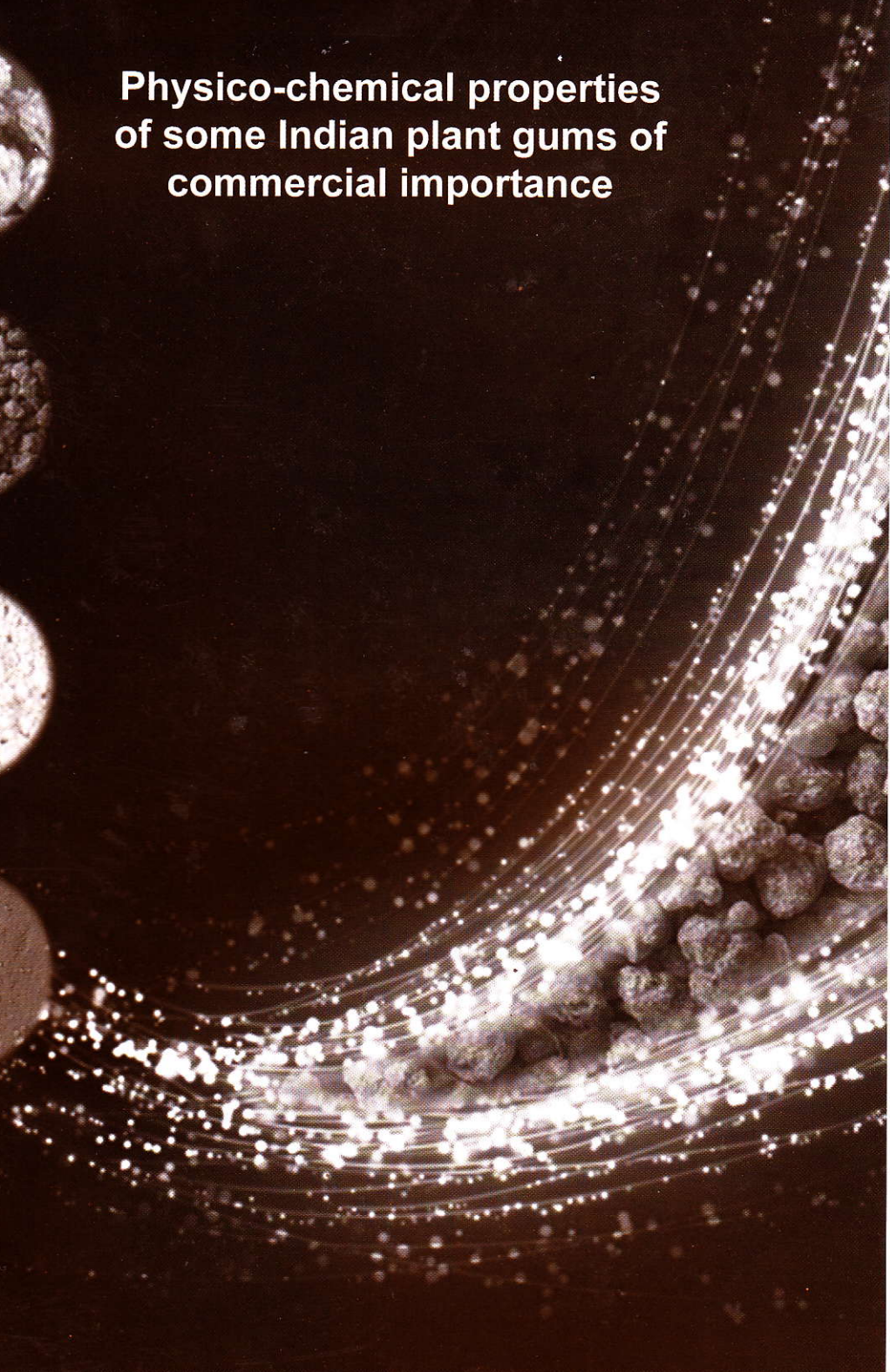
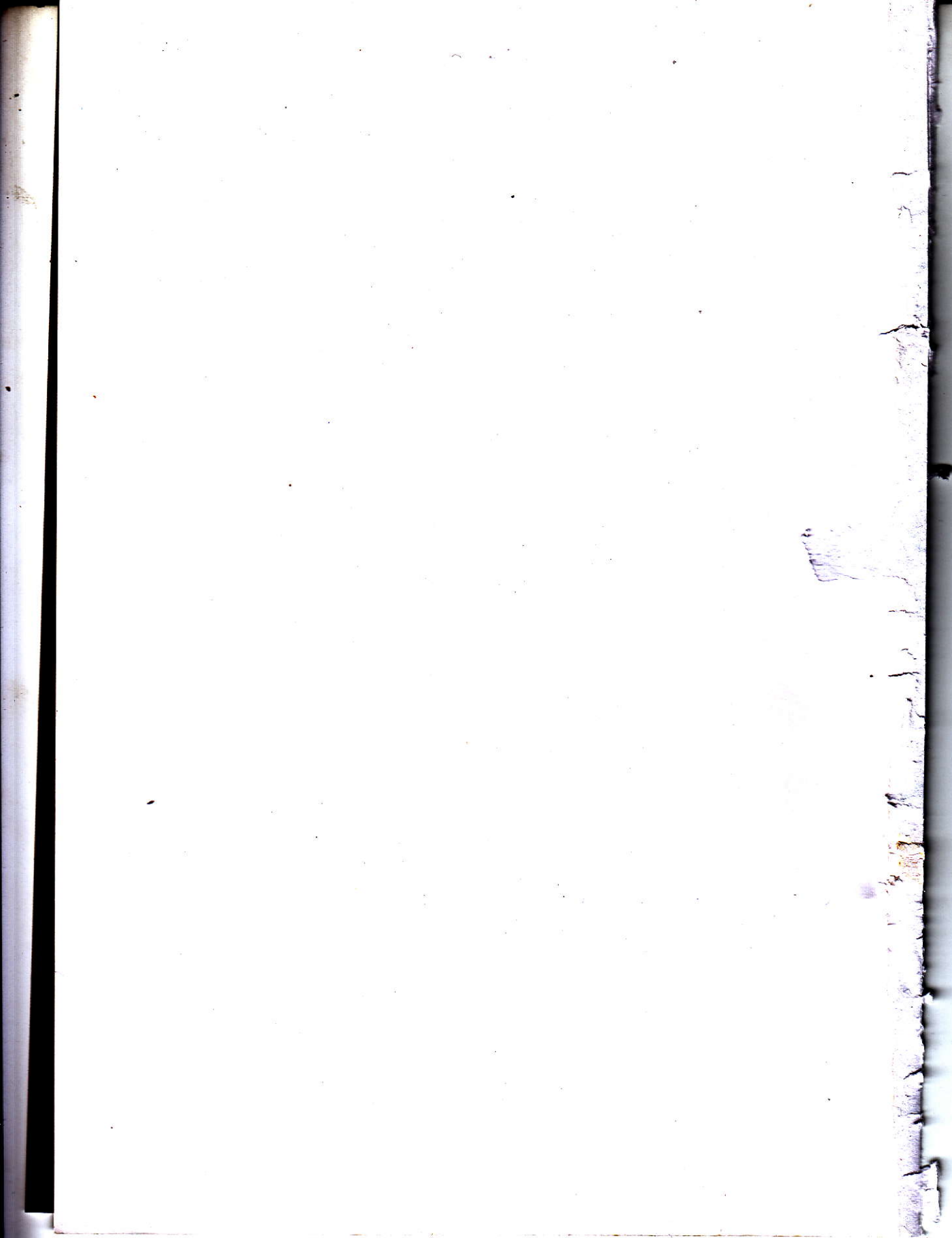


