

**GUAR GUM: PRESENT STATUS AND APPLICATIONS**Surendra Tripathy¹, Malay K Das^{2*}¹Chandra Shekhar Singh College of Pharmacy, Kaushambi, India²Department of Pharmaceutical Sciences, Dibrugarh University, Dibrugarh, India

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ABSTRACT

Naturally occurring excipients are currently getting prime importance among which the polysaccharides occupy a special position because of their easy availability, non-toxic, eco-friendly and biodegradable nature. The objective of this review was to explore the excipient profile of Guar gum which is obtained from *Cyamopsis tetragonolobus* (Linn. Leguminosae). The chief constituent of guar gum is a Gallactomannan which is composed of galactose and mannose in a ratio of 1:2 that provides the main physical phenomenon of gelling or thickening to this gum. The chemistry of this gallactomannan suggested the presence of multiple hydroxyl groups which are proved to be excellent for derivatization by grafting or cross-linking with other polymers to create new chemically modified entity of desired properties. The native as well as guar gum derivatives are found to have therapeutic importance in certain physiological disorders. Guar gum is used as suspending, emulsifying and stabilizing agent in the conventional dosage forms. In tablet dosage form it is used as a potential binding and disintegrating agent. The swelling property of guar gum is used for controlling the drug release rate in the novel pharmaceutical dosage forms. By virtue of its better thickening and stabilizing power accompanied by a sound safety profile, guar gum has acquired a wide acceptance in cosmetics and food industry.

Keywords: Gallactomannan, Natural polysaccharide, Guar gum, Gelling, Pharmaceuticals, Cosmetics.

INTRODUCTION

Gums are plant exudates and are often misunderstood with resins, rubbers and latex. So more specifically the gums are those substances which can be dissolved or dispersed in water to form more or less viscous colloidal solutions or dispersions. The gums are naturally occurring substances, mainly carbohydrate in nature and are being used since the beginning of the civilization for various purposes like food ingredient (for human and cattle), mastiche and manufacturing domestic items. Some properties which are known from a long time about the natural gums include its gelling, thickening and binding properties¹. Guar gum, a naturally occurring gum, also called Guarana, is a galactomannan. It is obtained from an annual pod bearing plant *Cyamopsis tetragonolobus* or *C. psoraloides*, belonging to family Leguminosae. It is a high molecular weight carbohydrate. It is white to yellowish white in colour, odourless and is available in different viscosities and different granulometries^{1,2}. The seed is composed of the hull (14-17 %), the endosperm (35-42 %) and the germ (43-47 %); (Figure 1). The germ and hull of the guar seeds are called Guar meal, which is rich in protein. The commercially important part of the guar seed is the endosperm. Guar gum is primarily the ground endosperm of guar beans prepared after dehushing the guar seeds³. Guar gum powder is extracted from the guar seeds after a multistage industrial process. The production technique depends upon the desired end product. The dried guar seeds are crushed after pod removal and the endosperm is separated. The fibrous part i.e. the husk is removed by polishing techniques from the endosperm. The polished dehushed endosperms are then powdered to get the final finished powdered form. Heat treatment is involved during processing just before the crushing stage to inactivate the enzymes contained in seed germs, which are found toxic^{4,5}. The guar crop gains its economic significance after the discovery of the galactomannan, which is the gummy substance in it. Guar bean is principally grown in India and

Australia, with smaller crops in United States, China, Pakistan and Africa. India produces 1- 1.25 million tonnes of guar annually and responsible for 80 % of world guar production. Industrial guar gum accounts for about 45 % of the total demand. The versatile use of guar gum in different industries has made it a sound trading commodity across the seas from decades.

