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NATURAL GUMS: IT'S ROLE AS EXCIPIENTS AND DIVERSE APPLICATIONS IN PHARMACY – A COMPREHENSIVE REVIEW

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Abstract:
All pharmaceutical dosage forms contain many additives in addition to the active ingredient to assist manufacturing and to obtain the desired therapeutic efficacy of the pharmaceutical active ingredients. The advances in drug delivery have concurrently urged the discovery of novel excipients which are safe and fulfill specific functions and directly or indirectly influence the rate and extent of release and /or absorption. Now a days, the natural gums and mucilages are widely used as pharmaceutical excipients and more advantageous than synthetic polymers. The natural gums are biocompatible and biodegradable. They are also cheap and abundantly available. Natural gums can be easily modified. As the natural gums offer many advantages synthetic polymers can be substituted with the natural gums. The gums and mucilages obtained from natural sources are the complex polysaccharide which has many applications in the pharmaceutical industry and they also influence the rate and extent of drug release. They represent truly renewable source and they have no adverse impact on humans or environmental health. They 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. Most gums and mucilages are obtained from edible sources. This review discusses about the various natural sources of gums and mucilages, their advantages over synthetic polymers, applications in pharmaceutical industries etc.

Key words: *Natural Gums, Mucilages, Controlled release*

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INTRODUCTION:

Natural gums are the polysaccharide hydrocolloids which consist of multiple sugar units linked together. Upon hydrolysis the polysaccharides yield monocasccharides and depending upon hydrolysis, they may be pentosans or hexosans [1]. Natural gums have been successfully employed in various solids, liquids and semisolid dosage forms. Many researchers have been exploring the usefulness of natural gums, in the development of novel drug delivery systems [2].

Natural gums are widely used as pharmaceutical excipients as they have the ability to meet the needs of advanced drug delivery systems. They are also efficient in fulfilment of multifunctional roles such as improvement of solubility and stability of dosage form due to which the bioavailability of active ingredient is improved and it can also modify the drug release [3]. They are widely used in controlled release dosage forms as the gums can efficient in imparting the release retardant properties of the dosage form. The use of the natural gums, in dosage forms as pharmaceutical excipients enhances the patient acceptability and also ensures the ease of manufacture [4].

Synthetic polymers are toxic in nature, its production involves high cost and also environmental pollution occurs during its synthesis and moreover its side effects leads to poor patient compliance [5-7]**.** The gums obtained naturally are more superior than synthetic polymers as they are nontoxic, economical, easily available, biodegradable and biocompatible. Natural gums can be easily modified chemically and biochemically to obtain the desirable properties required for the designing of drug delivery system that can compete with the synthetic polymers [8].

The use of natural gums have been investigated for their applications in different pharmaceutical dosage forms like ophthalmic solutions, suspensions, microspheres, buccal films, matrix controlled systems etc. [9]. They are also efficient as stabilizers, binders, disintegrants, coating agents, gelling agents, emulsifying and suspending agents in various dosage forms. The properties of the gums can be enhanced when one or more gums are interacting with each other due to the presence of numerous OH groups [10-11].

Gums are obtained from different natural sources like plants, animals, microbial exudates etc. A large number of gums obtained from plants are available today. Some of them are underutilized which could find applications in pharmaceutical industry [12]. In the formulation of new drug delivery systems, the discovery and design of novel polymers are important which could meet the special needs of drug formulators. Because of the many advantages of natural gums over synthetic ones, the importance of the natural gums has been strongly increased.

A) Advantages of Natural Gums in Pharmaceutical Sciences:

The following are the number of the advantages of natural gums.

1.Biodegradable: Naturally occurring polymers are produced by all living organisms. They do not show any adverse effects on the environment or human being.

2.Biocompatible and non-toxic: Chemically, all of the natural gums are carbohydrates composed of repeating sugars [mono saccharides] units. Hence, they are non-toxic.

3.Economic: They are cheaper and their production cost is less than synthetic material.

4.Environmental-friendly processing: Gums and mucilages can be collected in large quantities from different sources and the production processes involved is very simple.

5.Local availability [especially in developing countries]: The production of the plant gums like guar gum and tragacanth is being promoted by the government in the developing countries because of the wider applications in a variety of industries.

6.Safe and devoid of side effects: They are from a natural source and hence, safe and without side effects.

7.Better patient tolerance as well as public acceptance: There is less chance of side and adverse effects with natural materials compared with synthetic one. For example PMMA, povidone.

8.Edible sources: Most gums and mucilages are obtained from edible sources.

B) Disadvantages of Natural Gums [13- 14]**:**

1.Microbial contamination: Ten percent or more equilibrium moisture content is present in the gums and mucilages and chemically gums are carbohydrates and, during production, they are exposed to the external environment and, so there is a chance of microbial contamination. However, this contamination can be prevented by proper handling and the use of preservatives.