**Physico-chemical properties
of some Indian plant gums of
commercial importance**



Indian Institute of Natural Resins and Gums
(Indian Council of Agricultural Research)
Namkum, Ranchi - 834 010 (Jharkhand)





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Dr K P Sao



Indian Institute of Natural Resins & Gums
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Dr R Ramani

Director

Compiled & Edited by

Dr K P Sao

Produced by

Dr Vibha Singhal

Mr M F Ansari

Dr A Mohanasundaram

Dr Anjesh Kumar

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Indian Institute of Natural Resins and Gums

Namkum, Ranchi-834 010

Tel : 0651-2260117

: 0651-2260202 (Fax)

e-mail : iinrg@ilri.ernet.in, iinrgmr@gmail.com

Visit us at : <http://ilri.ernet.in>

Preface

Plants based natural gums are hydrophilic carbohydrate polymers of high molecular weights that can be dissolved or dispersed in water to give a thickening and gelling effect. These are colloidal in nature and referred as hydrophilic colloids or hydrocolloids. They are generally insoluble in oils or organic solvents such as hydrocarbons, ether, or alcohols. Plant gums are mainly classified as (i) exudates gums which are exudates from the bark of trees or shrubs and (ii) seed gums which are obtained from endosperm of the seed.

There is a growing interest worldwide in natural gums particularly in food, pharmaceutical and cosmetics applications. India is a rich centre of biodiversity and offers great potential for the sustainable utilization of these natural resources by converting plant wealth into economic wealth. Their increased role in socio-economic development, incentive design and livelihood support is already well appreciated as a major part around 80 percent of natural gums produced in our country are exported.

The physico-chemical properties of natural gums are of first importance in determining their uses and their commercial value. The numerous technological applications of natural gums can be attributed to their physico-chemical properties. However the physicochemical properties are known to vary considerably with botanical sources, soil and climate, age, absorbed impurities, treatment after collection and storage conditions. Gums are water soluble or water dispersible hydrocolloids, and possess suspending, dispersing and stabilizing properties. They can act as emulsifiers, coagulants, adhesives, bulking, encapsulating, flocculating, gelling, suspending, swelling, thickening and whipping agents, crystallization inhibitors, film formers, stabilizers and protective colloids. Due to the above properties the industrial applications of gum have expanded tremendously in recent years. The major uses are in food, pharmaceutical, cosmetic, textile, paper and petroleum industries. The vast scope of gums and its contribution to economy call for sustained research input mainly in the areas of grading, quality improvement, value addition and use diversification. The present bulletin can serve as a useful information source which may be helpful to accelerate the research programme on commercially important Indian gums. Research on value addition and application will help to increase the exports and the income generation of tribals who collect it.

The author acknowledges the help received from National Botanical Research Institute (NBRI), Lucknow, Forest Research Institute (FRI), Dehradun and Indian Institute of Technology (IIT), Kharagpur, during the collection of information on various gums. Thanks are especially due to Prof. R. N. Choudhary and Prof. B. K. Mathur of Department of Physics & Meteorology, IIT Kharagpur for their kind help during collection of information on gums.

K P Sao

THE HISTORY OF THE UNITED STATES

The history of the United States is a story of growth and change. From the first European settlers to the present day, the nation has expanded its territory and diversified its population. The early years were marked by the struggle for independence and the establishment of a new government. The middle years saw the westward expansion and the Civil War, which tested the nation's unity and values. The late years have been characterized by rapid technological advancement and the rise of a global superpower.

The early years of the United States were marked by the struggle for independence. The colonists fought for the right to self-governance and to be treated as equal to the British. The American Revolution was a turning point in the nation's history, leading to the birth of a new country. The Constitution was drafted to provide a framework for the new government, and the Bill of Rights was added to protect the liberties of the people.

The middle years of the United States were marked by westward expansion. The discovery of gold in California and the opening of the transcontinental railroad led to a massive migration of people to the West. The Civil War, which lasted from 1861 to 1865, was a defining moment in the nation's history. It was fought over the issue of slavery and resulted in the abolition of the institution. The war also led to the Reconstruction era, which sought to rebuild the South and integrate African Americans into the nation.

The late years of the United States have been characterized by rapid technological advancement. The invention of the automobile, the airplane, and the computer have transformed the way we live and work. The United States has also become a global superpower, with a significant influence on the world. The Cold War, which lasted from 1945 to 1991, was a period of tension between the United States and the Soviet Union. The end of the Cold War led to a new era of global cooperation and peace.

The United States has a rich and diverse history. From the first European settlers to the present day, the nation has grown and changed in many ways. The story of the United States is a story of resilience and achievement. It is a story of a people who have fought for their rights and values, and who have built a nation that is a source of pride and inspiration for all.

