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Guar Gum

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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, ecofriendly 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 crosslinking with other polymers to create new chemically modified entity of desired properties. Guar gum is a novel agrochemical processed from endosperm of cluster bean. It is largely used in the form of guar gum powder as an additive in food, pharmaceuticals, paper, textile, explosive, oil well drilling and cosmetics industry. Industrial applications of guar gum are possible because of its ability to form hydrogen bonding with water molecule. Thus, it is chiefly used as thickener and stabilizer. It is also beneficial in the control of many health problems like diabetes, bowel movements, heart disease and colon cancer.

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I. INTRODUCTION:

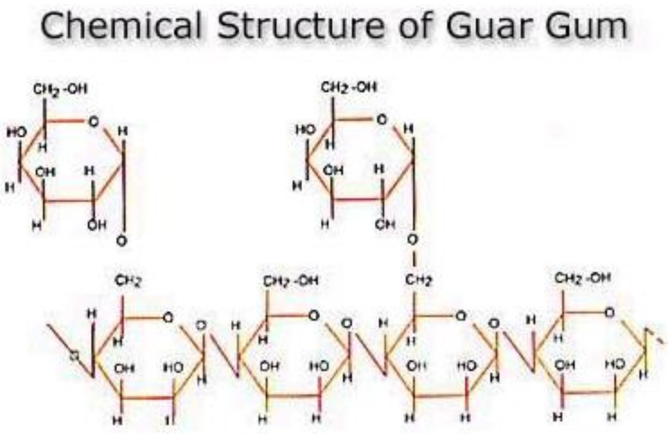
The gums are naturally occurring substances, mainly carbohydrate in nature and are being used since the beginning of the civilization for various purposes like food ingredient (for human and cattle), mastiche and manufacturing domestic items. Guar gum, naturally occurring gum, also called Guaran, is galactomannan. It is obtained from an annual pod bearing plant Cyamopsis tetragonolobus or C. psoraloides, belongin to family Leguminosae.

II. COMPOSITION

Guar gum is comprised of a high molecular weight polysaccharides composed of galactomannans consisting of a (1→4)-linked β-D-mannopyranose backbone with branch points from their 6-positions linked to α-D-galactose (i.e. 1→6-linked α-D-galactopyranose). There are between 1.5-2 mannose residues for every galactose residue.

Possible impurities The commercial samples of guar gum contain approximately 4-12% moisture, 2-5% acidsoluble ash, 0.4-1.2% ash, and 2-6% protein. The samples of clarified guar gum contain approximately 5-10% moisture, 0.2-0.8% acid-soluble matter, 0.1-0.5% ash, and 0.1-0.6% protein. Apart from the gum content, the guar gum contains:

- husk residues represented by the acid-insoluble-matter criterion (not more than 7.0%)
- proteins from the germ represented by the protein criteria (not more than 10.0%)
- ethanol/isopropanol residues for washing or extraction solvent(not more than 1% singly or in combination)
- microbiological contamination



III. PHYSIO-CHEMICAL PROPERTIES

1.Rheology

Rheology is the study of flow and deformation of material when external force is applied. Guar gum in aqueous solutions shows pseudoplastic or shear-thinning behaviour which means reduction in viscosity with increasing shear rate as shown by many high molecular weight polymers. This shear-thinning behavior of guar gum aqueous solution increases with polymer concentration and molecular weight. Guar gum aqueous solutions also do not show yield stress properties. Aqueous solutions of guar gum at 1% concentration show a typical behavior of macromolecular biopolymer with dominating loss modulus (G″) over storage modulus (G′) in lower frequency range. However, in high frequency range storage modulus dominates the loss modulus. With time guar gum aqueous solutions showed a decrease in storage modulus (G′) and loss modulus.

2.Viscosity

The most significant characteristic of guar gum is its ability to hydrate rapidly in cold water systems to give highly viscous solutions. Guar gum forms a viscous colloidal dispersion when completely hydrated which is a thixotropic rheological system. Dilute solution of less than 1% concentration of guar gum are less thixotropic than solutions of concentration of 1% or higher. As like the other gums, viscosity of guar gum is dependent on time, temperature, concentration, pH, ionic strength and also on type of agitation. Schlakman and Bartilucci (1957) examined thirteen different commercial samples, and found great variation in the viscosity property, particle size and rate of hydration. A 1% aqueous dispersion of good quality guar gum may show a high viscosity value of 10000 cP .