2.Batch to batch variation: Synthetic manufacturing is controlled procedure with fixed quantities of ingredients while production of natural polymers is dependent on environment and various physical factors.

3.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 and mucilages.

4.Slow Process: The production rate mainly depends upon the environment and many other factors, it can't be changed. So natural polymers have a slow rate of production.

5.Reduced viscosity on storage: The gums and mucilages when come in contact with water there is an increase in the viscosity of the formulations.

Due to the complex nature of gums and mucilages [mono saccharides to poly saccharides and their derivatives], it has been found that the viscosity is reduced on storage.

6.Heavy metal contamination: There are chances of Heavy metal contamination often associated with herbal excipients.

C) Chemical Nature of gums

Gums are polysaccharides in nature and they are also the translucent amorphous substances. Upon hydrolysis, gums produce an indefinite number of mono saccharides [15]. They can be further classified into pentosans [e.g., xylan] and hexosans [e.g., starch and cellulose] depending on the type of hydrolysis products obtained. Gums contain 'polyuronides'. Polyuronides are the products that consist of complex substances of calcium, potassium and magnesium salts [16]. Hemicelluloses produced by gums are galactose and arabinose. Gums are biodegradable and with few exceptions they are also biocompatible [17]. There is possibility of chemical modifications [18]. Natural gums are safe for oral consumption, hence can be used in the form of food additives or drug carriers [19]. Gums are metabolised by the intestinal flora and are ultimately degraded into their individual component sugars [20].

By the process of hydrolysis using dilute mineral acids, followed by the use of different chromatographic techniques for separation of liberated mono saccharides, constituent sugar units in a polysaccharide can be easily identified [21]. By phenol-sulfuric acid method the total carbohydrate content of the polysaccharides and also the content of monosaccharide can be estimated [22]. Methylation, periodate and lead tetra-acetate oxidation methods are used to determine the mode of linkage between the mono saccharides. For structural elucidation of gums is carried out using NMR and mass spectroscopy techniques [23].

D) Characterization of gums and mucilages:

The extraction and characterization of polysaccharide gums is an essential step in establishing their suitability as pharmaceutical excipients. The prospects of natural polymers are brighter but even here extensive testing will be required. A suitable strategy is required to save money and time. Over characterization is not desirable, because excessive use of time and resources could actually delay the launch of innovative excipients.

The characterization of gums and mucilages is initially achieved by only a multiple-technique approach. For excipients analysis, analytical techniques can be classified according to the type of information generated.

- **Structural**: 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 using NMR and mass spectroscopy.
- **Purity**: 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 are carried out.
- **Impurity profile**: Testing for impurities must be carried out using suitable analytical techniques.
- **Physico-chemical properties**: Color, odor, shape, taste, touch, texture, solubility, pH, swelling index, loss on drying, hygroscopic nature, angle of repose, bulk and true densities, porosity and surface tension. Different ash values are also estimated. The microbial load, presence of specific pathogens and *in-vitro* cytotoxicity are also determined. Thermal characterization was carried out by using differential scanning calorimetry [DSC] and thermogravimetric analysis [TGA] under nitrogen atmosphere [24]. The rheological properties of excipients are important criteria for deciding their commercial use since gums and mucilages are highly viscous in nature. The flow behaviour of the samples is determined.
- **Toxicity:** The acute toxicity of gums and mucilages are determined by the following fixed-dose method as per OECD guideline No.425. A sub-acute toxicity study, determination of the LD_{50}, etc., is carried out in rats and guinea pigs of both sexes.

D) Classification of Natural Gums [24-29]**:**

The natural gums are classified based on their chemical structure, shape, charge, gelation behaviour and origin.

[i] Based on chemical structure:

Chemical Structure	Examples
Galactomannans	Fenugreek gum, guar gum, cassia gum, tara gum.
Glucomannans	Konjac glucomannan
Uronic acid conjugating systems	Xanthum gum
Tri-heteroglycans	Gellan gum, Arabino xylans
Tetra heteroglycans	Gum Arabic, Psyllium seed Gum
Penta-heteroglycans	Gum ghatti, tragacanth

[ii] Based on shape:

Shape	Examples
Linear	Algins, amylase, cellulose, pectins.
Branched a) Short branches b) Branch on branch	 Xanthan, Xylan Amylo pectin, gum arabic, tragacanth

[iii] Based on charge:

Category	Examples
Non-ionic seed gums	Guar gum, locust bean gum, tamarind seed gum, Xanthan gum, amylase, arabinans, cellulose, Galactomannans
Anionic gums	Arabic gum, karaya gum, tragacanth, gellan gum, agar, algin, Carrageenans
Cationic gums	Chitosan