The history of the United States is a story of growth and change. From the first European settlers to the present day, the nation has expanded its territory and diversified its population. The early years were marked by the struggle for independence and the establishment of a new government. The middle years saw the westward expansion and the Civil War, which tested the nation's unity and values. The late years have been characterized by rapid technological advancement and the rise of a global superpower.

Babul gum (*Acacia nilotica*)



General Information

Babul (*A. nilotica* subsp. *Indica*), a moderate-sized, almost evergreen tree is found throughout the drier parts of India. Bark of the tree is dark brown to almost black, longitudinally fissured or deeply cracked. The gum exudes from wounds in the bark, mostly during March-May. The gum obtained from *Acacia nilotica* is known as "Indian gum arabic". Though some trees yield a maximum of around 1kg per year, the average is only a few grams. The yield lessens with the age of the trees. It is believed that tapping accelerates the flow, but it is not often practiced. Incisions made (6cm x 1cm and 10cm x 0.5cm) have shown maximum yield 12g/tree/annum.

The gum of *A. nilotica* subsp. *Indica*, although called gum arabic, is not true gum arabic which is obtained from *A. senegal*.

Physico-chemical properties

Babul gum occurs in the form of rounded or ovoid tears about 1cm in size and the colour varies from pale-yellow to brown or almost black according to the age of the tree and the conditions of collection.

The gum is tasteless and almost completely soluble in water (50g/100ml). The darker samples contain tannin and are much less soluble, and leave behind a gelatinous residue.

Babul gum is very slightly dextrorotatory, whereas the gum of *A. senegal* is slightly laevorotatory.

It contains 13% of moisture and on ignition, it leaves behind 1.8% of ash (CaO, 52.2; and MgO, 19.7%).

Molecular weight : The gum of *A. nilotica* has a higher molecular weight (Mw, 2.3×10^6) than *A. Senegal* (Mw, 600,000).

Chemical nature : The gum contains galactose, L-arabinose, L-rhamnose, and four aldobiouronic acids, viz. 6-O-(β -glucopyranosyluronic acid)-D-galactose; 6-O-(4-O-methyl- β -D-glucopyranosyluronic acid)-D-galactose; 4-O-(α -D-glucopyranosyluronic acid)-D-galactose and 4-O-(4-O-methyl- α -D-glucopyranosyluronic acid)-D-galactose. The 3, 5, di-O-methyl-L-arabinose and a new crystalline arabinobiose, 2-O- β -L-arabinopyranosyl-L-arabinose ($C_{10}H_{18}O_9 \cdot \frac{1}{2}H_2O$, mp 103°C) have been isolated from the gum. It also contains arabinobiose, 3-O- β -L-arabinopyranosyl-L-arabinose. The structural evidence suggests that gum molecules possess highly branched galactan frameworks to which are attached uronic acid residues and arabinose-containing side chains.

The chemical composition and microbial standards of gums obtained from different acacia tree species have been compared and shown to be appropriate for use in food.

Table 1 Chemical composition of gums obtained from *Acacia nilotica* and *Acacia senegal*

Constituents	<i>Acacia nilotica</i>	<i>Acacia senegal</i>
Ash (%)	2.5	2.5
Heavy metals (ppm)	<20	<20
Moisture (%)	5.8	3.5
Protein (%)	5.25	2.15

Table 2 Microbiological testing of gums obtained from *Acacia nilotica* and *Acacia senegal*

Organism	<i>Acacia nilotica</i>	<i>Acacia senegal</i>
Aerobic plate count/g	>500	>1000
Yeast and Molds/g	>100	>100
E.Coli/12.5g	Negative	Negative
Salmonella/25g	Negative	Negative
Staph Aureus 10g	Negative	Negative

Viscosity: The viscosity of 30 percent of *A. nilotica* and *A. senegal* gums at shear rate of 9.6 Sec^{-1} was found to be 120 cps and 95 cps respectively. Viscosity of both the gums decreases as the shear rate increases. Therefore, both the gums can be termed as pseudo-plastic material. Studies on viscosity and temperature have shown that drop in viscosity of these gums are significant when heated from 30° to 90°C . Viscosity of *A. nilotica* drops from 120 cps to 46 cps and *A. senegal* drops from 95 cps to 33 cps. Viscosity of 5% solution of these gums showed synergistic increase when 0.5% and 1% xanthan gum was added and in both the gums synergistic viscosities were lower than the viscosity of 0.5% and 1% xanthan gum alone. Synergistic increase in the viscosity of a mixed solution decreases on addition of urea (4.0, 6.0 and 8.0 M), thereby showing that increase in viscosity is due to hydrogen bonding. A comparison of the physico-chemical properties of *A. nilotica* gum solution with those of *A. senegal* gum solutions suggests that there are important differences in the molecular architecture of the two gums in addition to fine structure variations, which are predictable from knowledge of the difference in chemical composition of the two gums.

Electrical conductivity : Gum arabica obtained from *acacia* tree has been found to be an ionic conductor. It has been found to show high value of ionic conductivity after swelling which may be due to release of ions during swelling. The overall conduction mechanism has been suggested to be protonic in nature rather than electronic one.

Uses

- In calico-printing and dyeing
- As a sizing material for silk and cotton, and in the manufacture of paper
- As a mucilage or adhesive
- In the preparation of sweetmeats
- As a possible ice-cream stabilizer it gave better results at 0.5 per cent level.
- As a masticatory.
- In pharmacy, as a substitute for true gum arabic
- In the indigenous medicine, *e.g.* it is useful in diarrhoea, dysentery, diabetes mellitus, sore throat *etc.*
- In the manufacture of matches, inks, distempers and certain types of paints and mortars

Unfortunately, the collection of babul gum in India does not receive proper attention as it is entirely in the hands of ignorant people. The gum is sold throughout India in large amount. An unofficial estimate puts its annual production in India at around 25 thousand tones. If necessary steps are taken for the babul gum production to become an organized industry, just as karaya gum production (*Sterculia urens*) has, there is no reason why good quality babul gum should not find a place in the export list of the country.