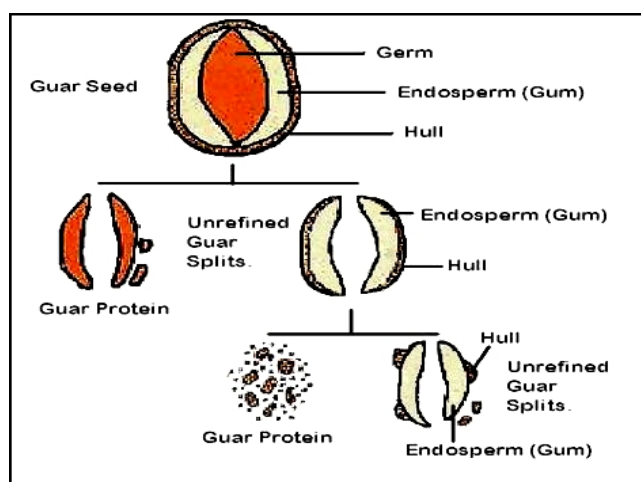


Figure 1 Schematic diagram showing the different parts of guar seed
(Source: <http://www.biokimkimya.com/images/prodimages/3-2.jpg>, retrieved on Dt.26.6.2013.)

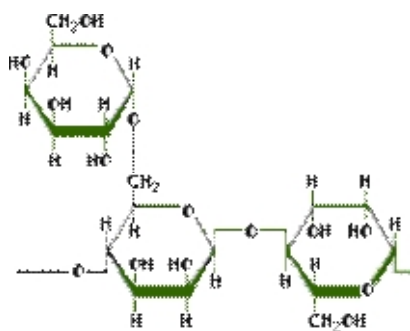
Chemistry of Guar Gum

Guar gum is an uncharged natural gum. It contains 41 % dry weight and acetone insoluble solids of the seeds. At least 75 % of acetone insoluble solids of the endosperm are galactomannose and 12 % being accounted for pentosan, protein, pectin, phytin, ash and dilute acid insoluble residues⁵. The chemistry of the guar gum shows the following typical composition (Table 1):

Table 1: Table showing the composition of Guar gum

Constituent	Percent present
Protein	3.5-4.0
Phosphorus	0.06
Ash	1.07
Water soluble polysaccharide	86.50
Water insoluble fraction	7.75
Alcohol soluble fraction	1.50

The material contains 10-13 % moisture. The guar gum lacks the uronic acid, which is generally found in other plant gums and mucilage, that's how it differentiate itself from the other gums and mucilages. The galactomannan unit composed of 36.6 % D-galactose anhydride and 63.1 % Mannose anhydride⁶. The chemistry of the galactomannan unit confirmed from the chemical tests (acid hydrolysis, methylation etc), analytical tests (chromatography and Infra Red spectroscopy) and physical tests (optical rotation, stress-strain measurement and X-Ray analysis) that the guar gum molecule is a linear carbohydrate polymer with a molecular weight of the order of 2, 20,000. It is having a straight chain of D-mannose unit linked together by β (1-4) glycoside linkage and D-galactose units are joined to it at each alternate position by an (1-6) glycosidic linkage (Figure 2). Hence, the guar gum forms a rod like polymeric structure with a mannose backbone linked to galactose side chains, which are randomly placed on mannose backbone with an average ratio of 1:2 galactose to mannose^{1,7}. The polymeric structure contains numerous hydroxyl groups, which are treated for manufacturing different derivatives used for various applications in industries. The properties of galactomannan mainly depend upon their chemical features like chain length, abundance of cis-OH group, steric hindrance, degree of polymerization and additional substitutions⁷.

**Figure 2: Chemical structure of Guar gum**

(Source: http://www.guargum.biz/guargum_chemical_structure.html, retrieved on Dt. 26.06.2013.)

Physical Properties of Guar Gum

The guar gum is having unique solubility and viscosity producing properties. Regarding the solubility of guar gum, it is insoluble in hydrocarbons, fats, alcohols, esters and ketones. The only solvent for this galactomannan is water. Guar gum rapidly hydrates when dispersed in both hot and cold water to form a viscous colloidal solution even at a low amount. Guar gum achieves its full viscosity in cold water unlike other gums, which need prolonged hot water treatment for achieving the same viscosity^{1,8}. The performance index and grade of guar gum is determined from its viscosity property. The variables responsible for influencing viscosity of guar gum include its concentration, dispersion, pH, temperature and presence of foreign substances. The most interesting feature of guar gum in solution form is its stability

over a wide range of pH, which is due to its non-ionic nature. Further, extreme pH conditions like below pH 4 and above pH 10.5 the viscosity potential starts declining, because of the destruction of the protein which form a complex with the carbohydrate polymer at high pH and possible hydrolysis by strong acids at very low pH. An increase in temperature causes the water molecules to lose their ordering around the guar gum molecule, thus the conformation is disturbed resulting in reduced viscosity⁹. Guar gum in solution form shows the decreased viscosity with increasing shear rate, hence having a shear thinning behaviour and Non-Newtonian flow in pseudoplastic sub-class. Guar gum is found very thixotropic above concentration of 1 %¹⁰.