[iv] Based on gelation behaviour:

Gels	Examples
Cold set gels [form gels on cooling the solution]	Gellan gun, flaxed gum, Gelatin
Heat set gels [forms gels on heating the solution]	Konjac glucomannan
Re-entrant gels [from which galactose residues are removed]	Xyloglucan

[v] Based on origin:

Origin	Examples
Seed gums	Guar gum, tamarind gum, ipomea, locust bean gum, karaya gum
Plant exudates	Arabic gum, acacia gum, tragacanth, gum gatthi, chicle gum, Konjac glucomannan, karaya gum, locust bean gum.
Plant extracts	Pectin, larch gum.
Plant tuber and roots	Potato starch.
Microbial exudates	Gellan gum, tara gum, xanthan gum, dextran, spruce gum.
Sea weeds	Alginic acid, sodium alginate, agar-agar, carrageenans.
Animal origin	Chitin, chitosan, chondroitin sulphate, hyaluronic acid.

E) Applications of gums:

Gums of different sources and their derivatives represent a group of polymers widely used in pharmaceutical dosage forms. Various kinds of Gums are used in the food industry and are regarded as safe for human consumption.

However, there is growing concern about the safety index of pharmaceutical excipients derived from natural sources. Plant gums and exudates are now screened for their use as pharmaceutical excipients. Newer uses of different gums in cosmetics and textiles have increased the demand and screening of gums has become an important pharmaceutical area. However, different gums and mucilages used as pharmaceutical adjuvants have stringent specifications, which few natural agents can fulfil [30].

Gums are the complex, branched polymeric structures because of which they exhibit high cohesive and adhesive properties. These properties are highly useful in pharmaceutical preparations. Hence, gums find diverse applications in pharmacy. They are used in medicine for their demulcent properties for cough suppression. They are ingredients of dental and other adhesives and can be used as bulk laxatives [9]. These hydrophilic polymers are useful as tablet binders, disintegrants, emulsifiers, suspending agents, gelling agents, stabilizing agents, thickening agents, protective colloids in suspensions and sustaining agents in tablets and coating agents in microcapsules including those used for protein delivery[31].

❖ ***Applications in tablet formulation***

Gums are widely used in tablet formulation as binders because of their adhesive nature. They impart cohesiveness to the powder mass and convert them into granules, which are further compressed into tablets [32]. They can also be used as disintegrants in tablets because the gums and mucilages have the ability to absorb water and swell. They can swell up to 5 times their original volume and this swelling leads to breakage of

tablets into smaller pieces, due to which the dissolution rate is improved [33].

Binders

Common Name	Botanical Name	Family	Ref
Albizia gum	*Albizia zygia*	Leguminoseae	[34]
Cassia tora	*Cassia tora Linn*	Leguminosae	[35]
Guar gum	*Cyamompsis tetraganolobus*	Leguminoseae	[36]
Gum acacia	*Acacia arabica & Acacia senegal*	Leguminoseae	[37]
Gum ghatti	*Anogeissus latifolia*	Combretaceae	[38]
Khaya gum	*Khaya grandifolia*	Meliaceae	[39]
Neem gum	*Azadirachta indica A. Juss.*	Meliaceae	[40]
Okra gum	*Hibiscus esculentus*	Malvaceae	[41]

Disintegrants

Common Name	Botanical Name	Family	Ref
Moringa oleifera	*Moringa oleifera*	Moringaceae	[42]
Takmariya	*Ocimum americanum*	Lamiaceae	[43]
Fenugreek mucilage	*Trigonella foenum graecum*	Leguminoseae	[44]

❖ ***Applications as emulsifying and suspending agents***

Gums can also be used as emulsifying and suspending agents. They can effectively stabilize the emulsion via interfacial absorption and the subsequent formulation of condensed films of high tensile strength that resist coalescence of droplets. They stabilize oil/water emulsions by forming a strong multi-molecular film around each oil globule and thus retard the coalescence by the presence of a hydrophilic barrier between the oil and water phases. Natural gums increase the tensile strength of the hydration layer formed around the suspended particles, through hydrogen bonding, and molecular interactions. These function better in presence of wetting agents as they don't reduce the surface and interfacial tension. Gums are also widely used as protective colloids or thickeners. Natural gums are hydrophilic colloids, which form dispersion with water and increase the viscosity of continuous phase, so that the solid particles remain suspended in it for a sufficient long time to measure a uniform dose.