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Khair gum (*Acacia catechu*)



General information

The gum from *Acacia catechu*, khair gum, is of very good quality and is regarded as the best substitute for true gum arabic (*A. Senegal*). *Acacia catechu* is a moderate-sized deciduous tree with a light feathery crown, occurring throughout India in dry types of mixed forests on a variety of geological formations and soils. Lac can be successfully grown on *Khair* trees. It is best used for raising the *Aghani* crop and the encrustation produced is similar in quantity and quality to that produced on kusum (*Schleichera oleosa*) trees. The bark exudes a light gum. The tears may be as large as 3cm in diameter and pale yellow to dark brown in colour. It is not collected separately and is generally mixed up with other *Acacia* gums. The gum has a sweetening taste and is said to give thicker and better mucilage than *babul* gum.

Physico-chemical properties

Chemical nature: Purified, exudates gum from *khair* contains D-galactose, L-arabinose, L-rhamnose, and D-glucuronic acid in a molar ratio of ~ 14.4:5.4:1.5:1. The polysaccharide of *khair* gum had ash (0.28%), nitrogen (0.02%), methoxyl (1.7%), anhydrouronic acid (3.8%) and specific rotation $[\alpha]_D^{25} -30^{\circ}$ (c, 0.16% in acetate buffer, pH 4.8). Hydrolysis of the gum showed that it is composed of D-galactose (64.57%), L-arabinose (24.21%), L-rhamnose (6.72%) and D-glucuronic acid (4.03%). 4-O-methyl-glucuronic acid (1.7% of total glucuronic acid) is also present in the gum. The structure investigation of gum polysaccharide showed that main core of the gum is constituted of 1→3 linked galactose units to which are attached side chains of galactose and arabinose by 1→2 linkage.

Molecular weight: Ultra centrifugal analysis of polysaccharide showed its sedimentation constant to be 6.86 which corresponded to molecular weight of 40,010.

Solubility & Viscosity: Gum of *A. catechu* is soluble in cold water to a high degree. Percentage of water-soluble portion in 2% solution (on dry basis) is reported as 94.2% compared to 97.8% for *babul* gum and 99.2% for gum arabic. The viscosity determined with Redwood viscometer of 1%, 5% and 10% solutions of *A. catechu* gum were 25.0, 29.6 and 36.3 in Redwood seconds respectively. The viscosity of 1%, 5% and 10% solutions of *babul* gum and gum arabic were 26.0, 30.4 & 39.3 and 26.8, 31.1 & 36.5 in Redwood seconds respectively.

Adhesiveness: The adhesive strength of *A. catechu* gum and *babul* gum were found to be somewhat lower than that of gum arabic.

Other studies: Differential thermo grams, infrared spectra and SEM studies were made for identification of gum from *A. catechu*

Uses

- As a good substitute for true gum arabic
- In mastictories, hair dyes.
- Flocculation characteristics of *khair* gum in relation to synthetic dyes containing effluents have been studied.

The gum is not collected separately and is generally mixed with other *acacia* gums.

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Karaya gum (*Sterculia urens*)



General Information

Karaya gum also known as Indian tragacanth is the dried exudate from the tree *Sterculia urens*. It is also known as Katira gum or Kullu gum in the trade. The tree *Sterculia urens* is common in India in the tropical deciduous forests mostly in dry and rocky areas. Major areas producing gum karaya are M.P., Andhra Pradesh, Maharashtra, Orissa, Rajasthan, Tamil Nadu and Mysore. The best quality gum is collected during April-June *i.e.* before commencement of monsoon. As the weather becomes warmer, the gum yield and quality improves. Collection may be repeated after the monsoons in September, although this gum may be darker in color and lower in viscosity. When trees are incised or blazed, gum begins to flow immediately, and exudation continues for several days. The maximum amount of exudation occurs within the first 24hr. The yield of the gum from matured trees is estimated at 1 to 4.5 kg per tree per season. The average tree can be tapped five times during the lifetime.

In the natural state, the gum is in irregularly shaped pieces, sometimes of worm like appearance. They are white or pinkish-brown in colour and generally striated. The gum, especially when fresh, may have an acetous odour.

Physico-chemical properties

Chemical nature: It is partially acetylated complex polysaccharide. It contains approximately 8% acetyl groups and around 37% uronic acid residues with acid number varying from 17.4 to 22.7. Partial acid hydrolysis gives D-galactose, L-rhamnose (6-deoxy-L-mannose) and D-galacturonic acid along with the aldobiouronic acids [2-O-(α -D-galactopyranosyluronic acid)-L-rhamnose, and 4-O-(α -D-galactopyranosyluronic acid)-D-galactose] and acidic trisaccharide [O-(α -D-glucopyranosyluronic acid)-(1 \rightarrow 3)-(β -D-galactopyranosyluronic acid)-(1 \rightarrow 2)-L-rhamnose]. The proportions of various components are 43% D-galactouronic acid, 13% D-galactose and 15% L-rhamnose. Methylation and hydrolysis studies show that D-galacturonic acid and L-rhamnose units are branch points in polysaccharide structure. The molecular structure is still incompletely known.

Molecular weight: The molecular weight of karaya gum is 9,500,000. It was determined by the Svedberg ultracentrifuge method and calculated by Svedberg's formula for which the determination of sedimentation constants. (s), diffusion constants (D), and partial specific volumes (V) were made.

Swelling behaviour & Viscosity: It forms viscous mucilage at low concentrations and the swelling behaviour is caused by the presence of acetyl groups. Chemical deacetylation through an alkali treatment results in a water-soluble gum. Dilute solution properties of karaya gum were studied using size-exclusion chromatography, static and dynamic light scattering and viscosity experiments. The native acetylated karaya gum assumes a rather

compact and branched conformation in aqueous solution. In contrast, the fully deacetylated karaya gum assumes a mere expanded conformation and behaves as a random coil.

Normal viscosities of gum karaya dispersions range from about 400cp (0.5% concentration) to 10,000cp (3% concentration). Up to 0.5% concentration, the viscosity increases linearly with concentration thereafter it behaves as non-Newtonian. The activation energy for flow was high at low shear rates but decreased with increasing shear rate.

The viscosity development depends on particle size. Boiling reduces the viscosity. The viscosity decreases upon the addition of acid or alkali.

The normal pH of 1% dispersion is ~ 4.5-4.7. Above pH 8, deacetylation occurs resulting in increase in viscosity and degree of ropiness.