Gelling Mechanism of Guar Gum

It is already discussed that the guar gum is able to form a high viscous solution even at low concentration. Upon dispersion in water the galactose side chains attached to mannose back bone interact with water molecule leading to an inter-molecular chain entanglement of guar gum molecule in the aqueous phase, which leads to development of viscosity in the solution causing gelling or thickening. When the guar gum concentration is enhanced the entanglement or degree of inter-molecular chain interaction enhanced causing an increase in viscosity and gelling. The water molecules form an orderly structure around the guar gum molecule during the gel formation stage. Temperature plays an important role in the gelling of guar gum. With increase in temperature the gelling property is reduced because of the greater molecular movement by energy dissipation and the viscosity returns to its original value when the temperature is gradually decreased. Hence, the temperature causes a reversible change in gelling of guar gum¹¹. Presence of salt plays a peculiar role in the gelling mechanism. In the presence of salt in guar solution the availability of water for the complete expansion of guar gum is inadequate, which causes a decrease in viscosity and gelling. The added salt restricts the complete hydration of guar gum in the solution. However, the phenomenon is applicable for guar gum solution with a high concentration. In case of a solution of low concentration the salt addition facilitates the formation of intermolecular aggregates due to alteration of charge density and conformation of gum. Some reports suggest the possible mechanism for this phenomenon is the disruption of intra- and inter-molecular associations causing expansion of chain conformation^{9,11,12}.

Guar Gum and Its Pharmaceutical Applications

Lipids, carbohydrates and proteins are natural polymeric materials widely used in pharmaceuticals. Natural polysaccharides and their derivatives form a large group of polymers that are profoundly used in pharmaceutical formulations as excipients as well as agents for controlling the release rate of drug from a dosage form¹. Guar gum is a potential candidate for many pharmaceutical applications by virtue of its ability to form viscous dispersions or gel in aqueous media. The increasing popularity of this gum is also assisted by its non-toxic and biodegradable nature. Moreover, it is cost effective and is obtained from renewable natural resources, so its supply meets its demand in pharmaceutical industries. As an excipient this gum and its derivatives have occupied unique position in almost all areas of drug delivery. Guar gum plays its role as excipient in solid, liquid and semisolid dosage forms. The various excipient roles of guar

gum are disintegrating agent, binding agent, film forming agent, matrix former, release modifier (retardant), viscosity enhancing or thickening or gelling agent, stabilizer, emulsifier, suspending agent, bioadhesive agent etc. Guar gum and its derivatives are widely used as binder and disintegrating agent in tablet dosage form, which provides cohesive nature to the drug and other excipients present. The formulations like inhalations, injectable, beads, microparticles, nanoparticles, solid monolithic matrix films, implants also facilitate the use of guar gum in these novel dosage forms¹³. The use of guar gum in drug delivery is due to its structural attribute, where its polymeric nature and functional groups are used for conjugating it with different molecular weight polymers to create novel derivative molecule with desired chemico-physical properties. Often these derivatizations are done to get rid of certain disadvantages of guar gum too. The high swelling characteristic of guar gum hinders its use as a drug delivery carrier some times, which is modified by derivatization, grafting and network formation to improve its excipient profile. Guar gum and its derivatives can be used for targeted drug delivery by forming coating matrix systems, hydrogels and nano-micro particles¹⁴. The glycosidic linkage present in guar gum is degraded in large intestine due to the microbial enzyme present there¹⁵. Studies regarding drug release under conditions simulated with mouth to colon transit shows that guar gum protects the drug from being released completely in the stomach and small intestine environment and acts as release retardant. So for drugs which are targeted for intestine can be best formulated with guar gum. Graft polymers of guar gum like poly-acryl-amide-grafted-guar gums are reported to have good colon targeting properties. Highly water soluble drugs are difficult to be delivered to a target site, but the release profile of such drugs can be controlled by using guar gum in matrix tablets or compression coated tablets^{16,17}. Carboxy methyl guar (CMG) is anionic semi synthetic guar gum derivative which is found very much useful in preparing transdermal drug delivery systems (TDDS). The CMG provide good release rate, stability, safety and convenience of use in TDDS¹⁸. Guar gum possesses excellent bioadhesive property. Its shear stress measurements and detachment force measurements suggests a strong interaction between the polymer and mucus lining of the tissue increasing the contact time and localization at the site of contact¹⁹. In micron and submicron systems the use of guar gum in cross-linked form is wide enough to prepare microparticles, nanoparticles, nanocapsules, lipid complexes, polymeric micelles and dendrimers. The cross linked semi synthesized guar gum derivatives like glutaraldehyde cross linked Guar gum, poly acrylic acid conjugated guar gum, hydroxyethyl guar gum, hydroxyl methyl guar gum, 4-vinyl pyridine conjugated guar gum are widely used in the novel drug delivery systems^{13,20,21}.