3. Hydration rate

Rate of hydration of guar gum varies. Hydration of about 2 h is required in practical applications in order to reach maximum viscosity. Hydration rate largely depend on particle size of guar gum powder. Hence, for quick initial viscosity, very fine mesh guar gums are available . However, a considerable time interval is still desired for maximum hydration and viscosity to be achieved.

4. Hydrogen bonding activity

Hydrogen bonding activity of guar gum is due to the presence of hydroxyl group in guar gum molecule. Guar gum shows hydrogen bonding with cellulosic material and hydrated minerals. With slight addition of guar gum, there is alteration in electrokinetic properties of any system markedly. Substitution of hydroxyl groups in guar gum with hydroxypropyl causes steric hindrance that decreases the stability of hydrogen bonds.

Factors affecting viscosity and hydration rate

Viscosity and hydration rate of guar gum does not remain constant but changes with conditions like temperature, pH, solute, concentration, etc.

1.Temperature

Temperature is the most significant factor that affects the rate of hydration and maximum viscosity. Guar solutions reach maximum viscosity much faster when prepared at higher temperatures than those at lower temperatures. But the prolonged heat is also considered to have degradative effect. In most of the cases, guar gum solutions prepared by heating have a lower final viscosity than the same solutions prepared with cold water and allowed to hydrate slowly. Temperature range of 25–40 °C is desirable for maximum viscosities of guar gum dispersion. The viscosity of 0.5%(w/w) guar solution at 25 °C is significantly higher thanthat of 37 °C.

2. Concentration

Guar gum solution shows very high viscosity even at very low concentration. In most of the food applications it is it is recommended at below 1% concentration. Its solution viscosities increase proportionally with increases in guar gum concentration.This is due to the interaction of galactose side chain of guar molecule with water molecule. Increase in concentration of guar gum enhances the inter-molecular chain interaction or entanglement which leads to increase in viscosity.On doubling the concentration guar gum shows tenfold increase in viscosity (Carlson et al. 1962). Upto 0.5% concentration, guar gum solutions behave as Newtonian system whereas above this concentration level guar solutions behave as nonNewtonian and thixotropic systems. It is also reported that viscosities of different concentration of guar gum at constant temperature reduces with increase in shear rate.

3. pH

Guar gum solutions are stable over a wide pH range of about 1.0–10.5. This is due to its nonionic and uncharged behaviour. Final viscosity of guar gum is not affected by the pH, but the hydration rate shows variation with any change in pH. Fastest hydration is achieved at pH 8– 9, however slowest hydration rate occurs at pH above 10 and below 4.

4. Sugar

In guar-sugar solution, sugar competes with guar gum molecule for the water available in the solution, hence presence of sugar in guar gum solution causes delay in hydration of guar gum molecules. The viscosity of guar-sugar solution decreases gradually and is inversely proportional to the sugar concentration. Sweeteners like aspartame, acesulfame-k, cyclamate and neotame do not affect intrinsic viscosity of guar gum solutions significantly.

5. Salt

Salt is most widely used ingredient in foods other than water, its effect on guar gum has been extensively studied. Guar gum solutions in brine behave same as in water. Hydration rate is not influenced by salt; however, the presence of sodium chloride slightly increases the final viscosity of fully hydrated guar gum. Physiological buffer i.e. Krebs bicarbonate decreases the viscosity of 0.25% guar gum solution as compared to gaur gum in water alone. Salts restrict the hydration of guar gum solution. Srichamroen demonstrated that viscosity of 0.5% guar gum solution increases with added salts. Presence of salts can help the intermolecular interactions due to change in the charge density and conformation of gum.