The pH value had a marked effect on the degree of dispersion of the gums in H₂O and on the viscosity of the aqueous dispersion. The viscosity-pH curves showed pronounced maxima, but at different pH values for the two samples of karaya gum (Indian and W. African); that for the Indian gum occurred at pH 8.75, and that for African gum at pH 7.2.

Karaya gum loses viscosity forming ability when stored in dry state; the loss is greater for a powdered material than for a crude gum. Cold storage inhibits the degradation.

Specifications: The following specifications are being adopted by Girijan Co-operative Corporation (GCC), Visakhapatnam

Grade	Appearance	Swelling (ml, min.)	Viscosity (cps, min.)	BFOM (% max.)	Moisture (% max.)
I	White to off White	400	1200	0.7	20
II	Tan coloured	350	1000	1.8	21
III	Dark Tan to Brown	300	800	5.0	21

(BFOM – Bark and Foreign Organic Matter)

Adhesive property: Gum karaya forms smooth films. It shows strong wet-adhesive properties at concentrations of 20 to 50% in water. Blending the powdered gum with mild alkali improves adhesiveness.

Karaya gum has been modified to develop hydrogels for use in drug delivery.

Compatibility: It is compatible with other plant hydrocolloids as well as with proteins and carbohydrates.

Electrical property: At low voltages gum arabic (I) and karaya gum (II) obeyed Ohm's law, while at high voltages space-charge-limited current in I and II was observed. Band gaps for *acacia* and *karaya* were calculated to be 3.15 eV and 8.63 eV respectively.

The dielectric constant and the loss tangent of *Acacia* and *Karaya* gums under different

a.c. frequencies and temperatures were studied. Various changes inside the bulk of the polysaccharides were identified to be due to the breaking of glycosidal bonds and release of imbibed water from the gum micelles containing Ca^{++} , Mg^{++} and K^+ arabates.

Gamma ray irradiation: The viscosity of the acidic polysaccharides, gum karaya and gum tragacanth, following gamma irradiation. at low doses (<1 kGy) was unchanged or slightly higher when compared to the unirradiated control samples. Above 1 kGy dispersion viscosity decreased with increasing dose. For these polysaccharides chain hydrolysis seems to occur during irradiation at all doses, resulting in an increase in the amount of soluble polymer and hence increased viscosity at low doses, whereas at high doses, viscosity decreases due to extensive polymer hydrolysis. The microbiological contamination of karaya gum which originates from the mode of storage and handling can be decreased to a very low acceptable level by radio sterilization of powdered samples.

Karaya gum & Tragacanth: Karaya gum is inferior to tragacanth, but that it does possess valuable characteristics. Karaya gum is more readily soluble in water. Mucilage of karaya gum becomes thinner on aging; whereas that of tragacanth becomes thicker. Mucilage of karaya gum may be prepared without heat; whereas tragacanth requires heat to procure greatest viscosity. Karaya gum has less mucilaginous properties and high acid number than tragacanth.

Uses

Gum karaya is an important raw material in food, pharmaceutical, cosmetic, paper, textile and other industries.

Pharmaceutical industry :

- As a binder in denture adhesives and colostomy rings.
- As a bulking agent in bulk laxatives
- As a gelling agent in cosmetics

Food Industry :

- As a stabilizer in sherbets, ices, meringues, toppings, and whipped cream products.
- As an emulsifier in processed meats and sausages and in cheese spreads.

Textile industry :

- As a dye thickener for direct-color printing operations

Pulp and paper industry :

- As a deflocculent and binder for lightweight paper manufacture.

Petroleum industry :

- As a thickening agent for drilling muds and as a plugging agent for secondary recovery operations.

Other uses : In the manufacture of dry cell batteries as well as insect repellent emulsifiers. It has been reported to treble the effectiveness of nicotine sprays in cigars when gum upto 0.2% is added. Use of this gum for the manufacture of moulding powders based on phenol-formaldehyde resin (Bakelite) is also reported.

It may be mentioned here that the exports of gum karaya are declining gradually since 1984-85. The reasons could be manifolds such as shortage in commercial supply, restrictions on the extent of tapping of trees (to help conserve forest resources), grading and quality, increased official pricing policies, government policy changes to transfer the exportation network from private traders to official Indian government agencies (NAFED, TRIFED), availability of synthetic substitutes and availability of gum at lower prices in other countries. For use in pharmaceutical and foodstuffs very strict microbiological cleanliness is essential in the production, cleaning, grading and transportation of all gum karaya exported.

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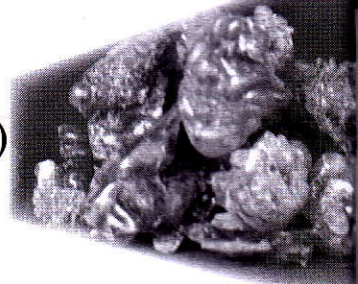
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Gum ghatti (*Anogeissus latifolia*)



General information

Gum ghatti also known as Indian gum is exudates from *Anogeissus latifolia* tree. The tree is characteristic of the dry, deciduous forests and is common almost throughout India. It avoids very moist and very dry regions but is common in sal forests and in other types of moderately moist forest. Trees have a greyish bark and leaves that turn red in dry season. The exudation of the gum has been observed to take place as a result of localized peeling of bark. The exudations are natural, but yield can be increased by making artificial incisions. Exudate tears are normally less than one cm in diameter and often occur in large vermiform masses varying in color from nearly white to dark brown. Generally, color varies in relation to the age of the exudate. The best gum crops are obtained in the absence of monsoon rains; the largest harvest is in April. The sun-dried gum is classified according to color and impurities and processed by grinding to a fine powder. The gum has a glassy fracture and is transparent internally although the surface is usually dull white, roughened and opaque.

Physico-chemical properties

Chemical nature : Analysis of gum is reported to give moisture 15.8%, pentosan 26.3%, methyl pentosan 7.6%, galactan 16.4%, N 0.99%, ash 3.0% and riboflavin 68.92 μ g/g. It is a calcium and magnesium salt of an acidic polysaccharide composed of L-arabinose, D-galactose, D-mannose, D-xylose and D-glucuronic acid in a molar ratio of 10:6:2:1:2. Traces of deoxyhexose (<1%) was observed. Partial hydrolysis gives two aldobiouronic acids, namely 6-O-(β -D-glucopyranosyluronic acid)-D-galactose, and 2-O-(β -D-glucopyranosyluronic acid)-D-mannose.

