Guar Gum

An abundant source for thickening requirements

The guar bean (*Cyamopsis tetragonolobus*), an annual legume, is the source of guar gum. It grows best under conditions with frequent rainfall, but tolerates arid conditions well. India grows 80% of world production of Guar gum but due to strong demand, it is being introduced into new areas. It is mainly grown in areas of India (Rajasthan, Haryana, Gujarat and Punjab), Pakistan, Sudan, and USA. India produces 6.0-7.5 lakh tons of guar annually. In India Rajasthan and Haryana states contribute 85% of the total production. In Rajasthan, the districts where guar production is done are Churu, Bikaner, Jaisalmer, Barmer, Nagaur, Hanumangarh, Jodhpur, Ganganagar, Jaipur, Sirohi, Dausa, Jhunjhunu and Sikar.

The districts in Haryana indulged in the production of guar are Bhiwani, Sirsa, Mahendragarh and Rewari and the districts in Gujarat are Kutch, Banaskantha, Mehsana, Sabarkantha and Ahmadabad. Jodhpur city in Rajasthan is one of the major processing centers of guar gum in India.

Guar also known as cluster bean (*Cyamopsis tetragonoloba* (L.) Taub) is a drought hardy leguminous crop. Guar is being grown for seed, green fodder, vegetable and green manuring. It is an annual plant, about 4 feet high, vertically stalked, with large leaves and clusters of pods. Each pod is about 5-8 cm long and has on an average 6-9 small grayish-white pea shaped seeds. The pods are used as a green vegetable or as a cattle feed besides the industrial extraction of guar gum. (Fig-1)
Guar seed consists of major three portions viz. the seed coat, the endosperm and the innermost proteinacious portion, the germ. The endosperm is mechanically separated from seeds which yields 35-42% of gum (galactomannan). The left out portion, i.e., the outer seed coat and the germ together constitute guar meal.

**Chemistry of Guar Gum**

Chemically, guar gum is a straight chain galactomannan, which is 75-85% of the endosperm, has a chain of \((1\rightarrow4)\)-linked-\(\beta\)-D-mannopyranosyl units with single \(\alpha\)-D-galactopyranosyl units connected by \((1\rightarrow6)\) linkages to, on the average, every second main chain unit. The ratio of D-mannopyranosyl to D-galactopyranosyl units is about 1.8:1. The average molecular weight of guaran is in the range of \(1.2 \times 10^6\) dalton. The cis-position is important since adjacent hydroxyl groups reinforce each other in hydrogen bonding reactions.

**Guar Gum Manufacturing Process**

Depending upon the requirement of the end product, various techniques are used for processing guar. In India, commercial production of guar gum contains process of roasting, differential attrition, sieving and polishing. Using heating, grinding and polishing process, the husk is separated from the endosperm halves and the refined guar gum split is obtained. (Fig-2 and 3).
The stage-wise process of manufacturing guar gum powder is as follows:

**Screening of guar splits**: Selected guar splits are screened to remove their impurities like dust, *churi* and *korma* particles.

**Prehydration of guar splits**: Screened guar splits are required amount of water is added in the mixer. Prehydrating stage is very important in the process as it derives the rate of hydration of the final product.

**Flaking, grinding and drying of guar splits**: Soaked and hydrated guar splits, which have reasonably high moisture content, are passed through a flaker. The flaked guar splits are ground, followed by drying of the material.

**Screening of guar powder**: The powder is then screened through rotary screens to deliver required particle size. Oversized material is either recycled or reground, as per viscosity and particle size requirements. The soaked splits are difficult to grind. Direct grinding of such splits generates more heat in the grinder, an undesirable process, as it results in insoluble or reduced hydration in the end product.

During the splits separation process, husk and germ are obtained and these are widely used as cattle feed, as they are rich in protein. It is widely sold in the international market as guar meal.
Modification of Guar Gum

1. Modification by chemical reactions: Chemical modifications are intended to impart desired properties in the galactomannan like increased solubility in water, solution clarity, increased shelf life, ionic character and to impart some very peculiar behaviors like solubility in various organic solvents according to the needs of the particular final application.