Suspending and Emulsifying agents

Common Name	Botanical Name	Family	Ref
-	Abelmoschus esculentus	Malvaceae	45
-	Albizia zygia	Leguminoseae	46
Karaya gum	*Sterculia urens*	Sterculiaceae	47
Leucaena seed gum	*Leucaena leucocephata*	Fabaceae	48
Pectin	*Citrus aurantium*	Rutaceae	49
–	*Sterculia foetida*	Malvaceae	50
Gum ghatti	*Anogeissus latifolia*	Combretaceae	51

❖ ***Applications as coating agents***

Many gums and mucilages are also used as coating agents, because they have the ability to sustain the drug release, or can protect the drug from degradation in stomach. It has been reported that the mucilage obtained from drumstick, i.e., polysaccharide, can be used as a good film-coating polymer at 2% concentration for paracetamol granules. It retarded the drug release from the granules as the number of coatings increased, the drug release was found to be reduced.

Coating agents

Common Name	Botanical Name	Family	Reference
Gum copal	*Bursera bipinnata*	Burseraceae	[52]
Gum dammar	*Shorea wiesneri*	Dipterocarpaceae	[53]

❖ ***Application as sustaining materials in dosage forms***

Matrix drug delivery system prolongs and controls the release of drug that is dissolved or dispersed. The inclusion of polymeric materials in a matrix system is a common method of controlling the drug release. Many natural gums have been used as polymer for sustained release formulations. An extensive research is being continued in the formulation of drug delivery system using natural polymers and their semi synthetic derivatives as the key performers in matrix systems for retarding the drug release [54]. Various polymers have been examined as drug retarding agents, each presenting a different approach to the matrix system. Matrix

systems are usually classified into three main groups based on the features of the retarding polymer as hydrophilic, hydrophobic and plastic. Hydrophilic polymers are the most suitable for retarding drug release and hence widely used in sustained drug delivery. These polymers when come in contact with water get hydrated and form a gel [55]. The release of drug from the gel will be sustained over a prolonged time as this is diffusion controlled.

Sustaining materials [Hydrophilic polymers]

Common Name	Botanical Name	Family	Ref
Okra gum	*Hibiscus esculentus*	Malvaceae	[56]
–	*Sterculia foetida*	Malvaceae	[57]
Honey locust gum	*Gleditsia triacanthos*	Fabaceae	[58]
–	*Mimosa scabrella*	Mimosaceae	[59]
–	*Mimosa pudica*	Mimosaceae	[60]
–	*Lepidium sativum*	Cruciferae	[61]
–	*Abelmoschus esculentus*	Malvaceae	[62]
Gum cordia	*Cordia Obliqua*	Boraginaecae	[63]
Guar gum	*Cyamopsis tetragonoloba*	Fabaceae	[64]
	Delonix regia	Fabaceae	[65]
Aloe mucilage	*Aloe species*	Liliaceae	[66]
	Anacardium occidentale	Anacardiaceae	[67]
Satavari mucilage	*Asparagus racemosus*	Aapocynaceae	[68]
Cactus mucilage	*Opuntia ficus-indica*	Cactaceae	[69]

❖ ***Applications as gelling agents***

The utilization of natural gums as gelling agents is a new concept. Gelling is due to the formation of numerous inter and intra molecular associations to produce a three-dimensional network, within which the water molecules are entrapped. Such associations are possible because of either physical [pH change, altering temperature] or chemical [addition of suitable reagents] treatments. The mechanism of gelation in acidic polysaccharides such as pectin involves the formation of hydrogen bonds between the macromolecular chains as a result, junction zones are formed between hydrogen bonded segments of chains. In alginic acid, the gel formation occurs as a result of interaction with calcium ions [70]. Galactomannans form elastic gels when interacts synergistically with xanthan gum or carrageenans.

Gelling agents

Common Name	Botanical Name	Family	Ref
Konjac	*Amorphophallus konjac*	Araceae	[71]
Sesbania gum	*Sesbania grandiflora*	Leguminosae	[72]
Fenugreek mucilage	*Trigonella foenum graecum*	Leguminoseae	[73]
Cactus mucilage	*Opuntia ficus-indica*	Cactaceae	[74]
–	*Anacardium occidentale*	Anacardiaceae	[75]
–	*Cassia sophera*	Fabaceae	[76]
–	*Dillenia indica*	Dilleniaceae	[77]
–	*Coriolus hirsutus*	Polyporaceae	[78]

❖ ***Applications as mucoadhesive agents***

The use of natural gums in the development of novel drug delivery systems is extensively studied by the researchers. Mucoadhesive drug delivery techniques are controlled release drug delivery systems, which gets retained in the stomach for longer period of time, which helps in absorption of drug for the intended duration of time. This process improves the bioavailability and reduces drug wastage. It also improves the solubility of drugs that are less soluble at high pH environment [e.g. weakly basic drugs like domperidone and papaverine]. Natural gums and mucilages are added to pharmaceutical formulations as mucoadhesive agents by studying their physicochemical properties, structure and compatibility. The FTIR spectrophotometry and DSC techniques can be used for the drug and excipient compatibility studies.