The gum contains a backbone of 1, 6-linked β -D-galactopyranosyl units. Acid-labile side chains are attached to the backbone through L-arabinofuranose residues. The gum yields 28.2% of furfural (dry basis).

Molecular weight : The molecular weight of the soluble portion of gum ghatti determined by osmotic pressure measurements is 11,860. The gum fractionated by ethanolic precipitations or by chromatography on silica gel showed equivalent weights of 1750, 1800, and 2040, respectively.

Solubility & Viscosity : It is not completely soluble in water. It is insoluble in 90 percent alcohol. Gum ghatti forms a viscous dispersions in water when in concentrations of 5% or greater. The dispersions are thixotropic and non-Newtonian in behaviour. The viscosity increases geometrically with concentration (Table 1)

Table 1 Change in viscosity with concentration of gum ghatti solution at 25°C & 30rpm

Concentration %	1	2	5	7.5	10
Viscosity, cp	2	35	288	1012	2444

The dispersions are less viscous than those of gum karaya, although they are more viscous than those of gum arabic, and they do not have shear stability.

Soluble molecules may have an overall rod shape. One percent solution of the gum has a pH 2.63 with no buffering activity. The solutions attain their maximum viscosity at pH 8.0 and drops sharply on both sides. A higher apparent viscosity can be obtained by dispersing the gum in 25% ethanol or increasing the pH to about 8.0. A dispersion in 50% ethanol does not hydrate completely. Gum ghatti solutions may be slightly colored because of traces of pigment remaining in the gum. The viscosity of the spray-dried gum is somewhat lower than that of natural dry-milled gum. Ageing of gum ghatti dispersions increases their viscosity. Removal of calcium ions from the gum reduces the viscosity, which can not be restored by addition of calcium ions.

Adhesiveness: The adhesiveness of gum ghatti dispersions is similar to that of gum arabic. Adhesiveness is better than those of babul gum and khair gum. Gum ghatti has all the required properties to substitute the imported gum arabic for adhesive purposes.

Film & Gel: Films prepared from gum ghatti dispersions are relatively soluble and brittle. Gum ghatti does not form a true gel.

Emulsifying properties: Gum ghatti has good emulsifying properties which serve as the basis for most of its applications. It produces emulsions with appreciably greater stability at all pHs.

Commercial grades: Commercial grades of gum ghatti as imported into the United States are as given in Table 2.

Table 2 : Gum ghatti grades as imported into the United States

Grade	Impurities %	Total ash %	Acid-insoluble ash, %	Viscosity, cp (5% solution)	Moisture %
1	0.9-1.6	1.4-1.9	0.02-0.2	30-400	12-15
2	1.4-3.6	2.2-3.9	0.2-1.0	30-350	12-15
Unassorted	11.0-15.0	6.0-10.0	3.7-5.8	30-300	12-15

Indian standard specifications for gum ghatti (IS: 7395:1989) are given below (Table 3).

Table 3 Indian standard requirements for gum ghatti (IS 7395: 1989)

Characteristics	Grade 1	Grade 2	Grade 3
• Colour by visual examination	Off-white to buff	Light amber to brown	Dark brown to near black
• Bark and Foreign organic Matter, percent by mass, <i>Max</i>	1.3	2.5	5.0
• Volatile matter, percent by mass, <i>Max</i>	14	14	15
• Total ash, percent by mass, <i>Max</i>	2.2	3.0	4.0
• Acid-insoluble ash, percent by mass, <i>Max</i>	0.2	0.3	0.8
• Viscosity of 5% solution in centipoises at 27°C, <i>Min</i>	1000	900	800

Uses

- Calico printing and in confectionary.
- As an emulsifier, stabilizer and thickener in ceramics, foods, and pharmaceuticals.
- Preparation of stable, powdered, oil-soluble vitamins.
- To stabilize table syrup emulsions containing about 2% butter
- As stabilizer (0.5-0.6%) for ice-cream
- As binder for making compressed tablets
- In hair setting agents.
- Petroleum and Mining: Drilling muds, Oil-well acidizing, Emulsification of waxes
- In the explosives as a preferential water adsorbant or desiccant.
- Polymerization aid in forming prills of polystyrene
- As a source for production of arabinose
- Aid in analytical procedures: As a stabilizer for Persian blue in photoelectric determinations; As a protective hydration layers around clay particles for soil analysis

Gum ghatti is used in applications also served by gum arabic. There are, moreover, no recognized specifications; as a result, gum ghatti has a trade reputation for being extremely variable in composition and quality. Proper attention is required in this respect to improve international demand for gum ghatti. Chemical work on ordinary commercial samples of gum ghatti is hardly likely to achieve useful results and step should be taken to ascertain definitely the botanical source.

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Salai gum (*Boswellia serrata*)



General information

Boswellia serrata tree is native to India. It is a medium sized deciduous tree with ash coloured papery bark common in most part of Madhya Pradesh, Bihar, Orissa, Andhra Pradesh, Rajasthan, Southern U.P. and north Gujrat. The tree on tapping exudes an oleo-gum-resin known as 'Dhup', Indian Frankincense, Indian olibanum or salai guggal. The yield per tree may vary from 0.9 to 2.5 kg/tree/year. It is light yellowish to brownish yellow to brown in colour. The olibanum or frankincense of commerce consists of ovoid or pear-shaped tears, or stalactitic fragments, varying in size, usually pale yellow, but often with a reddish or greenish tinge. They are brittle, easily broken with the fingers, and form a plastic mass when chewed. The taste is slightly bitter and odor fragrant. The oleo-gum-resin consists of essential oil, gum and terpenoids. The terpenoid portion contains the bowelled acid. Indian olibanum has the following average composition: moisture, 10-11; volatile oil, 8-9; rosin, 55-57; gum, 20-23; insoluble matter, 4-5%. The gum resin exudate of *Boswellia serrata* (Salai guggal) has traditionally been used in the Ayurvedic system of medicine in India for treatment of inflammatory diseases.