In industry, various substitution reactions (Michael addition type) are being carried out to impart desired properties in the backbone of guar gum. By these modifications lot of opportunities are opened, where chemically modified guar derivatives can be used for rheology management of the system.

- **Depolymerization of guar gum:** Depolymerization of guar gum is carried out by oxidation of guar gum either by peroxides in presence of alkali or by reacting with strong acid in a temperature range of 40° to 70°C depending upon the end use purposes. These are mainly used food as well as in textile printing applications.

- **Quaternization of guar gum:** These are also known as cationic guar gum, manufactured by reacting guar gum with a quaternary ammonium compound to obtain Guar-2-hydroxy-3-(trimethylammonio) propyl ether chloride or Guar hydroxypropyl trimonium chloride. Cationic guar gums are mostly used in cosmetic and paper industries.

- **Carboxymethylation of guar gum:** Sodium carboxymethyl guar is manufactured by reacting guar gum with sodium monochloro acetate (SMCA) in the presence of alkaline medium. These derivatives are very often used in textile printing and water based paints.

- **Hydroxypropylation of guar gum:** Hydroxypropyl guar (HPG) is manufactured by reacting guar gum with propylene oxide (PO) in the presence of alkaline medium. Hydroxypropyl guar are widely used in oil well drilling, paints, textile and cosmetics.

- **Cross linked guar gum:** Cross linked guar gum is manufactured by reacting guar gum with sodium borate in the presence of alkaline medium. These grades are chiefly used in carpet printing and oil well drilling.

2. Modification by mechanical process

- **Normal guar gum:** In this process guar splits are manufactured using conventional methods and finally converted into fine 200 mesh powder. This kind of guar powder is used in food and pharmaceutical industries.
Uses of Guar gum

Slow hydrating guar gum: In this process guar splits are ground in coarse particle size with reduced prehydration and sieving through higher pore sieves so as to achieve coarser powder with delayed hydrating properties. This kind of guar powder is also used in food and pharmaceutical industries where, in applications, water absorption is required for long duration.

Fast hydrating guar gum: In this process over swelled prehydrated guar splits are ground in very fine particle size so as to achieve fast hydrating properties. This type of guar gum powder is widely used in oil well drilling operations.

Uses of Guar gum and derivatives thereof

(A) Food: The uses of guar gum always involve systems where water is an important factor. The most common single component of food is water, and guar gum is effectively used wherever there is a desire to modify the behavior of water or of food systems in which other ingredients are associated with aqueous phase. Guar gum works as a thickener, stabilizer, and suspending agent in various food applications. Guar gum is relatively used in small percentage into a wide variety of foods, where, to perform the same function, a larger percentage of starch or other thickening agents are required.

In Baked Food Industry: Stabilizers are often added to packaged cakes, mixes and guar gum offers several functional advantages in single step mixing procedures, reduced better mixing time, and reduced crumbing in the finished cakes. Guar gum prolongs shelf life due to greater water absorption in cake. In bread it is useful for bread softness, and increased shelf life.

In Salad Dressing Industry: Guar gum is often used as a thickener in salad dressing in a very low usage level. Its advantages are cold water dispersibility, Its compatibility with highly acidic emulsions and its comparatively low cost on a viscosity basis.

In Meat and Pet Foods Industry: In processing, canning and smoking process, Guar gum increases the viscosity while cooking in the kettle so that there is less splashing on the floor and canning operation can be operated at full speed.

In Beverages Industry: Guar gum is used as a thickening or viscosity control agent in the beverages at a level of 0.25 to 0.75% of the total weight of the products. Sugarless dietetic beverages require incorporation of a gum to improve body and mouth feel. Guar gum is useful because of its resistance to breakdown under low pH (minus the decimal
logarithm of the hydrogen ion activity in an aqueous solution) conditions. In addition since guar is soluble in cold water, it is easy to use in most beverage processing plant.