IV. PRODUCTION

Guar gum is a gel-forming galactomannan obtained by grinding the endosperm portion of Cyamopsis tetragonolobus, a leguminous plant grown for centuries mainly in India and Pakistan where it is a most important crop that has long been used as food for humans and animals (Chandirami 1957). The guar plant is essentially a sun-loving plant, tolerant of high environmental temperatures but very susceptible to frost. For maximum growth the plant requires a soil temperature of 25–30 °C and ideally, a dry climate with sparse but regular rainfall. Guar plant requires

rain for optimum growth before planting and again to induce maturation of seeds (Anderson, 1949). Excess of moisture during early phase of growth and after maturation of seeds results in lower quality guar beans. The rain pattern of the monsoons in the northern parts of India and Pakistan generally provides ideal growing conditions for guar. Almost 90% of world's guar is grown in India and Pakistan. India accounts for 80% of the total guar produced in the world and 70% of it is cultivated in Rajasthan. India is the world leader for production of guar, which is grown in the northwestern parts of country encompassing states of Rajasthan, Gujrat, Haryana and Punjab. During 1970s guar was also grown regularly in the State of Uttar Pradesh (U.P.), Madhya Pradesh (M.P.) and Orissa. In Orissa too guar is not cultivated any more. The annual production of guar during last 3 years ranged from 11, 00,000 to 12, 87,000 MT

V. PROCESSING

Guar gum processing varies from plant to plant. When guar seeds are removed from their pods these are spherical in shape, brownish in color, smaller than pea seeds in size. The gum is commercially extracted from seeds essentially by a mechanical process of roasting, differential attrition, sieving and polishing. The seeds are broken and the germ is separated from the endosperm. Two halves of the endosperm are obtained from each seed and are known as undehusked guar split. When the fine layer of fibrous material, which forms the husk, is removed and separated from the endosperm halves by polishing, refined guar splits are obtained.

The hull (husk) and germ portion of guar seed are termed as guar meal which is a major byproduct of guar gum powder processing and is utilized as cattle feed. The refined guar splits are then treated and finished into powders (known as guar gum) by a variety of routes and processing techniques depending upon the end product desired. The pre hydrated guar splits are crushed in flacker mill and then uniformly moved to ultra fine grinder, which grinds the splits without producing too much heat. The grinded material is dried and passed through screens for grading of the material according to the particle size. Various grades are available depending upon color, mesh size, viscosity potential and rate of hydration. In industrial processing of guar gum extrusion is also included before hydration and flaking. After these steps grinding and drying are done. Inclusion of extrusion gives guar gum powder with improved hydration rate. The byproducts of guar gum industry are Churi and Korma which are utilized

VI. APPLICATIONs IN FOOD INDUSTRY

In food industry, guar gum is used as a novel food additive in various food products for food stabilization and as fiber source (Morris 2010). It is liked by both manufacturer and consumer because it is economical as well as natural additive.

1. Beverage

s Guar gum is used in beverages for thickening and viscosity control because of its several inherent properties. The important property of guar gum is its resistance to breakdown under low pH conditions present in beverages. Guar gum is soluble in cold water which makes it easy to use in beverage processing plants. It improves the shelf life of beverages.

2. Processed Cheese

In cheese product, syneresis or weeping is a problem of serious concern. Guar gum prevents syneresis or weeping by water phase management and thus also improves the texture and body of the product (Klis 1966). In cheese products it is allowed upto 3% of the total weight. Guar gum in the soft cheeses enhances the yield of curd solids and gives a softer curve with separated whey. Low-fat cheese can be produced with addition of guar gum (at concentration 0.0025–0.01% w/v) without changing the rheology and texture compared with full-fat cheese.

3. Dairy Products

Guar gum has important role in ice cream stabilization because of its water binding properties. Its use in high temperature short time (HTST) processes is very favorable because such processes require hydrocolloids that can fully hydrate in a short processing time. Guar gum should be used in ice cream mix at a concentration level of 0.3%. Guar gum in ice cream improves the body, texture, chewiness and heat shock resistance.

4. Processed Meat Products

Guar gum has strong water holding capacity in both hot and cold water. Hence, it is very effectively used as a binder and lubricant in the manufacturing of sausage products and stuffed meat products. It performs specific functions in processed meat products like syneresis control, prevention of fat migration during storage, viscosity control of liquid phase during processing and cooling and control of accumulation of the water in the can during storage. Guar gum also enhances the creaming stability and control rheology.

5. Bakery Products

Addition of guar gum in cake and biscuit dough improves the machinability of the dough that is easily removed from the mold and can be easily sliced without crumbling. At 1% addition of in batter of doughnuts, it gives desirable binding and film-forming properties that decreases the penetration of fats and oils. Guar gum in combination with starch is found to be effective in prevention of dehydration, shrinking and cracking of frozen-pie fillings. In wheat bread dough, addition of guar gum results in significant increase in loaf volume on baking. Guar gum along with xanthan gum retard staling in gluten-free rice cakes by decreasing the weight loss and retrogradation enthalpy. Similarly, guar gum also retards staling in chapati at room temperature as well as refrigerated temperature by controlling retrogradation of starch.