Mucoadhesive agents

S. No	Common Name	Botanical Name	Family	Reference
1	–	*Caesalpinia pulcherrima*	Fabaceae	79
2	–	*Leucaena leucocephala*	Fabaceae	80
3	Hakea gum	*Hakea gibbosa*	Proteaceae	81
4	Moringa oleifera	*Moringa oleifera*	Moringaceae	82
5	Myrrh oleo gum	*Commiphora myrrha*	Burseraceae	83

❖ ***Applications in the food industry***

Gums have a variety of applications in the food industry. Different gums have different uses like water retention and stabilization [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].

❖ ***Industrial uses***

Gums used in cosmetics [acacia, tragacanth and karaya gum], textiles [starch, dextrin, cellulose, pectins, and tamarind gum], adhesives [acacia gum, and tragacanth], lithography [gum arabic, tragacanth, and locust bean gum], paints [pectins, hemicellulose, and resins] and paper manufacturer [tamarind, and cellulose].

F) Modification of gums

Gums can be modified through derivatization of functional groups, cross linking with the ions or grafting with the polymers, the derivative gums are suitable for modifying the drug release properties of pharmaceutical dosage forms. The modified gums overcome many problems such as uncontrolled rates of hydration, pH dependent solubility, thickening, drop in viscosity on storage and microbial contamination. The modified drugs can also be used for specific drug purposes. The process of carboxy methylation of gums increases the hydrophilicity of gums and solution clarity and makes them more soluble in aqueous systems [84]. Natural gums swell in the presence of dissolution media due to their hydrophilic nature. Hence, there is a possibility of the entrapped drug leaking out prior to arrival of the drug at its site of absorption. The process of cross-linking of gums reduces the enormous swelling of gums and overcomes this problem [85].

CONCLUSION:

The natural gums are more economical, abundantly available, biodegradable, biocompatible and non toxic. There is also possibility of modification of gums. These all reasons made the natural gums more superior over the synthetic ones. As the natural gums have wide spread applications in pharmaceutical industries the researchers are attracted towards the role of natural polymers in the development of novel drug delivery systems.

REFERENCES:

1. Krishna LN, Kulkarni PK, Dixit M, Lavanya D, Raavi PK. Brief Introduction of Natural Gums, Mucilages and their Applications in Novel Drug Delivery Systems-a review. IJDFR. 2011; 2:54-71.
2. Kumar S, Gupta SK. Natural polymers, gums and mucilages as excipients in drug delivery. Polim. Med. 2012; 42(3-4):191-7.
3. Rajamma AJ, Yogesha HN, Sateesha SB. Natural gums as sustained release carriers: development of gastroretentive drug delivery system of ziprasidone HCl. DARU J Pharm Sci. 2012; 20:58.
4. Varshosaz J, Tavakoli N, Kheirolahi F. Use of hydrophilic natural gums in formulation of sustained-release matrix tablets of tramadol hydrochloride. aaps Pharmscitech. 2006; 7(1):E168-74.
5. Bhardwaj TR, Kanwar M, Lal R, Gupta A. Natural gums and modified natural gums as sustained-release carriers. Drug development and industrial pharmacy. 2000; 26(10):1025-38.
6. Singh A, Sharma PK, Malviya R. Release behavior of drugs from various natural gums and polymers. Polimery w medycynie. 2011; 41(4):73-80.
7. Choudhary PD, Pawar HA. Recently Investigated Natural Gums and Mucilages as Pharmaceutical Excipients: An Overview. Journal of Pharmaceutics. 2014 Apr 7;2014.
8. Prajapati VD, Jani GK, Moradiya NG, Randeria NP. Pharmaceutical applications of various natural gums, mucilages and their modified forms. Carbohydrate polymers. 2013; 92(2):1685-99.
9. Choudhary PD, Pawar HA. Recently Investigated Natural Gums and Mucilages as Pharmaceutical Excipients: An Overview. Journal of Pharmaceutics. 2014; 2014.
10. Reddy K, Mohan GK, Satla S, Gaikwad S. Natural polysaccharides: versatile excipients for controlled drug delivery systems. Asian J Pharm Sci. 2011; 6(6):275-86.
11. Guo JH, Skinner GW, Harcum WW, Barnum PE. Pharmaceutical applications of naturally occurring water-soluble polymers. Pharmaceutical science & technology today. 1998; 1(6):254-61.

