz*, Karnataka, Chhattisgarh, Madhya Pradesh, Gujarat, Rajasthan and Andhra Pradesh has been documented (51-145).

The other important gums are Gum Arabic (*Acacia senegal),* Gum Kondagogu (*Cochlospermum gossypium),* Saja gum (*Terminalia tomentosa*), Jhingan gum (*L. coromandelica),* Babool gum (*Acacia nilotica*), Palas gum (*Butea monosperma*), Khair gum (*Acasia catechu*) and Char gum (*Buchanania lanzan Spreng*) (51). Gujarat, India is major Guggal gum and Prosopis gum or Mesquite gum (*Prosopis juliflora*) and Babool/Babul gum (*Acacia nilotica*) producing state (51). Gum Kondagogu is a naturally occurring nontoxic polysaccharide derived as an exudate from the bark of *Cochlospermum gossypium* (*Bixaceae* family), a native tree of India (51-135).

TYPES OF GUMS

Gums are grouped into three major categories namely A) **Natural gums**, B) **Modified gums**, and C**) Synthetic gums** (1-41).

A) **Natural gums** are obtained in a natural state such as the tree exudates, extracted from seeds of some legumes or seaweed hydrocolloids such as gum Arabica, Guar gum, and Tamarind gum. In many pharmaceutical formulations, plant-based gums and mucilage's are the key ingredients due to their bioavailability, widespread accessibility, non-toxicity, and reasonable low prices (1-41).

Further natural gums offer several advantages due to their natural abundance. Some of the **advantages of natural gums** are as follows

1. They are biodegradable polymers as they are produced by living organisms.
2. They are biocompatible and non-toxic.
3. Relatively cheap as the production cost is very low.
4. Readily available as a local source or through cultivation.
5. Environmental-friendly processing—Gums from different sources are easily collected in different seasons in large quantities due to the simple production processes involved.
6. Biodegradable— Naturally available biodegradable polymers are produced by all living organisms. They represented truly renewable source and they have no adverse impact on humans or Environmental health (e.g. skin and eye irritation). The production is eco-friendly.
7. Many of the gums are obtained from an edible source, hence they are easily acceptable (1-41).
8. Better patient tolerance as well as public acceptance-. There is a less chance of side and adverse effects with natural materials compared with synthetic one. For example, PMMA, povidone.

However, the **disadvantages** of natural gums are related to their production from a natural source. Some of the **disadvantages of natural gums** are as follows (1-41).

1. Microbial contamination due to high moisture content and possible degradation. The equilibrium moisture content present in the gums is normally 10% or more and, structurally, they are carbohydrates and, during production, they are exposed to the external environment and, so there is a chance of microbial contamination. However, this can be prevented by proper handling and the use of preservatives (1-41, 51-135).
2. Batch to batch variation—Synthetic manufacturing is a controlled procedure with fixed quantities of ingredients, while the production of gums is dependent on environmental and seasonal factors (1-41, 51-125).
3. Environmental and seasonal factors will influence the quality variation of gums. Uncontrolled rate of hydration—Due to differences in the collection of natural materials at different times, as well as differences in region, species, and climate conditions, the percentage of chemical constituents present in a given material may vary. There is a need to develop suitable monographs on available gums.
4. The difference in collection and climatic conditions also leads to quality variation of gums (1-41).
5. Natural gums showed a decrease in viscosity on storage. Reduced viscosity on storage—normally, when gums come into contact with water there is an increase in the viscosity of the formulations. Due to the complex nature of Gums (monosaccharide's to polysaccharides and their derivatives), it has been found that after storage there is reduced in viscosity (1-27).

Therefore, in order to eliminate these disadvantages and reduce the limitations, the use of plant nanosystems are used in drug delivery (41). Natural and synthetic nanoparticles, such as liposomes, nanoparticles, and micelles, improved the stability and bioavailability, as well as the biological distribution of the plant natural products (41). Nanosystems are able to deliver drugs to specific areas, so that they can increase the local drug concentrations and significantly reduced the adverse effects of drug uptake (1-41). Therefore, natural plant nano-formulations have attracted a lot of attention (41).

B) **Modified Gums -** They are chemically modified natural gums or derivatives of naturally occurring materials such as cellulose or starch. Ex: Carboxy methylcellulose (1-41).

C) **Synthetic Gums -**They are completely synthesized chemical products. Ex: polyvinyl pyrrolidone, polyethylene oxide (1-41).

SYNTHETIC POLYMERS

Synthetic polymers are used as excipients for the progress of polymer-based drug delivery systems with the purpose of targeted drug delivery (41). However, synthetic polymers have high physical, chemical, and mechanical stability but can cause cytotoxicity and are bio-incompatible (41). Synthetic polymers have disadvantages, such as: poor adaptation to the patient's body, high cost, and can also cause acute and chronic side effects (41). The synthetic polymers have certain disadvantages such as high cost, toxicity, environmental pollution during synthesis, non-renewable sources, side effects, and poor patient compliance. Acute and chronic adverse effects (skin and eye irritation) have been observed in workers handling the related substances such as methyl methacrylate and poly- (methyl methacrylate) (1-41). Reports of adverse reactions to povidone primarily concern the formation of subcutaneous granulomas at the injection site produced by povidone (1-41). There is also evidence that povidone may accumulate in organs following intramuscular injections. Acute oral toxicity studies in animals have indicated that carbomer-934P has a low oral toxicity at a dose of up to 8 g/Kg (1-41). Carbomer dust is irritating to the eyes, mucous membranes and respiratory tract. So gloves, eye protection and dust respirator are recommended during handling (1-41). Studies in rats have shown that 5% polyvinyl alcohol aqueous solution injected subcutaneously can cause anemia and can infiltrate various organs and tissues (1-41). Other **disadvantages of synthetic polymers** used in tissue engineering include: low biocompatibility, release of acidic products during degradation that can cause systemic and local reactions, and rapid loss of mechanical strength (41, 51-145).

The use of natural plant-derived polysaccharides as excipients has increased in the pharmaceutical industry and can solve formulation problems and reduced the side effects of synthetic polymers (1-41, 51-145). The utilization of plant natural polymers has increased in drug delivery (1-41). In addition to this, the use of *Piper betel* leaves extract incorporated polyvinyl alcohol‐oxidized maize starch based biodegradable polymers in food packaging industries has shown increased applications (42-145). The leaf extract of *Piper nigrum*, *Spathodea campanulata Solanum nigrum*, rutin induced, *Syzygium* cumini leaves extract, and *Phyllanthus reticulatus* anthocyanin have been extensively used in the preparation of blend films in the packaging industries instead of synthetic polymers (42-103). Moreover, the obtained blend films were hydrophilic, water soluble and biodegradable in nature (42-50). Therefore, the use of biodegradable polymers instead of synthetic polymers has increased recently and found successful (42-103). The resins and tannins in the gums are responsible for providing and delivering retardant properties to the dosage form and transmitting release inhibitory properties (41-50, 51-145).