Guar Gum in Pharmacotherapy

Guar gum, as a water-soluble fibre, acts as a bulk-forming laxative and is effective in promoting regular bowel movements and relieving constipation and chronic related functional bowel ailments, such as diverticulosis, Crohn's disease, colitis and irritable bowel syndrome²². The native guar gum along with its derivatives is also used in some physiological disorders. The intake of partially hydrolyzed guar gum (PHGG) reduces the post-prandial blood glucose absorption in small intestine and

glucose level in systemic circulation²². It is also reported that partially hydrolyzed guar gum for prevention of FeCl₃-induced arterial thrombosis and hyperlipidemia in the high fat diet fed hamsters²³. The granulated guar gum was studied in patients with severe hypercholesterolemia for a longer period of nine months. The results of the study indicated that guar gum was found to be efficacious in long term treatment of hypercholesterolemia. The sulfonated degraded guar gum also reported to reduce cholesterol and fibrinogen effectively²⁴. Some reports are also there where it was found that the PHGG were found effective in treating cholera in adults²⁵. The PHGG undergoes fermentation and liberates fatty acids and are found helpful in treating diarrhoea when mixed with oral rehydration solutions²⁶. The PHGG also controls functional constipation and enhances bowel movement and prevents the risk of colorectal cancer as reported by Belo GM *et al*²⁷. Gamal Eldeen AM *et al* reported the C-glycosylated Guar gum and its sulphated derivatives to have chemopreventive and anti-inflammatory property. The modified guar gum has potential to prevent cancer by inhibiting carcinogen activating enzymes and promoting the carcinogen detoxification enzyme glutathione-S-transferase²⁸.

Guar Gum in Food Industry

Food industry covers the largest market of Guar gum. It stands as one of the cheapest hydrocolloids in food industry with a seldom health hazard. The importance of this gum in food application is due to its unique functional properties like water retention capacity, reduction in evaporation rate, alteration in freezing rate, modification in ice crystal formation, regulation of rheological properties and involvement in chemical transformation². United States Food and Drug Administration (FDA) regulate the use of gums and classify these gums as either food additives or generally recognized as safe (GRAS) substances. The use of guar gum at a concentration not exceeding 2 % is allowed in food application. It is used as gelling, thickening, clouding and binding agent. It is also used for emulsification, stabilization, preservation, water retention and enhancement of water soluble fibre content²⁹. Guar gum is used for increasing the dough yield in baked goods. It reduces unparallel moisture preservation to the dough and retards fat penetration in baked food, which provides greater resiliency and improves texture and shelf life. In pastry fillings, the guar gum prevents weeping or syneresis of the water in the filling, keeping the pastry crust crisp³⁰. In dairy products it thickens milk, yoghurt and liquid cheese products. It helps to maintain the homogeneity and texture of ice cream and sherbets³¹. In frozen food products guar gum reduces crystal formation, acts as a binder and stabilizer to extend shelf life of ice creams³². The binding property of guar gum is used in meat products. In salad dressings, sauces, relishes, ketchups and canned soup it improves stability and appearance. Guar gum controls viscosity, bloom, gel creation, glazing and moisture retention to produce the best grade confections³³. Beverages contain guar gum as viscosity controlling agent as well as to reduce calories in them. Guar gum is an important non-calorie source of dietary fibre and used in capsules as dietary fibre. The guar gums are also safe for animals and widely used in pet foods too^{34,35}. Guar gum is preferred to be blended with other gums like gum tragacanth, karaya gum, xanthan gum and other cellulosic gums to obtain synergistic effect in viscosity.