12. Avachat AM, Dash RR, Shrotriya SN. Recent investigations of plant based natural gums, mucilages and resins in novel drug delivery systems. Ind J Pharm Edu Res. 2011; 45(1):86-99.
13. Goswami S, Naik S. Natural gums and its pharmaceutical application. J Sci Innovative Res. 2014; 3:112-21.
14. Deogade UM, Deshmukh VN, Sakarkar DM. Natural gums and mucilage's in NDDS: applications and recent approaches. Int J Pharm Tech Res. 2012; 4(2):799-814.
15. Norman AG. The chemical constitution of the gums: Part I. The nature of gum arabic and the biochemical classification of the gums. Biochemical Journal. 1929; 23(3):524.
16. Mahfoudhi N, Chouaibi M, Donsì F, Ferrari G, Hamdi S. Chemical composition and functional properties of gum exudates from the trunk of the almond tree (Prunus dulcis). Food Science and Technology International. 2012; 18(3):241-50.
17. Mirhosseini H, Amid BT. A review study on chemical composition and molecular structure of newly plant gum exudates and seed gums. Food Research International. 2012; 46(1):387-98.
18. Dodi G, Hritcu D, Popa MI. Carboxymethylation of guar gum: Synthesis and characterization. Cellulose chemistry and technology. 201; 45(3):171.
19. Su L, Ji WK, Lan WZ, Dong XQ. Chemical modification of xanthan gum to increase dissolution rate. Carbohydrate polymers. 2003; 53(4):497-9.
20. Shi X, BeMiller JN. Effects of food gums on viscosities of starch suspensions during pasting. Carbohydrate polymers. 2002; 50(1):7-18.
21. Reddy MR, Manjunath K. Pharmaceutical applications of natural gums, mucilages and pectins-a review. International Journal of Pharmaceutical And Chemical Sciences. 2013; 2(3).
22. BeMiller JN. Plant Gums. eLS. 2001.
23. Tomasik P, editor. Chemical and functional properties of food saccharides. CRC Press; 2003.
24. Kokate CK, Purohit AP, Gokhale SB. Pharmacognosy. Nirali Prakashan, Pune. 2006.
25. Rangari VD. Pharmacognosy & Phytochemistry. Nashik, India: Career Publication; 2006.
26. Wallis TE. Text Book of Pharmacognosy. New Delhi, India: C B S Publishers and Distributors; 2004.
27. Mohammed A. Text Book of Pharmacognosy. New Delhi, India: C B S Publishers and Distributors; 2005.
28. Ansari SH. Essential of Pharmacognosy. New Delhi, India: Birla Publications Pvt. Ltd.; 2006.
29. Kumar T, Gupta SK, Prajapati MK, Tripathi DK. Natural excipients: A review. Asian Journal of Pharmacy and Life Science ISSN. 2012; 2231:4423.
30. Kumar S, Gupta SK. Rosin: A naturally derived excipient in drug delivery systems. Polim. Med. 2013; 43(1):45-8.
31. Jani GK, Shah DP, Prajapati VD, Jain VC. Gums and mucilages: versatile excipients for pharmaceutical formulations. Asian J Pharm Sci. 2009; 4(5):309-23.
32. Aspinall GO. Gums and mucilages. Advances in carbohydrate chemistry and biochemistry. 1969; 24:333.
33. Dharmendra S. Natural Excipients A Review. International Journal of Pharmaceutical & Biological Archive. 2012; 3(5).
34. ODEKU OA. Assessment of Albizia zygia gum as binding agent in tablet formulations. Acta pharmaceutica. 2005; 55(3):263-76.
35. Pawar H, D mello PM. Isolation of seed gum from Cassia tora and preliminary studies of its application as a binder for tablets. INDIAN DRUGS-BOMBAY-. 2004; 41:465-8.
36. G. T. Kulkarni, K. Gowthamarajan, B. G. Rao, et al.Evaluation of binding property of Plantago Ovata & Trigonella Foenum Gracecum mucilage. Indian Drugs, 2002, 39: 422 – 425.
37. E. Shefter. Gum Acacia. In: C. R. Raymond, J. S. Paul, J. W. Paul, ed. Handbook of Pharmaceutical Excipients. The Pharmaceutical Press and The American Pharmaceutical Association; 2003:1-2.
38. Deshmukh AS, Setty CM, Badiger AM, Muralikrishna KS. Gum ghatti: A promising polysaccharide for pharmaceutical applications. Carbohydrate Polymers. 2012; 87(2):980-6.
39. Odeku OA, Itiola OA. Evaluation of the effects of khaya gum on the mechanical and release properties of paracetamol tablets. Drug development and industrial pharmacy. 2003; 29(3):311-20.
40. Ogunjimi AT, Alebiowu G. Neem Gum as a Binder in a Formulated Paracetamol Tablet with Reference to Acacia Gum BP. AAPS PharmSciTech. 2014; 15(2):500-10.
41. Tavakoli N, Ghasemi N, Hamishehkar H. Evaluation of okra gum as a binder in tablet dosage forms. Iranian Journal of Pharmaceutical Research. 2010; 47.
42. Patel VB, Chobey NE. Evaluation of MoringaOleifera gum as tablet disintegrant. International Journal of Pharmacy and Pharmaceutical Sciences. 2012; 4(1):210-4.