PLANT GUMS AND MUCILAGE'S

Plant gums and mucilages are highly viscous. Gums and mucilages are polysaccharides, converted to monosaccharides by hydrolysis (1-41, 51-145). Mucilages are the natural products of metabolism and are formed in the plant cell and do not dissolve easily in water (41-103). The sugars in gums and mucilages are galactose and arabinose. Mucilages are found in diverse parts of the plant. Mucilage is a thick, sticky substance produced by almost all plants and some microorganisms (41). Gums and mucilages have **certain similarities;** both are plant hydrocolloids (41). They are also a mixture of clear amorphous polymers and monosaccharide polymers and are combined with uronic acid (41). Gums and mucilages contain hydrophilic molecules that can combine with water to form viscous or gel-like solutions (41). Advantages of using gums and mucilages in the pharmaceutical industry include: that they are biodegradable, biocompatible, nontoxic, provide better tolerance to the patient and have fewer side effects, do not cause allergies in humans, do not irritate the skin or eyes, and have low production costs (1-41, 51-125).

Gums and mucilages are widely used in the medicine and, food, textile, cosmetic industries and can also be modified for use in a variety of drug delivery systems. Gums and mucilages are composed of many compounds, including polysaccharides (41-103). The types of hydrolysis products can include pentosan (e.g., xylan) and hexose (e.g., starch and cellulose). Gums contain the salts of potassium, calcium, and magnesium, known as "polyuronides". Mucilages are sulfuric acid esters; the ester group is a complex polysaccharide (51-103). Gums and mucilages are found in large amounts in a varieties of land-plant sources (e.g., gum tragacanth, gum arabica, gum ghatti, and karaya gum), animal sources (e.g., hyaluronic acid, chitin and chitosan, and chondroitin sulfate.), marine origin/red seaweeds (e.g., agar and carrageenan) and brown algae sources (e.g., alginate and laminarin), and fungi and other microbial sources (e.g., xanthan, dextran, curdian, pullulan, zanflo, emulsan, schizophyllan, lentinan, krestin, scleroglucan, and Baker's yeast glycan.), where they perform many structural and pharmaceutical applications. Among them, plant sources provide the largest amounts (1-41, 51-103). Plant-derived gums are the polysaccharides formed from different parts of the plant. Gum tragacanth is one of the most common gums, which has been applied medicinally for many years (1-41, 51-135). Gums and mucilages have a variety of applications in the food industry. Different gums have different uses like water retention and stabilizztion (guar and locust bean gum), stabilizers for ice-cream, meat products and instant pudding (carrageenanas), dairy, confectionary and meat products (agar), confectionary, beverages, backed product, and sauces (gum arabic, tragacanth, pectins, alginates and xanthan gum) (51-145).

Pharmaceutical and other applications of plant gums

Natural gums and mucilages are naturally occurring components in plants, which are essentially cheap and plentiful. They are widely employed as natural excipients for conventional and novel dosage forms and showed potential to be biodegradable polymeric materials (51-145). Natural gums obtained from plants have diverse applications in drug delivery as a disintegrant, emulsifying agent, suspending agents and as binders (Table-1) (1-41, 51-103). They have also been found useful in formulating immediate and sustained-release preparation. A large number of plant-based pharmaceutical excipients are available. Gums are widely used as natural excipients for conventional and novel dosage forms (1-41, 51-103). Excipients are additives used to convert the active pharmaceutical ingredients into dosage forms suitable for administration to patients. Excipients are primarily employed as diluents, binders, disintegrants, adhesives, glidants and sweeteners as in ancient indefinite quantity forms like tablets, capsules *etc*. Gums possessed a complex, branched polymeric structure because of which they exhibit high cohesive and adhesive properties. These properties were used in pharmaceutical preparation (51-125). Hence plant gums find diverse application in pharmacy. They are ingredients in dental and other adhesive and as bulk laxative. These natural polymers are useful as tablet binder, disintegrating agent, emulsifier, suspending agent, thickener, gelling agent, stabilizing agent, protective colloids in suspension and sustain agent in tablets. They act as adjuvant in some pharmaceutical formulation (51-135).

Different starches like rice, potato, maize, corn, wheat, tapioca starch and gums like ferula gummosa boiss, gum olibanum, beilschmiedia seed gum, okra gum, Aegle marmelod gum, gum cordial, and *Cassia roxburghii* seed gum, plant fruit like date palm fruit and orange peel pectin showed good potency as a natural binding agent (51-125). Binding agent or binders are employed to convey the cohesiveness to the granules. Binders are added to the tablet formulation to impart plasticity as well as increases inter-particulate bonding strength in the tablet that ensure the tablet remains intact after compression (51-145). They also holds some other properties like filler, disintegrant, thickening agent and are safe and economical than synthetic polymers like PVP (51-145). To hold various powders together to form a tablet, binder is added either in dry mix or mix in granulating liquid and form matrix with fillers and drug embedded in it. On drying solid binder forms glue which holds the particles together, the wet binder is the most important ingredient in the wet granulation process, most binders are hydrophilic and most of the times soluble in water. Most of the natural polymer (gum and mucilage) are formed by high molecular weight carbohydrates (51-145). They are biodegradable, biocompatible and non-hazardous polymers showing irregular physical-chemical properties and environmentally sustainable features (51-145). Carbohydrates represented the most abundant biological molecules, covering a large array of fundamental roles in living things: from the reserve and transport of energy, (starch and glycogen), to the development of structural components (cellulose in plants, chitin in animals), to the linking between intercellular walls (hemicellulose) *(51-145).*

With the increasing interest in polymers of natural origin, the pharmaceutical world has compliance to use the most of them in the formulations (1-41, 51-125). A mixture of *Khaya senegalensis* gum and sodium alginate was a favourable polymer composition for formulation with controlled release (1-41). The 2:3 formulation ratio containing Khaya gum and sodium alginate produced microspheres with controlled release sketches comparable to the trading metformin tablets (1-41, 51-125). Plant gums were used as a drug carrier to form hydrogels and to improve pharmacokinetics (1-41). The oral delivery system for protein drugs was evaluated by plant gums. Natural polysaccharides were also tested as carriers for oral insulin administration (1-41, 51-125). Due to their non-toxicity, degradability, and cheap and easy availability, plant gums have many uses in the pharmacological production (1-41, 51-125). An insulin delivery system based on *Sterculia striata* gum with a high possibility for oral administration of protein drugs, which is a valid option for the effective delivery of those drugs has been reported (1-41, 51-145). Gums can also be modified in different ways to obtain tailor made materials for drug-delivery systems and thus can compete with the available synthetic excipients (41). Gums and mucilages based on plants were used in formulations as an excipient to improve the physical and chemical properties and stabilization (1-41, 51-145).