VII. NON-FOOD APPLICATIONS

Demand of guar gum has increased during last few decades due to the development of different derivatives of guar gum like anionic and cationic derivatives. Present commercial importance of guar gum is because of its use in oil and gas well stimulation specifically hydraulic fracturing in which high pressure is used to crack rock. Guar gum makes the fracturing fluid thicker so that it can carry sand into fractured rock. This fracture remains open due to presence of sand which creates a path for gas or oil to flow to well bore. Guar derivatives for use in fracturing fluids are hydroxypropyl guar (HPG) and carboxymethyl hydroxy- propyl guar (CMHPG). In textile and carpet printing, guar gum thickens the dye solutions which allow more sharply printed patterns to be produced. Guar gum has been used in explosives for over 25 years as an additive to dynamite for water blocking. In recent years, it has become the primary gelling agent in water based slurry explosives. Water blocking, swelling and gelling property of guar gum make it enable to use as an additive in explosive industry. Explosive property is maintained by mixing of ammonium nitrate, nitroglycerine and oil explosives with guar gum even in wet conditions. The production of paper is enhanced by an addition of small amounts of guar gum to the pulp. It serves as a fiber deflocculent and dry-strength additive. It provides denser surface to the paper used in printing. Research investigation shows that high viscosity guar gum derivatives can be obtained by treatment of guar gum with complexing agents like organic titanates, chromium salts and aluminum salts. These agents react with guar gum to form complexes with high viscosity gel.

VIII. HEALTH BENEFITS

Various studies have been conducted on animals to test for both harmful and beneficial effect of guar gum. Guar is completely degraded in the large intestine by Clostridium butyricum Guar gum shows cholesterol and glucose lowering effects because of its gel forming properties. It also helps in weight loss and obesity prevention. Due to gel forming capacity of guar gum soluble fiber, an increased satiation is achieved because of slow gastric emptying. Diet supplemented with guar gum decreased the appetite, hunger and desire for eating. Mechanism behind cholesterol lowering by guar gum is due to increase in excretion of bile acids in faecus and decrease in enterohepatic bile acid which may enhances the production of bile acids from cholesterol and thus hepatic free cholesterol concentration is reduced. Hypotria cylglycerolaemic effects are due to decrease in absorption of dietary lipids and reduced activity of fatty acid synthas in liver. Toxicity study on partially hydrolyzed guar gum has revealed that it is not mutagenic upto dose level of 2500 mg/day. Adequate intake of guar gum as dietary fiber helps in the maintenance of bowel regularity, significant reductions in total and LDL-cholesterol, control of diabetes, enhancement of mineral absorption and prevention of digestive problems like constipation.

IX. GUAR GUM COSTING

According to industry estimates, the cost of one kg Guar Gum powder has increased by over 30% in the last two months due to volatility in Guar Gum prices. Currently, manufacturers are not able to sell Guar Gum powder for less than Rs 70 per kg, which is driving away overseas buyers. “The market price of Guar Gum is at Rs 59 per kg. The processing cost is around Rs 8 per kg and the packaging cost of Rs 3-4 per kg further spirals the Guar Gum powder costing. The export volumes have come do wn drastically from 2 lakh tonnes to 1 lakh tonnes.

X. CONCLUSION

Guar gum is an important agrochemical derived from the seed endosperm of guar plant i.e. Cymopsis tetragonolobus which is cultivated in India and Pakistan from ancient times. Guar gum is a useful material to investigate. It has a strong hydrogen bond forming tendency in water which makes it a novel thickener and stabilizer. Aqueous solutions of guar gum are very viscous in nature. Because of these properties it has wide applications in the industries like food, pharmaceutical, textile, oil, paint, paper, explosive and cosmetics. Another reason for its popularity in the industry is its low cost. Its economical nature makes it popular in gums and stabilizers industry. In food industry, it has wide applications in ice cream, sauce, beverages, bakery and meat industry. It is also used in food products for supplementation as dietary fiber. Its consumption reduces the risk of heart diseases by reducing the cholesterol level in body, control diabetes and maintains the bowel movement in human beings. 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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