43. Patel DM, Prajapati DG, Patel NM. Seed mucilage from Ocimum americanum linn. as disintegrant in tablets: separation and evaluation. Indian journal of pharmaceutical sciences. 2007; 69(3):431.
44. Kumar R, Patil S, Patil MB, Patil SR, Paschapur MS. Isolation and evaluation of disintegrant properties of fenugreek seed mucilage. International Journal of PharmTech Research. 2009; 1(4):982-96.
45. Kumar R, Patil MB, Patil SR, Paschapur MS. Evaluation of Abelmoschus esculentus mucilage as suspending agent in paracetamol suspension. Int J PharmTech Res. 2009; 1(3):658-.
46. Femi-Oyewo MN, Adedokun MO, Olusoga TO. Evaluation of the suspending properties of Abizia zygia gum on sulphadimidine suspension. Tropical journal of pharmaceutical Research. 2007; 3(1):279-84.
47. Rao BS, Prasanna RY, Mary S. Design and studies of gum karaya matrix tablet. Int. J. Pharm. Expt. 2000:239-42.
48. Verma PR, Razdan B. Studies on Leucaena leucocephala seed gum: evaluation of suspending properties. STP pharma sciences. 2001; 11(4):289-93.
49. Piriyaprasarth S, Sriamornsak P. Flocculating and suspending properties of commercial citrus pectin and pectin extracted from pomelo (Citrus maxima) peel. Carbohydrate Polymers. 2011; 83(2):561-8.
50. Chivate AA, Poddar SS, Abdul S, Savant G. Evaluation of Sterculia foetida gum as controlled release excipient. AAPS PharmSciTech. 2008; 9(1):197-204.
51. Jain JK, Dixit VK. Studies on gums and their derivatives as binding agents. Indian Journal of Pharmaceutical Sciences. 1988; 50(2):113.
52. Umekar MJ, Yeole PG. Characterization and evaluation of natural copal gum-resin as film forming material. International Journal of green pharmacy. 2008; 2(1):37.
53. Morkhade DM, Fulzele SV, Satturwar PM, Joshi SB. Gum copal and gum damar: novel matrix forming materials for sustained drug delivery. Indian journal of pharmaceutical sciences. 2006; 68(1):53.
54. Jain A, Gupta Y, Jain SK. Perspectives of biodegradable natural polysaccharides for site-specific drug delivery to the colon. J Pharm Pharm Sci. 2007; 10(1):86-128.
55. Colombo P, Bettini R, Santi P, Peppas NA. Swellable matrices for controlled drug delivery: gel-layer behaviour, mechanisms and optimal performance. Pharmaceutical science & technology today. 2000; 3(6):198-204.
56. Kalu VD, Odeniyi MA, Jaiyeoba KT. Matrix properties of a new plant gum in controlled drug delivery. Archives of pharmacal research. 2007; 30(7):884-9.
57. Chivate AA, Poddar SS, Abdul S, Savant G. Evaluation of Sterculia foetida gum as controlled release excipient. AAPS PharmSciTech. 2008; 9(1):197-204.
58. Üner M, Altınkurt T. Evaluation of honey locust (Gleditsia triacanthos Linn.) gum as sustaining material in tablet dosage forms. Il Farmaco. 2004; 59(7):567-73.
59. Ughini F, Andreazza IF, Ganter JL, Bresolin TM. Evaluation of xanthan and highly substituted galactomannan from M. scabrella as a sustained release matrix. International journal of pharmaceutics. 2004; 271(1):197-205.
60. Singh K, Kumar A, Langyan N, Ahuja M. Evaluation of Mimosa pudica seed mucilage as sustained-release excipient. AAPS PharmSciTech. 2009; 10(4):1121-7.
61. Avachat MK, Dhamne AG. Oral controlled release drug delivery system with husk powder from Lepidium Sativum seeds. Patient No. WO02100438.
62. Ameena K, Dilip C, Saraswathi R, Krishnan PN, Sankar C, Simi SP. Isolation of the mucilages from Hibiscus rosasinensis linn. and Okra (Abelmoschus esculentus linn.) and studies of the binding effects of the mucilages. Asian Pacific Journal of Tropical Medicine. 2010; 3(7):539-43.
63. Mukherjee B, Dinda SC, Barik BB. Gum cordia: a novel matrix forming material for enteric resistant and sustained drug delivery—a technical note. Aaps Pharmscitech. 2008; 9(1):330-3.
64. Al-Saidan SM, Krishnaiah YS, Patro S, Satyanaryana V. In vitro and in vivo evaluation of guar gum matrix tablets for oral controlled release of water-soluble diltiazem hydrochloride. AAPS PharmSciTech. 2005; 6(1):E14-21.
65. Krishnaraj K, Chandrasekar MJ, Nanjan MJ, Muralidharan S, Manikandan D. Development of sustained release antipsychotic tablets using novel polysaccharide isolated from Delonix regia seeds and its pharmacokinetic studies. Saudi Pharmaceutical Journal. 2012; 20(3):239-48.
66. Jani GK, Shah DP, Jain VC, Patel MJ, Vithalani DA. Evaluating mucilage from Aloe Barbadensis Miller as a pharmaceutical excipient for sustained-release matrix tablets. Pharm. Technol. 2007, 31, 90-98.
67. Gowthamarajan K, Jawahar N, Wake P, Jain K, Sood S. Development of buccal tablets for curcumin using Anacardium occidentale gum. Carbohydrate Polymers. 2012; 88(4):1177-83.
68. Gowthamarajan TG, Rao GB, Suresh B. Evaluation of binding properties of selected