Plant-based gums and mucilages are used by many pharmaceutical formulations as one of their main ingredients (1-41, 51-125). Plant-based materials can be modified and has been widely used for the functional and non-functional purposes, to coat tablets, capsules, granules, powders, and pellets (1-41). Grewia gum was used as a film coating agent in theophylline tablet formulation (1-41). Gums posses a complex, branched polymeric structure because of which they exhibit high cohesive and adhesive properties (1-41, 51-145). In novel drug and gene delivery systems, the task of plant-based gums and mucilages has affected the overall understanding of plant-based gums and mucilages and gained them an identity as a possible matrix/carrier material for a broad range of new drug delivery systems (1-41, 51-125). Natural excipients are additives used to convert the active pharmaceutical ingredients into dosage forms suitable for administration to patients (1-41). Plant-mediated nanoparticles are also possible treatments for HIV, infectious illnesses, malaria, hepatitis, cancer, and other severe diseases (1-41, 51-103). The modification of natural gum has created a new class of polymers that are useful in developed drug delivery systems. With these modifications, natural gum has expanded its applications as novel drug delivery systems in nanomedicine and gene delivery (41-103). Gum derived plants are used as a stabilizer in many nano-pharmaceuticals. Another interesting application of gum in nanomedicine is gene delivery (51-135). Polymeric vectors are a pioneering class of gene carriers among non-viral vectors engineered for the safe delivery of genes to target sites because of many benefits, such as safety, cost-effectivity, lower toxicity, and the ability to deliver larger genes (41, 51-135). A carboxymethylated guar gum-grafted-polyethyleneimine copolymer (CMGG-g-PEI) was reported as an effective gene carrier (41, 51-145).

Natural gum excipients are preferred over the synthetic as they are inert, safe, non-toxic, biocompatible, biodegradable, low cost, eco-friendly and abundantly available in nature (1-41, 51-103). Gums have a variety of applications in pharmacy (Table-1). They are used in medicine for their demulcent for cough suppression, dental, other adhesive and as bulk laxatives (1-41, 51-125). Gums are widely used in pharmacy as thickeners, suspending agents and emulsifying agents (1-41). Natural gums are hydrophilic colloids that form dispersion with water and increases the viscosity of the continuous phase so that solid particle suspended is sufficient for a long time to measure the uniform dose (1-41, 51-103). The use of *Ocimum gratissimum*, *Butea monospermama*, *Leucaena leucocephala* seed gum, and *Cordia gharaf* gum as suspending agent has been reported (1-41, 51-125). These polymers are useful as tablets binder, disintegrating agent, stabilizing agent protective colloids in suspension, and sustain agent in tablets (1-41, 51-125). Natural gums have a wide range of pharmaceutical applications that include their use as binder, disintegration in tablets and used as sustaining agents in tablet (1-41, 51-125). Natural polymer, gums modify the drug release from formulations (1-41).

Natural gum has a good binding property in wet granulation for the manufacturing of tablets (1-41, 51-145). Further *Cassia roxbughii* seed gum has been reported as a binder in paracetamol tablets (1-41). *Magnifier indica* gums was also used as a binder in paracetamol tablets (1-41). Cashew gum as binder in metronidazole tablets (51-125). Natural gums are used widely in pharmaceutical dosage forms, and their use as biodegradable polymeric materials (1-41). The use of several natural gums such as Guar gums, Xanthan gums and Karaya gum has been explored for the development of sustained-release dosage forms (1-41, 51-125) (Table-1). Microencapsulation is defined as a process to entrap one substance with another substance**.** The gums because of their ability as a coating and matrix-forming agent can be utilized for microencapsulation of drug particles for sustaining the drug release (1-41, 51-125). Several gums such as Kondagogu, Xanthan, Guar gum has been utilized in microencapsulation (1-41). Some thickening agents are gelling agents and Galactomannan interacts synergistically with Xanthan gums and Carrageenan to form as elastic gel (1-41, 51-145).

Natural gums have also been utilized for the development of nanoparticles (1-41, 51-125). Recent reports have shown on the development of nanoparticles using Guar gum, Kondagogu, gum Ghatti (1-41). The multi-functionality of nanoparticles confers the ability to deliver medicine and imaging agents (1-41, 51-145). Natural polysaccharides due to their excellent biocompatibility, low toxicity, biodegradability and functionalities that the body can identify which, make them excellent materials for theranostics (1-41). A theranostic is a delivery system fabricated to deliver both medicine and imaging agent(s) in a single dose, bridging the gap between imaging and therapy, thereby facilitating real-time monitoring of therapeutic efficacy of the incorporated drug (1-41). The nanoparticles were then characterized for *in-vitro* cellular uptake, *ex vivo* tissue distribution, *in-vivo* distribution, and tumor targeting (1-41).

Other natural polymers such as alginate, dextran and chitosan have been used (1-41). Plant polysaccharides should be explored in fabrication of theranostics as they exhibit functionalities recognized by the body as compared to those of the polymers in biological systems (1-41, 51-125). Polysaccharides are the materials for drug targeting and concentration at the site of action. Considering cancer therapy, some polysaccharides have exhibited anti-tumor activity (1-41). Incorporation of chemotherapeutic into a polysaccharide carrier may enhance cancer therapy (1-41). Nano-capsules with fish oil–garlic essential oil using persian gum were successfully produced. Nano-capsules have a good physicochemical properties indicating good stability in food industry (41). Gum kondagogu has been used in the removal of various toxic metal ions in the water purification (41-135).

Natural polysaccharides, particularly gums and mucilages, are considered as sustainable materials due to their unique structural, biological, physicochemical, and biomechanical features (1-41, 51-125). The gums and mucilages derived from the plants are widely used in food-processing, pharmaceutics, and nanomedicine (1-41, 51-125). Outstanding examples of these include gum Tragacanth (from several species of the genus Astragalus), and Arabic gum (*Acacia senegal* (L.) Willd.). These natural plant materials have advantages over synthetic ones owing to their outstanding structural features, less expensive price, nontoxicity, ease of modification, biocompatibility, abundant availability, and also promising potential (1-41, 51-135).