Separation of gum: The processes generally followed for the separation of three components oil, gum and resin are

1. Steam distillation and
2. Solvent extraction followed by Steam distillation

Oil is recovered by steam distillation. The residue left in the distillation contains the dissolved gum. The water layer containing the dissolved gum is concentrated and the gum is precipitated by adding pure alcohol. In another method, the residue after steam distillation is heated with water (2.5 parts) under 30lb. pressure for one & half hours in an autoclave. The resin melts, becomes mobile and separates completely as a molten mass at the top, and later solidifies on cooling. The gum forms a flocculent precipitate or mucilage and settles at the bottom of the vessel. After removal of the supernatant aqueous layer, the mucilage is strained off and carefully evaporated to dryness. This yields the gum in the form of a dark mass, which on grinding becomes a grey powder.

In the process of solvent extraction followed by steam distillation, the oleo-gum-resin is treated with minimum quantity of pure ethyl alcohol with vigorous shaking to separate rosin and oil. The gum was separated by filtration. The residue is subjected to usual steam distillation to recover the oil and resin.

Physicochemical properties of gum:

Chemical nature: Analysis of purified gum gave acid insoluble ash (0.85%), nitrogen content (0.75%), methoxy value (3.8%), Pentosan content (18.88%), equivalent weight 844, specific rotation $+35^\circ$ and uronic acid anhydride (30.9%). Hydrolysis of the pure gum yields mainly pentoses (65% as arabinose) with a high proportion of arabinose. Galactose and xylose are present only in small quantities. The gum also contains oxidizing and diastatic enzymes, and 3.03% of total nitrogen. The gum mainly contains D-galactose (46.22%), D-arabinose (11.66%) and 4-D-methyl glucuronic acid along with minor quantities of D-mannose and D-xylose in the molecular architect. The gum on methylation and subsequent hydrolysis of methylated product yielded a complex mixture of O-methyl sugars. The main types of linkages in between galactose units were found to be 1 \rightarrow 3 and 1 \rightarrow 6. TLC examination of the carbohydrate constituents of the gum portion of the *B. serrata* exudate showed that besides xylose, arabinose, and galactose, the gum contained diglucose, rhamnose, and galacturonic acid.

Physico-chemical properties of gums separated by different process: The physico-chemical properties of gum separated by (I) steam distillation and (II) solvent extraction followed by steam distillation are as given in Table 1 below:

Table 1 Physico-chemical properties of the gums

	Gum obtained by Process I	Gum obtained by Process II
1. Yield	30.0%	34.0%
2. Moisture content	4.0%	8.5%
3. Pet. Ether : Chloroform extract 1:1	4.65%	10.6%
4. Crude fibre	3.42%	3.95%
5. Ash content	7.52%	8.29%
6. Viscosity 25% solution (Red wood viscometer)	85 seconds	150 second
7. Adhesiveness	Good	Very good
8. Constituents of sugars	Galactose, Arabinose	Galactose, Arabinose

Emulsifying, suspending & adhesive property: Salai gum is also good emulsifying agents. Emulsions prepared with salai gum were slightly better than that prepared with *acacia*. Addition of cationic, anionic and nonionic surfactants improved the stability coefficient values.

Suspension studies reveal that salai gum is not a good suspending agent.

The gum, insoluble in alcohol forms thick mucilage with 3 parts of water. A paste of 25% solution showed excellent adhesive property to paper slip. Tablets prepared with 9% Salai gum mucilage were comparable to those prepared with 5% *acacia* mucilage.

Uses

- As adhesive
- In Saleya balsam, a good substitute for Canada balsam
- In the manufacture of incense stick ('Dhoop batti')

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Tamarind gum (*Tamarindus indica*)

General Information

Tamarind gum is the pulverized endosperm of the seed of tamarind tree (*Tamarindus indica*). Tamarind trees are commonly found in India, Bangladesh, Burma, Srilanka and other parts of the world but are indigenous to South India & Africa. Trees are large evergreens growing to a height of about 12ft (4m) bearing fruit after 13 years, with an average yield of 180-225 kg for a full-grown tree. Tamarind seed is about 1.6 cm (0.7in) in length and 0.7cm (0.3in) thick. Tamarind gum, obtained from the endosperm of the seeds came into commercial production in 1943 as a replacement for starch in cotton sizing used in Indian textile mills. The tamarind fruit contains seeds 33.9% by weight. The seed has about 70% endosperm enclosed by about 30% seed coat or testa. The seed coat or testa, becomes brittle when heated to 150 °C for 10 to 15 minutes. The testa is removed by mechanical milling and the endosperm that remains is pulverized. The endosperm powder, also known as tamarind kernel powder (TKP) is creamy white to light tan in colour. It has a fatty taste and adour. It has a tendency to lump. The composition of tamarind kernel, the source of gum, resembles the cereals. 15.4 to 22.7% protein, 3.0 to 7.4% oil, 0.7 to 8.2% crude fibre, 65.1 to 72.2% nonfibre carbohydrates, 2.45 to 3.3% ash, all measured on a dry basis. Tamarind gum polysaccharide, the purified product is a free-flowing, pale, creamy white powder without taste or odor.

Physico-chemical properties

Chemical nature: Chemically tamarind kernel powder is a highly branched carbohydrate polymer. The chemical structure has not been fully elucidated. The backbone is believed to be a β -D-(1 \rightarrow 4) linked glucopyranosyl chain with single (6 \rightarrow 1) linked D-xylopyranosyl units branching from the backbone. D-galactosyl units extend from these D-xylopyranosyl branches by (2 \rightarrow 1) linkages. Methylation and periodate analyses showed D-glucopyranosyl, D-xylopyranosyl, D-galactosyl and L-arabinosyl components in a ratio 7.8: 4: 2:1.2. This study suggested a highly branched polymer without (1 \rightarrow 3) branching. It also indicated that the branching from polyglucopyranosyl backbone was one or two D-xylopyranosyl units capped by D-xylopyranosyl, D-galactosyl, and L-arabinosyl units.

Molecular weight: The molecular weight of the polymer is probably between 52,000 and 56,000 though some studies show the weight as high as 115,000.

Derivatives: Tamarind gum has been hydrolyzed with fungal enzymes as well as with acids. Metal complexes are formed when an aqueous solution of the polysaccharide is treated with a solution of a metal hydroxide or an alkaline salt. Dextrinization has also been achieved by dry roasting the polymer in the presence of acid. This dextrinization creates a tamarind derivative with decreased viscosity and increased capacity to penetrate into fibres.