natural mucilages. Journal of Scientific & Industrial Research. 2002; 61:529-32.
69. Cárdenas A, Higuera-Ciapara I, Goycoolea FM. Rheology and aggregation of cactus (Opuntia ficus-indica) mucilage in solution. Journal of the Professional Association for Cactus Development. 1997; 2:152-9.
70. Saha D, Bhattacharya S. Hydrocolloids as thickening and gelling agents in food: a critical review. Journal of food science and technology. 2010; 47(6):587-97.
71. Thomas WR. Konjac gum. InThickening and gelling agents for food 1997 (pp. 169-179). Springer US.
72. Patel GC, Patel MM. Preliminary evaluation of sesbania seed gum mucilage as gelling agent. Int. J. Pharm. Tech. Res. 2009; 1(3):840-3.
73. Gowthamarajan K, Kulkarni GT, Muthukumar A, Mahadevan N, Samantha MK, Suresh B. Evaluation of fenugreek mucilage as gelling agent. Int J Pharma Excip. 2002; 3:16-9.
74. Goycoolea FM, Cárdenas A. Pectins from Opuntia spp.: a short review. Journal of the Professional Association for Cactus Development. 2003; 5:17-29.
75. Kumar R, Patil MB, Patil SR, Paschapur MS. Evaluation of Anacardium occidentale gum as gelling agent in Aceclofenac Gel. International Journal of PharmTech Research. 2009; 1(3):695-704.
76. Wadhwa J, Nair A, Kumria R. Potential of plant mucilages in pharmaceuticals and therapy. Current drug delivery. 2013; 10(2):198-207.
77. Sahua BP, Sharmab HK, Dasc MK. Development and evaluation of a mucoadhesive nasal gel of felodipine prepared with mucoadhesive substance of Dillenia indica L. Asian Journal of Pharmaceutical Sciences. 2011; 5(5):175-87.
78. Budolfsen G, Pedersen LS, inventors; Novo Nordisk A/S, assignee. Gelling of pectic material using carboxylic ester hydrolase and oxidase and/or peroxidase. United States patent US 5,998,176. 1999.
79. Senthil V, Gopalakrishnan S, Sureshkumar R, Jawahar N, Ganesh G, Nagasamyvenkatesh D. Mucoadhesive slow-release tablets of theophylline: Design and evaluation. Asian Journal of pharmaceutics. 2010; 4(1):64.
80. Deodhar UP, Paradkar AR, Purohit AP. Preliminary evaluation of Leucaena leucocephala seed gum as a tablet binder. Drug development and industrial pharmacy. 1998; 24(6):577-82.
81. Alur HH, Pather SI, Mitra AK, Johnston TP. Evaluation of the gum from Hakea gibbosa as a sustained-release and mucoadhesive component in buccal tablets. Pharmaceutical development and technology. 1999; 4(3):347-58.
82. Goswami DS, Sharma MA. Development of new mucoadhesive polymer from natural source. Asian Journal of Pharmaceutical and Clinical Research. 2012; 5(3):247-50.
83. Arora G, Malik K, Singh I, Arora S. Formulation and evaluation of controlled release mucoadhesive matrix tablets: Assessment of myrrh oleo gum resin as a natural pharmaceutical excipient. Int J Pharm Sci Drug Res. 2011; 3(2):84-.
84. Sharma BR, Kumar V, Soni PL, Sharma P. Carboxymethylation of Cassia tora gum. Journal of applied polymer science. 2003; 89(12):3216-9.
85. Rana V, Rai P, Tiwary AK, Singh RS, Kennedy JF, Knill CJ. Modified gums: Approaches and applications in drug delivery. Carbohydrate Polymers. 2011; 83(3):1031-47.