Development of polyelectrolyte nanoparticles using *Moringa* gum has shown complexation techniques for controlled and extended-release of molecularly entrapped drug (1-41, 51-125). Various film modifiers like Xanthan gum, Carrageenan gum, and Locust bean gum was provided with proper texture to film and reduce recrystallization of drug (1-41, 51-125). Cross-linked *Plantago psyllium* gum (with methacrylamide) was also employed as colon-specific drug delivery system due to its response to pH and they produced hydrogels that respond to ions as well as pH (1-41, 51-125). Further cellulose derivatives respond to ions, pH and temperature and have been utilized for colon-specific drug delivery (1-41, 51-145).

Plant polymers should be explored for the fabrication of microneedles and other BioMEMS (1-41). Furthermore, BioMEMS refers to the Biomedical or Biological Microelectro mechanical systems also utilized plant based polymers (1-41). In addition, some recent applications of plant-based gums and mucilages in the field of biosynthesis and gene delivery of nanotechnology created an alternative path for more study and applications of plant-based gums and mucilages in the development of novel drug delivery systems particularly in the production of vaccines (1-41). Plant gums are usually acts as suspending agent, emulsifying agent, gelling agent in suppositories, surgical, lubricant, tablet disintegrant, medium for bacterial culture, laxative, tablet binder, demulcent and emollient in cosmetics, binding, sustaining and transdermal film-forming agent, gelling agent, stabilizer in emulsions and suspensions, in toothpaste and sustained-release agent (1-41, 51-135).

India is the leading in **Guar gum** (*Cyamopsis tetragonoloba*) (Family: Fabaceae) production due to its well established Guar gum industry in Jodhpur, Rajasthan (51). India contributes about 90 % to the world Guar gum production (51). India is native of Guar gum or cluster bean (51). The Indian states like Rajasthan, Gujarat, Haryana and Maharashtra has Guar seed collection Centers and Guar gum processing units (51). Recently, more units are also being established in Bikaner, Rajasthan with high capacity (51). Further, Sri Ganganagar, Hissar, Alwar, Sirsa, Jodhpur, Bikaner, Jaipur are the major markets for Guar seed (51). Major Guar gum is used in food, pharmaceutical, paper, cosmetic, painting, textile, oil drilling, mining, explosives, ore flotation and other various industrial applications (51).

In India, Guar is used as vegetable by households, as cattle food (whole green plant), and as a green manure crop in agriculture (51-103). Guar gum comes from the endosperm (30 %) of the seed of the legume plant *Cyamopsis tetragonoloba*, an annual plant belongs to family *Fabaceae* grown in dry regions of India (51). There are various grades of Guar gums pure or derivative. Guar gum is a white to creamy coloured, free flowing powder without any extraneous matter (51-125). Its ability to suspend solids, bind water by hydrogen bonding, control the viscosity of aqueous solutions, form strong tough films have accounted for its rapid growth (51). Guar gum–nano zinc oxide (GG/nZnO) biocomposite was used as an adsorbent for enhanced removal of Cr(VI) from aqueous solution in the water purification treatment (41).

Dhawda gum (*Anogeissum latifolia*) belongs to the family *Combretaceae* is mainly produced in the Indian states of Chhattisgarh, Gujarat, Jharkhand, Madhya Pradesh, Maharashtra and Andhra Pradesh (51). Gum Ghatti, Dhauda, Dhaura, Bakli, Tirman, Vekkali, Dhanda, Damado and Dhawda gum is the dry exudate of *Anogeissum latifolia* (51). It has a glassy fracture and occurs in rounded tears which are normally less than 1 cm in diameter. It often occurs in larger vermiform masses (51). The colour of the exudate varies from light to dark brown; the lighter the colour the better the quality (51). Dhawda gum (*Anogeissum latifolia*) is used by many industries (51). It is used as an emulsifier and stabilizer in beverages and butter containing table syrups; flavour fixative for specific applications; to prepare powdered, stable, oil-soluble vitamins; as a binder in long-fibered light weight papers; as an emulsifier of petroleum, and non petroleum waxes to form liquid, wax paste emulsions; used to prepare uniform and discrete prills of cross-linked polystyrene; used as a drilling mud conditioner, the acidizing of oil wells and also used in powdered explosives to improve resistance to water damage (51-145).

Gum Karaya (*Sterculia urens*): Vernacular names:-Kullu, Kadaya, Kadu, Galgala, Genduli, Tapsi, Panerukh, Kandol, Salad Gum karaya is the dry exudate of *Sterculia urens* and *Sterculia villosa* (51). It is also collected from *Sterculia urceolata* and *Sterculia foetida* in Indonesia, *Sterculia setigera* in Africa and from *Sterculia caudata* in Australia (51). It is also known by the name Indian tragacanth, as it resembles gum tragacanth produced by *Astragalus spp* (51). Gum Karaya is one of the least soluble gums used for many industries such as pharmaceutical, food, paper, textiles, and cosmetic industry (51). Superior grades of Karaya gum are used in ice-creams, Ink, rubber, linoleum, oil clothes, paper coatings, polishes, and lower grades in varnishes, engraving processes and in oil drilling operations (51). Gum Karaya is also used in dental compounds and colostomy rings (51). Gum Karaya is acting as mucilage and also used as a bulk laxative, as a binder, emulsifier and stabilizer in food industry (51).

Saja gum (*Terminalia tomentosa*) is a tree growing up to 30 m tall, with a trunk up to diameter of 1 m (51). A copious transparent gum exudes in large globular tears from the trunk (51). In India, the annual gum production is about 30-40 tons (51). It is used as incense and cosmetic. Saja gum (*Terminalia tomentosa*) has a remarkable attribute as some members of the species store water in the dry season (51).

Jhingan gum (*Lannea coromandelica*) (Jhingan, Indian Ash Tree, Moi tree) is a deciduous tree which grows upto 14 m height (51). Jhingan gum (*Lannea coromandelica*) is mostly obtained from natural exudation and sometimes by tapping. The annual Jhingan gum production in India is about 60-80 tons (51). It is used as an alternative to gum Arabic in food and other purposes (51). This is gum is mainly used in Agarbathi industries in India (51). In India particularly in Karnataka, Maharashtra, Tamil Nadu, Goa, Kerala, Andhra Pradesh, Telangana, Rajastan, Punjab, Uttar Pradesh, Madhya Pradesh state, the ***Acacia* gum** (*Acacia nilotica*), Tamrind gum (*Tamarindus indica*), Mango gum (*Mangifera indica*), Cashew gum (*Anacardium occidentale*) were used in the food industries particularly in the preparation of local sweets (Laddu). The consumption of sweets with additional supplementation of natural gums is very high for the pregnant women and after the delivery of baby as per the local traditional healers. The plant gum is also used as a herbal medicine for the relief of back bone pain particularly in the old age people in India (Table-1).