- **In Ice-cream Industry:** Frozen foods have been effectively stabilized by guar gum. The hydration and water binding properties of guar have given it a very important use in ice cream stabilizers, particularly for use in high temperature, short time (HTST) processes. Guar gum and its blends with other hydrocolloids hydrate in cold water and impart properties of body, texture, chewiness and heat shock resistance.

(B) Industrial

- **In Oil and Gas Industry:** Guar gum and its derivatives like hydroxypropyl guar gum (HPG) and carboxymethyl gum (CMG) have found a broad range of application in petroleum industry as additives for aqueous and water / methanol based fracturing fluids. They serve as water loss control, viscosity control, suspensions, friction reduction or mobility control agent. Hydraulic fracturing requires that a large volume of fluid be pumped very rapidly in to the well to separate the rock layers mechanically hence friction reduction by addition of water soluble polymers is practiced routinely, the same polymers usually aid in suspending the proppant (Hydraulic fracturing is a method used to create fractures that extend from a borehole into rock formations, which are typically maintained by a proppant, a material such as grains of sand or other material which prevent the fractures from closing. The method is informally called fracting or hydro-fracing) agent such as sand. Guar gum based product in aqueous fluids is used in drilling shallow wells. These applications utilize the gum’s properties to increase viscosity, reduce fluid loss and decrease fluid friction.

- **In Paper Industry:** The major use of galactomannan and its cationic derivatives in paper making, is the wet end of the process. The gum added to the pulp suspension just before the sheet is formed. The pulping process, which is designed to remove lignin and thereby produce a fibrous pulp, also removes a large part of the hemicelluloses normally present in wood which could contribute greatly to the hydration property of the pulp and the strength of the paper formed from the pulp. Galactomannans and cationic guar replace or supplement the natural hemicelluloses in the paper binding.

- **In Textile Industry:** Guar gum derivatives like depolymerized, carboxymethyl, cross linked guar are widely used in textile printing. These modified guar gum derivatives give
high color yield, reduced bleeding effect, sharpness and effective penetration of dye. Beside this it is also used as sizing agent.

- **In Mining Industry:** In the mining industry galactomannans are used as chemical flotation agents by getting absorbed onto hydrated mineral surfaces. In flotation, the galactomannan functions as depressant to block the absorption of other reagents onto the surfaces of talc and other gangues, which are mined along with the valuable minerals.

- **In Explosives Industry:** Water proofing, thickening and foam stabilizing properties are required in the preparation of explosives. Slurry explosives are generally based on various concentrated (60-80%) suspensions or solutions of nitrate salts; therefore gum to be employed must be compatible with high-level of salts. Oxidized guar gum are the most commonly used polysaccharides to thicken slurry explosives. In the production of water-resisting ammonium nitrate stick explosive, guar gum is used as a binding agent. When the explosive stick is immersed in water, the oxidized gum in the outer wall swells rapidly and the resultant gel retards leaching of the salts. It is also used as a thickener and gelling agent for slurry explosive.

- **In Cosmetic Industry:** Cationic guar, a derivative of guar gum is used to thicken various cosmetics products. Cationic guar products are specially used to impart performance functions such as thickening, conditioning, foam stability, softening and lubricity in cosmetics and toiletries like hair and skin care products, cleansing and bathing products.

**Market scenario of Guar gum**

India exports about 70 to 80 percent of guar gum annually. After India, Pakistan is the major competitor in exports. Since the crop is mainly monsoon dependent, monsoon has always remained a major factor for any sharp movement in Guar prices. In the current season too, it was only monsoon which has derived the Guar prices to such high levels. Nevertheless the export figures show a bright future of guar at global level.
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**Yearwise Guar Gum Export**

- **Qty (MT)**
- **Value (Crores)**
It is clear from the data presented above that export of guar gum is increasing every year which is a sign of stimulation of demand.

To sum up, the production of guar is dominated by India as a leading producer of this crop and being a versatile hydrocolloid and has wide range of applications in various segments of food and technical industries.

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