Guar Gum in Cosmetic Industry

Guar gum is an excellent raw material in cosmetic industry. The unique cosmetic properties of guar gum includes cold solubility, viscosity enhancing, solvent resistance film forming, protective colloid, wide pH range resistance, stability, non-toxic nature, safe and cheap. In the manufacturing of tooth pastes guar gum is used in sizeable scale to impart flowing nature so that the paste can be extruded from the collapsible tubes with the application of a little force. In the shaving cream preparations it does the same work, besides providing stabilizing the system, imports slip during shaving and improves facial skin after feel¹. In emulsion systems like cream and lotions guar gum lends itself to be used to prevent phase separation, prevent syneresis, increase emulsion stability, prevent water loss and use as protective colloid. It stabilizes the emulsion during freeze thaw cycle, where the water phase condenses out of the system. In lotions it additionally provides spreadability and an agreeable after feel^{1,9}. In aerosol dispensing aqueous liquid preparation as spray or mist, guar gum causes reduction of migration of fog. The inert and compatible nature of guar gum with the detergents makes it suitable for use in shampoo and cleansing preparation. It also makes the body of these preparations. Hair colorants contain guar gum as thickener. It is also available in self emulsifying grades. Guar gum can be used to prepare dry face mask preparation.

Safety Considerations of Guar Gum

Guar gum is a thermogenic substance. It is having low digestibility for which it is used in recipes as filler, which can help to provide satiety or slow the digestion of a meal, lowering the glycaemic index of that meal. In the late 1980s, some weight loss products containing guar gum were reported to cause oesophageal obstruction in patients taking a dose which exceeds the recommended dose. It was reviewed that in a case study 18 patients of oesophageal obstruction, 7 patients of small bowel obstruction and possibly 1 death were reported with the use of Cal-Ban3000, a guar gum containing diet pill³⁷. Water retaining capacity of the gum permits it to swell 10-20 folds and may lead to luminal obstruction. The US FDA recalled guar gum after such cases and banned the approval of guar gum as an over the counter weight loss aids in US. In July 2007, the European Commission issued a health warning to its member states after high level of dioxins were detected in guar gum, which was contaminated with pentachlorophenol, which is again generally contaminated with dioxins, which critically damages the human immune system. Abrupt addition of guar gum in diet too quickly may lead to intestinal gas, diarrhoea, abdominal bloating, cramping and constipation. It should be increased slowly to allow the bacterial flora in gastrointestinal tract to adjust to the change³⁸. Occupational asthma and rhinitis has been reported amongst those working with guar gum. Cautious use of guar gum is generally suggested in diabetic patients under medication to avoid the severe glucose deficiency³⁹. No teratogenic potential of guar gum has been reported but its use during pregnancy and breast feeding should be monitored. Guar gum may affect the absorption of co-administered drugs. It is observed to slow the absorption of digoxin, acetaminophen and bumetanide and reduces the absorption of metformin, penicillin V, ethinyl estradiol and some formulations of glyburide.


CONCLUSION

The review found that guar gum is versed with multiple physical and chemical properties which make it a strong candidate in the world of excipients in food, cosmetic and pharmaceuticals. Native guar gum and its derivatives are directly used in therapy in some of the disorders. The chemistry of guar gum allows it to be chemically modified to obtain derivatives of desirable properties which are less expensive, biodegradable and eco-friendly. It is a safe and non-toxic natural polysaccharide, obtained from a renewable natural resource and is easily and plenty available. The continued overwhelming researches in the field of natural excipients may bring a breakthrough in the coming years overcoming the disadvantages of this excipient. This review will hopefully provide some knowledge to the researchers having interest in natural excipients.

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