Dikamali gum (Gardenia gummiferra) belongs to the family *Rubiaceae* is the gum resin obtained from the leaf buds of a shrubby plant by making a cut on the stem or branches (51). It is geographically distributed in all districts of **South India**, particularly in **Karnataka state** (North Canara district, Karwar, Mangalore), Western ghat region of Karnataka, Tamil Nadu, Andhra Pradesh state, Kerala, Malabar coast, Burma, and Bangladesh (51). Other names are Dikamali, *Gandharaj, Hingunadika, Nadihingu, pindava*, *etc* (51). A number of flavonoids such as gardenin A, B, C, D, and E were isolated from Dikamali in the past. It contains 89.9% resin and 0.1% oil and gardenin, a coloring agent and annual production in India is 10-15 tons (51).

Asafoetida gum (Hing) Asafoetida or Asafetida (*Ferula anthrax* and *F. foetida*) is also known as “Food of the Gods”, “Stinking Gum”, “Devil’s Dung” is the dried latex prepared from the rhizome of several *Ferula* species occurring in Asia and North Africa (51). It is popular spice used in daily food by Indians. It was found to contain mainly ferulic acid, umbellic acid and ketonic substance known as umbelliferone (51). Powder of Asafoetida is used as carminative, it is also used in fainting, flatulent colic and chronic bronchitis as well as it is used to treat asthma in adults (51). The drug is used as a herbal remedy or spice especially in oriental countries since ancient times (51). It contains sesquiterpene coumarins, diterpenes, esters of ferulic acid and sulphur-containing organic compounds (51). The drug is traditionally used for the treatment of diseases of the digestive and respiratory tract. New pharmacological investigations indicated the possible anti-inflammatory, antidiabetic and anti-bacterial effects (51). Asafoetida gum has Cell toxicity and antimicrobial activity. Synthesis of silver nanoparticles using Asafoetida were found to be effective in inhibiting the multiplication of cancer cells (MCF-7). They also exhibited significant antibacterial and antifungal activity (41-145). *Alyssum homolocarpum* seed gum has been used in the synthesis of nanomaterials. Magnetic nanocomposite (Fe_3O_4 NPs) was synthesized and coated via Alyssum homo-locarpum seed gum successfully. The fabricated nanocomposite exhibits excellent antibacterial activity against Gram-positive and Gram-negative bacteria (41). *Azadirachta indica* gum was used in the preparation of Nano-carrier. The nanocarriers were found to be effective against MCF7 cancer cell line (41).

Salai gum (*Boswellia serrata*) *Frankincense*, is also known as *Olibanum*, is an aromatic oleogum resin obtained as pale yellow to red tears from the bark of trees belonging to the genera *Boswellia* of the *Burseraceae* family thriving in arid regions in the horn of Africa and Southern Arabia (51).

Boswellia serrata gum (Family: *Burseraceae*) is a deciduous middle sized tree, which is mostly concentrated in tropical parts of Asia and Africa (51). There are 43 different reported species in India, Arabian Peninsula and North Africa (51). In India it occurs in dry hilly forests of Rajasthan, Madhya Pradesh, Gujarat, Bihar, Assam, Orrisa as well as Central Penisular regions of Andhra Pradesh, Karnataka, Tamil Nadu and Assam (51). It is generally composed of 5–9% essential oil, 65–85% alcohol-soluble resin and the remaining water-soluble gums (51). Extracts from *Boswellia serrata* resin are currently used in India for the treatment of rheumatic diseases and ulcerative colitis (51). Furthermore, the extracts and essential oils of frankincense have been used as antiseptic agents in mouthwash, in the treatment of cough, asthma and as a fixative in perfumes, soaps, creams, lotions and detergents (51). Today frankincense is widely employed in aromatherapy. The main component of frankincense is oil (60%). It contains mono- (13%) and diterpenes (40%) as well as ethyl acetate (21.4%), Octyl acetate (13.4%) and methylanisole (7.6%) (51-145).

The main populations of gum-producing *Acacia* species are harvested in Mauritania, Senegal, Mali, Burkina Faso, Niger, Nigeria, Chad, Cameroon, Sudan, Eritrea, Somalia, Ethiopia, Kenya and Tanzania (51). *Acacia senegal* is tapped for gum by cutting holes in the bark, from which a product called Kordofan or Senegal gum is exuded (51). Seyal gum, from *Acacia seyal*, the species more prevalent in East Africa, is collected from naturally occurring exudations on the bark (51). Traditionally Acacia gum remains a main export of several African nations, including Senegal, Mauritania, Niger, Chad, and Sudan (51).

Recently, natural gum is used as a novel source for maintaining the postharvest quality, organoleptic properties, and extending the shelf life of fruits and vegetables during the storage period (52). The development of natural gum-based edible coating has increased remarkable growth in the past few decades (52). The use of natural gum to develop edible coating helps to improve the recyclability of packaging materials compared to synthetic packaging materials (52-125). It is also a good alternative to synthetic packaging and played an important role as a biodegradable and eco-friendly edible coating for improving the postharvest characteristics and shelf life of fruits and vegetables (52). Plant gums are naturally occurring carbohydrate/polysaccharide-based polymers obtained from natural/renewable sources (52-125). Plant-based gums and mucilages are used by many pharmaceutical formulations as one of their main ingredients (51-145). A new type of polymeric material explored for pharmaceutical applications is modified plant-based gums and mucilages, which have extended the scope of gums in the production of formulations. Recent applications of plant-based gums and mucilages in the field of biosynthesis and gene delivery of nanotechnology create an alternative path for more study and applications (41-144).

Plant gums: Coronavirus (SARS-CoV-2) disease (Covid-19)

The outbreak of second wave of coronavirus (SARS-CoV-2) mutants, Delta (B.1.617.2) and Delta Plus (AY.1) with mucormycosis has devastated India by more number of hospitalizations and increased death rates (146-151, 153-157). Therefore, two dose vaccination with additional dietary and medicinal therapy has helped to prevent the human body against invading viral antigen and improved the overall health condition of the Covid-19 patients (146-151, 153-157). In India, during the recent outbreak of Coronavirus (SARS-CoV-2), there are many local traditional herbal healers used the Okra gum (Bhindi) (*Abelmoschus esculentus*), Acacia gum (*Acacia nilotica*), Tamrind gum (*Tamarindus indica*), Mango gum (*Mangifera indica*) and Cashew gum (*Anacardium occidentale*) were used as a immunity booster for the Covid-19 patients. In general, these natural gums were prepared as sweets in the form of Laddus and consumed as the nutritional diet as an additional supplementation for the Covid-19 patients during hospitalization. All these gums in hot water or milk were used for the treatment of throat infections, cough, common cold, to reduce the mucus, and to protect the throat from irritation. Using Acacia gum for coughs can keep throat from becoming sore as well as ease or prevent symptoms, including losing voice. This has also helped in the speedy recovery of the covid-19 patients along with the regular medication during the Covid-19 outbreak in India. The promising effect of plant gums and mucilages can be attributed to its antioxidant, anti-inflammatory, immunomodulatory, cardioprotective, anti-platelet aggregation, antibacterial, antifungal, and broad antiviral activity. Lower concentrations of plant gums is used as herbal medicine. However, consumption of higher concentrations of plant gums is toxic. Kaddam *et al.,* (2020) (126) has investigated the potential efficacy of *Acacia senegal* extract Gum Arabic (GA) supplementation as immunomodulatory and anti-inflammatory dietary intervention among newly diagnosed COVID 19 Sudanese patients (126). There are no reports of clinical evidence in India to support natural gums and mucilages inhibited viral load and replication of the SARS-CoV-2 virus. Therefore, clinical experimental study should be conducted to support the scientific validation.

Isolation and purification of gums/mucilages

Gum and mucilages can be extracted from plant parts by various methods like heating, solvent precipitation, and microwave assisted extraction (57, 118, 125-145). The easiest method is solvent precipitation. In this method, the part of the plant containing gum/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 in distilled water and kept for 6–8 hour at room temperature (57, 125-129). The supernatant is obtained by centrifugation (57, 118, 125-129). The residue is then washed with water and the washings are added to the separated supernatant (57, 118, 125-129). Solvent for the precipitation is selected and, finally, the supernatant is mixed twice with the volume of precipitating solvent by continuous stirring (57, 118, 125-129). 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 then with distilled water (57, 118, 125-145).

Plant material is dried in sunlight (preferably) or in an oven at 105˚C to retain its properties unchanged (57, 125-129). Generally, chlorophyll or pigments are present in the plant which should be removed before isolating the mucilage. Plant material must be treated with petroleum ether and chloroform (to remove pigments and chlorophyll) and then with distilled water (57, 125-129). Care should be taken when drying the final isolated/extracted gum/ mucilage (125-129). It must be dried at a very low temperature (not more than 50˚C) or in a vacuum. The dried material is stored carefully in desiccators to prevent further moisture uptake or degradation (57, 125-145).

Baveja *et al.,* (127) and Wahi *et al.,* (128) reported the following method for the isolation of mucilage (57, 118, 125-135). The fresh plant materials were collected washed with water to remove dirt and debris, and dried. Then, the powdered material was soaked in water for 5-6 h, boiled for 30 min, and allows standing for 1 h so that all the mucilage was released into the water (57, 125-129). The material was then squeezed from cotton muslin bag to remove the marc from the solution. Following this, three volumes of acetone was added to the filtrate to precipitate the mucilage (57, 118, 125-129). The mucilage was separated, dried in an oven at a temperature less than 50˚C, and the dried powder was passed through a No. 80 sieve and stored in a desiccator until required (57, 125-128). The isolated mucilage from the plant was subjected to some preliminary confirmative testing (57, 118, 125-145).

In another method, plant material is powdered in a mechanical blender for 5 m and then soaked in distilled water for 24 h in a 1000 ml beaker. It is kept in a microwave oven along with a glass tube to prevent bumping when subjected to microwave irradiation. The beaker is removed from the oven and allowed to stand for 2 h to allow the mucilage to be released into the water. It is then processed in a similar way to the conventional procedure, weighed and stored (57, 118, 125-145).

Nagpal *et al.,* 2017 (152) has adopted the ultrasonic assisted extraction of gum from Okra (Bhindi) (*Abelmoschus esculentus*) fruits (152). The Okra fruits (bhindi) were cleaned, sliced and were mashed in 2% v/v glacial acetic acid solution to form a slurry and gum was extracted in distilled water in 1000 ml beaker with 1:1 ratio of water to raw material, 65 W ultrasonic power and 45 minutes extraction time at 65°C (152). After extraction, the slurry was filtered through muslin cloth to remove debris. Excess acetone was added for precipitating the gum. Finally, the precipitates were dried in vacuum oven at 50°C. The gum sample was further purified by dialysis. Purified gum obtained by lyophilization and ground to Okra gum powder (152).

Preliminary confirmative tests for dried mucilage powder has been carried out using 1) **Molisch's test**: (100 mg dried mucilage powder + Molisch's reagent + conc. Sulphuric acid on the side of a test tube) (57, 118, 125-129). Violet green color observed at the junction of the two layers for the confirmation of carbohydrate in the crude sample. 2) **Ruthenium test**: Take a small quantity of dried mucilage powder, mount it on a slide with ruthenium red solution, and observe it under microscope. This test will confirm the presence of mucilage in the crude sample (57, 125-135). 3) **Iodine test**: 100 mg dried mucilage powder + 1 ml 0.2 N iodine solution. No color observed in solution which will confirm the presence of Polysaccharides (starch is absent) (57, 118, 125-135).

Gums and mucilages are polysaccharides and contain sugars. So, confirmation of the different sugars is carried out by chromatography and structure elucidation can be carried out by NMR and mass spectroscopy. To determine the purity of the selected gum and mucilage, tests for alkaloids, glycosides, carbohydrates, flavanoids, steroids, amino acids, terpenes, saponins, oils and fats, and tannins and phenols should be carried out (57, 118, 125-145).

Table-1: Plant gums and pharmaceutical applications

SN	Common name	Botanical name	Family	Structure	Pharmaceutical & other applications
1	**Tragacanth gum**	Astragalus brachycalyx & Astragalus gummifer	Fabaceae	Pectinaceous Arabino galactans Xylogalacturonans	Emulsifying and Suspending agent Used as confectionary Analgesic, general tonic, laxative factor, and to cure cough and lip

SN	Common name	Botanical name	Family	Structure	Pharmaceutical & other applications
2	**Guar gum**	*Cyamopsis tetragonoloba*	Fabaceae (Leguminosae)	Galactose Mannose	1. Controlled drug delivery 2. Suspending agent 3. Sustained release 4. Anti inflammation 5. Medicine for constipation 6. Used for appetite suppressant
3	**Tamarind gum**	*Tamarindus indica*	*Fabaceae*	Glucosyl: Xylosyl: Galactosyl (3:2:1)	Matrix tablets Drug release Biodegradable carrier for colon specific release Used in textile, paper, pet food, mining and food industry
4	**Acacia gum (Babul gum)**	*Acacia nilotica* *Vachellia nilotica*	*Fabaceae*	1,3-linked- β-D-galactopyranosyl	Binder in tablets Suspending and Emulsifying agent Demulcent & Emollient in cosmetics
5	**Almond gum**	*Prunus dulcis* *Prunus amygdalus*	*Rosaceae*	Aldobionic acid L-arabinose L-galactose D-mannose	Uncoated tablet dosage Emulsifying Thickening Suspending Adhesive Stabilizing
6	**Karaya gum**	*Firmiana simplex*	*Malvaceae*	α-d-galacturonic acid α-l-rhamnose	Suspending and Emulsifying agent Dental adhesive Sustaining agent Mucoadhesive Buccoadhesive
7	**Neem gum**	*Azadirachta indica*	*Meliaceae*	Mannose Glucosamine Arabinose Galactose Fucose Xylose Glucose	Insectiside Binding property Sustained release Matrix tablet
8	**Tara gum**	*Caesalpinia spinosa*	*Fabaceae*	Galactomannans. mannoseto galactose in taragumis is 3:1	Controlled release carrier
9	**Cordia gum**	*Cordia myxa*	*Boraginaceae*	Galactose (27%) Rhamnose 21%) Mannose (17%) Xylose (11%) Glucose (10%) Arabinose (5%) and uronic acids (5%)	Oral sustained release matrix tablets
10	**Grewia gum**	*Grewia mollis*	*Malvaceae*	Glucose Rhamnose Galacturonic acid	Film forming property Suspending agent Binding property Control the release of cimetidine from tablets
11	**Albizia gum**	*Albizia zygia*	*Leguminosae*	Galactose Mannose Arabinose Glucuronic acid 4-0-α-methyl analogue	Used in Food industry Anti inflammatory agent Tablet binder Emulsifier Coating materials in compression-coated tablets
12	**Albizia odoratissima**	*Mimosa odoratissima*	*Leguminoseae*		Used for indoor construction
13	**Asafoetida gum**	*Ferula foetida regel*	*Umbelliferae*		Used as a powerful nervine stimulant
14	**Agar gum**	*Gelidium amansii*	Gelidaceae		Used in the preparation of jellies, confectionery, and laboratory media preparation
15	**Okra gum**	*Abelmoschus esculentus*	*Malvaceae*	Galactose Galacturonic acid Rhamnose Glucose Mmannose Arabinose Xylose	Controlled release tablet Sustained-release tablets Suspending agent

SN	Common name	Botanical name	Family	Structure	Pharmaceutical & other applications
16	**Ghatti gum**	*Anogeissus latifolia*	*Combretaceae*	β-1-3-linked D galactose units with some ß-1-6-linked D-galactose units	Binder Emulsifier Suspending agent
17	**Bhara gum**	*Terminalia bellirica*	*Combretaceae*	ß-sitosterol Gallic acid Ellagic acid Ethyl gallate Galloyl glucose Chebulaginic acid	Sustained release Microcapsules employing bhara gum release of famotidine Used in medicinal purpose
18	Bengal Kino **(Butea gum)**	*Butea monosperma*	*Leguminosae*		Used internally for diarrhoea and dysentery
19	**Cashew gum**	*Anacardium occidentale*	*Anacardiaceae*	Galactose Arabinose Rhamnose Glucose Glucuronic acid L-arabinose L-rhamnose D-galactose Glucuronic acid	Suspending agent Used as a jelling agent in canned food
20	**Konjac Glucomannan gum**	*Amorphophallus konjac*	*Araceae*	D-glucose & D-mannose in the ratio of 1: 1.6	Gelling properties
21	**Terminalia gum**	*Terminalia randii*	*Combretaceae*		Binding agent
22	**Olibanum gum**	*Boswellia serrata*	*Burseraceae*	5–9% Oil content 13–17% Resin acids, 20–30% Polysaccharides, 40–60% boswellic acid	Sustained release Binding agent Used in plasters and fumigating pastilles
23	**Mango gum**	*Mangifera indica*	*Anacardiaceae*		Binding agent Sustained release Disintegrating
24	**Hakea gum**	*Hakea gibbosa*	*Proteaceae*	Glucuronic acid Galactose Arabinose Mannose Xylose	Sustained release Binding agent
25	**Dammar gum**	*Shorea javanica*	*Dipterocarpaceae*	Alpha resin Beta-resin Dammarol acid	Sustained release
26	**Moringa oleifera gum**	*Moringa oleifera*	*Moringaceae*	Arabinose Galactose Glucuronic acid in the preparation of 10:7:2 Rhamnose	Gelling, Binding, Release retardant, Disintegrating, and Emulsifying property
27	**Honey Locust gum**	*Gleditsia triacanthos*	*Fabaceae*	Proteins Fats Carbohydrates Fibers	Matrix tablets at different concentrations (5% and 10%)
28	**Terminalia catappa gum**	*Terminalia catappa*	*Combretaceae*		Oral sustained release tablets
29	**Khaya gum**	*Khaya grandifoliola*	Meliaceae	Protein Sugar Phenol 61% Galactose 14% Arabinose 7% Rhamnose, 8% Glucose 5% Glucuronic acid <2% other sugar Residues	Binding agent Drug targeting Controlled release
30	**Locust bean gum (carob gum)**	*Ceratonia siliqua*	*Fabaceae*	D-galacto-D-mannoglycan pentane Proteins Cellulose	Super disintegrant Controlled drug delivery Drug targeting to the colon Super disintegrants Mucoadhesive

SN	Common name	Botanical name	Family	Structure	Pharmaceutical & other applications
31	**Salai gum**	Boswellia serrata	Burseraceae	Mono, di, tri, terpenes, β-boswellic acid	Used for lighting fires Treatment of various chronic inflammatory diseases Anti-inflammatory agent
32	**Prunus gum**	Prunus domestica	Rosaceae		Used as astringent
33	**Red gum** (Eucalyptus kino)	Eucalyptus rostrata	Myrtaceae		Used as astringent
34	**Odina gum**	Odina wodier	Anacardiaceae		Used as anti-inflammatory, respiratory irritation
35	**Malva nut gum**	Scaphium scaphigerum	Sterculiaceae		Used as Chinese medicine as a coolant
36	**Myrrh gum**	Commiphora mol mol	Burseraceae		Used in uterine stimulant
37	**Mastic gum**	Pistacia lentiscus	Anacardiaceae		Used for intestinal ulcers and muscle aches
38	**Lemon-scented gum**	Eucalyptus citriodora	Myrtaceae		Used to treat bladder inflammation
39	**Moi gum**	Lannea coromandelica	Anacardiaceae		Used in herbal medicine
40	**Mucuna gum**	Mucuna flagillepes	Papillionaceae		Used as herbal medicine
41	**Mimosa scabrella gum**	Mimosa scabrella	Mimosaceae		Used in paper and paint industry
42	**Kino gum**	Pterocarpus marsupium	Fabaceae		Used to treat boils and other skin diseases
43	**Katira gum**	C. religiosum	Bixaceae		As a gelling agent
44	**Leucaena seed gum**	Leucaena leucocephata	Leucocephata		Used to control stomach ache and contraception
45	**Kondagogu gum**	Cochlospermum religiosum	Bixaceae		Used in the paper, textile, paint and ink products
46	**Gamboge gum**	Garcinia henburii	Guttiferae		Used as a hydragogue cathartic
47	**Guggal gum**	Commiphora weightii	Burseraceae		Used as anti-inflammatory Used in essence sticks
48	**Ferula gum**	Ferula gummosa	Apiaceae		Used in the treatment of chronic bronchitis asthma
49	**Cassia tora gum**	Cassia tora	Leguminoseae		Used as a herbal medicine for skin disease
50	**Carragennan gum**	Chondrus cryspus	Gigarginaceae		Used in the Food industry, medicinal and industrial
51	**Cumbi gum**	Gardenia gummifer	Rubiaceae		Used as insecticide
52	**Carob gum**	Ceratonia siliqua	Leguminosae		Used in the food industry for calico printing
53	**Chicle gum**	Manikara zapata	Apocynaceae		Used in chewing gum and food industries
54	**Copal gum**	Bursera bipinnata	Burseraceae		Used in the printing ink, paints, and films
55	**Cordio gum**	Cordio oblique	Boraginaceae		Used as anti-fungal
56	**Baheda gum**	Terminalia Billerica	Combretaceae		Used as the herb of triphala
57	**Acacia gum**	Acacia senegal	Leguminoseae		Used as pigment binder and adhesive in painting Covid-19 tested
58	**Abelmoschus gum**	Abelmoschus esculentus	Malvaceae		Used as a polymer for gastric floating dosage form
59	**Ayoyo gum**	Cochorus olitorius	Tiliaceae		Used in printing and herbal medicine
60	**Aegle gum**	Aegle marmelos	Rutaceae		Used in printing and herbal medicine
61	**Almond gum**	Prunus amygdalus	Rosaceae		Used for hair and skin
62	**Dhawada gum**	Anogeissum latifolia	Combretaceae		Laddu's for pregnant women. Dhavada Gum is rich in protein and completely soluble for post-partum women's weak muscles and tissues
63	**Khair gum**	Acasia catechu	Fabaceae		Used as herbal medicine
64	**Jhingan gum**	Lannea coromandelica	Anacardiaceae		Herbal medicine
65	**Palas gum**	Butea monosperma	Fabaceae		Herbal medicine and used in food industries
66	**Char gum** (Chironji,charoli)	Buchanania lanzan	Anacardiaceae		Herbal medicine and used in food industries

Pharmaceutical applications of plant based mucilages

Plant mucilages have been traditionally used in the pharmaceutical formulations, as a binding factor and a drug excipient since mucilages are known for good bonding activities compared to synthetic materials (1-41, 51-145). Plant mucilages are also used in the production of tablet, as gelling, thickening agents, as an emulsifying, suspending agent and as a bio-adhesive agent (1-41, 51-145). There are many examples of plant mucilages used in the pharmaceutical formulations (51-145). The mucilage of the bark of *Grewia ferruginea* has been used as a suspending factor in the medicinal formulations (1-41). Cordia Mucilage (*Cordia dichotoma*) of *Boraginaceae* family is well known for binding and emulsifying agent (41-103). Another application of mucilage is cell proliferation scaffolds. Plant based mucilages were also used to create porous physical structures and cell Scaffolds. As a result, transplanted seed-mucilage-derived scaffolds have the potential to replace the common polysaccharides in the regenerative medical applications (1-125). Mimosa mucilage (*Mimosa pudica* L.) belongs to the family *Fabaceae* is commonly used for the release of a drug from the tablet. Another example is Hibiscus rosa-sinensis (*Hibiscus rosa-sinensis* L.) of the family *Malvaceae* is also used as a binding agent in the medicine formulations (41-125). Further, Asario Mucilage (*Lepidium sativum* L.) belongs to the family *Brassicaceae* has been used as a suspending and emulsifying agent (41).

In another study, Fenugreek Mucilage (*Trigonella foenum-graecum* L.) of the family *Fabaceae* has been employed as drug release retardant. Aloe Mucilage (*Aloe vera*) of family *Xanthorrhoeaceae* has been used in a controlled drug delivery system (41). Phoenix Mucilage (*Phoenix dactylifera*) of the family *Arecaceae* and Cassia tora Mucilage (*Senna tora* L.) of *Fabaceae* family are known for binding property and suspending agent (41-103). Dendrophthoe Mucilage (*Dendrophthoe falcata*) of family *Loranthaceae* also acts as a binding agent (41). Cocculus Mucilage (*Cocculus hirsutus* (L.) of family *Menispermaceae* is known for good gelling and anti-inflammatory properties (41). Further Ocimum Mucilage (*Ocimum americanum*) of family *Lamiaceae* is known for the disintegrating property (41). Drug delivery is one of the promising applications for plant based mucilages (41). In past years, the use of plant based mucilages in wound healing has risen dramatically (41, 125-144). In Iranian traditional medicine, quince seed mucilage (QSM) has been used for the treatment of wounds and burns and cell culture scaffolds (41-125). In another example, Basil seed mucilage has an antimicrobial property. The basil seed mucilage–chitosan films containing *Ziziphora clinopodioides* essential oil and MgO nanoparticles can be used for increasing the shelf-life of stored food commodities (41-145). Plant gums/mucilages are also widely used as natural excipients for the conventional and novel dosage forms. These natural materials have the advantages over synthetic ones since they are chemically inert, nontoxic, less expensive, biodegradable and widely available (118-145). Plant gums/mucilages can also be modified in different ways to obtain tailor made materials for drug-delivery systems, and thus can compete with the available synthetic excipients (51-145).

CONCLUSION

This review paper highlights the interesting facts and updates on the recent applications of natural plant gum and mucilages. Applicability of natural plant gums and mucilages has been well established in the fields of food, textile, cosmetic and pharmaceuticals. It is clear that gums and mucilages have many advantages over synthetic materials. *The use of natural gums and mucilages for pharmaceutical* applications is attractive because they are economical, readily available, nontoxic, capable of chemical modifications, potentially biodegradable, and with few exceptions, also biocompatible. During recent outbreak of Covid-19 in India, plant gums have been used to control the common cold, throat infections, and acts as immunomodulator. Natural gums and mucilages exposed good binding property in wet granulation for the manufacturing of tablets; granules are stable and less friable in contrast with other binders. Natural binders are non-polluting renewable resources for sustainable supply of cheaper pharmaceutical excipients or product. They have been shown good potential as binding agent as well as they hold some other properties like fillers, disintegrating agent, sustain releasing agent. *Natural gums/mucilages 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 (51-150).*

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