The alkyl and hydroxyalkyl forms of tamarind gum have improved swelling properties in water. Alkyl and carboxyalkyl ethers of tamarind gum are useful as emulsifiers and in textile printing paste. Alkoxy tamarind gum yields highly viscous dispersions.

Solubility and Viscosity: Tamarind gum hydrates quickly in cold water, but reaches maximum viscosity after boiling for 20 to 30 minutes. These solutions exhibit a non-Newtonian flow and are pseudo plastic. The tamarind gum solution was susceptible to bacterial degradation, but showed good salt tolerance and remarkable thermal stability. Cold-water-soluble tamarind seed gum was prepared having viscosity >10 cP (1% soln., Brookfield LVF viscosity meter spindle 1, 60 rpm) when hydrated at 5-35°C. Thus, 2% tamarind kernel powder dispersed in water, heated 10 min at 95°C, dried, pulverized, and dissolved (1%) at 20°C had viscosity 35 cP.

Indian standard specification for TKP for use in cotton and jute textile industries are moisture content, 13% Max; crude fiber, 1% Max; total ash, 3% Max, pH, 4.5 Min and viscosity at 90°C, 1000cP (IS:189 – 1977).

A blend of tamarind kernel powder and xanthan gum has been found to have a synergistically high viscosity in aqueous solution.

A tamarind gum solution attains its maximum viscosity at pH 7.0 to 7.5. Beyond these limits, whether on the acid or alkaline side, the viscosity falls. Carboxymethyl and hydroxypropyl derivatives show shear dependent and pseudo plastic flow characteristics. Carboxymethylation increased its solubility in cold water and stability of its paste to micro-organism.

Boiling has a profound effect upon the viscosity of tamarind gum dispersions or pastes. The viscosity first reaches a maximum, and then begins to fall. The viscosity of tamarind gum pastes increases as the temperature decreases, but in contrast with most starches, the tamarind gum pastes do not gel or retrograde upon cooling and are easily redispersed, even after storage for several days.

Variation of the viscosity of tamarind gum sols with temperature is not completely reversible.

The viscosities of equivalent weight solutions of tamarind are greater than those of corn starch. For example, at 5% (w/v), tamarind has a five fold greater viscosity than a 5% (w/v) starch solution.

Tamarind gum polysaccharide is more soluble but still requires some heat. The architecture of tamarind seed polysaccharide (TSP) has been investigated by light scattering (LS), small angle X-ray scattering (SAXS) and synchrotron radiation scattering (SRSAXS). The experimental data show that TSP in aqueous solution consists of multi stranded aggregates, with a high degree of particle stiffness. The angular dependence of the scattered intensity is typical for wormlike chains.

Physical nature: X-ray diffraction indicated that the structure is completely amorphous. It has a tendency to lump. It produces strong, smooth, continuous and elastic films-

properties useful for sizing. Some properties of polysaccharide identified recently are non-carcinogenicity, mucoadhesivity, biocompatibility, high drug holding capacity and high thermal stability.

Miscellaneous: Tamarind seed polysaccharide forms gels over a wide pH range in presence of high sugar concentrations (>65 wt %), and it can therefore substitute for fruit pectin.

A thermo-reversible gelation system was developed by mixing xyloglucan with an iodine solution. Xyloglucan dissolves in water to produce a colorless solution. However, the addition of iodine solution induces color and gelation; heating causes the gel to melt and become colorless. According to results from spectroscopic and small-angle x-ray scattering experiments, the gelation mechanism was proposed to involve two xyloglucan chains that associate side-by-side and incorporate iodine and/or iodide ions.

The tamarind seed polysaccharide is non-ionic, although chemical derivatives of it may be either cationic or anionic.

Tamarind seed polysaccharide (TSP), can improve sensory property and gel strength of the water chestnut cakes. It possesses good film forming properties.

A composite material of tamarind seed gum and the cellulosic-rich sisal plant fiber may be used in false roofing and room partitioning. It was also evaluated in bioadhesive tablets.

Composite magnetic microspheres have been synthesized and characterized based on tamarind gum and chitosan.

Uses:

- As a sizing and weaving agent for jute and cotton fabrics.
- As a creaming agent for the concentration of latex.
- As a binder and stabilizer in moulding, oil drilling, ice cream, mayonnaise.
- As an adhesive for bonding paper, glass, metal and in making plywood
- As a thickener in slurry explosives and as a water barrier in blasting explosives.
- As a dispersing and suspending agent in paper making.

The uses of commercial tamarind gum and purified tamarind seed polysaccharide promise to expand from their present major use in textiles and food and go into the cosmetic and the pharmaceutical industry.

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Guar gum (*Cyamopsis tetragonoloba*)

General Information

Guar gum is the powdered endosperm of the seeds of *Cyamopsis tetragonoloba* which is an annual legume. Guar is being grown for seed, green fodder, vegetable and green manuring. It is a short duration crop and is harvested within 3-4 months of its plantation. The crop is sown after the first rains in July and harvested in October. The plant about 4 feet high is 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. Guar seed range from 0.254 to 0.635 cm (0.1 to 0.25 in) in diameter and the endosperm is from 35 to 42% of the weight of seed. India is the major producer of guar in the world and its contribution to the world production is around 80%. Rajasthan, Haryana, Gujrat and Punjab are the important states for the production of seeds.

For obtaining the gum, the **hull** (seed coat, testa or husk) is removed by grinding the soaked seed, and then the naked seed is broken down into two portions, **gum-splits** (endosperm) and grits or **germ** (embryo or cotyledon). The difference in hardness of the germ and the endosperm is utilized in multistage differential grinding and sifting. The germ and seed coat together constitute the guar **meal**, which is obtained as a by-product during the manufacture of gum. The hull constitutes c.14-17 percent and the germ c. 43-47 percent of the seed. The endosperm is ground to fine particles and marketed as guar gum of commerce.

Physico-chemical properties

The endosperm contains a complex polysaccharide called galactomannan (guaran), a polymer of d-galactose and d-mannose. Guar gum is a white to yellowish white powder. It is nearly odorless. The Indian standard specifications for non-edible guar gum, crude and refined, respectively are: moisture (max), 13.0%, 13.0%; ash(max), 1.5%, 1.0%; protein (max), 9.0%, 5.0% (dry basis); residue (insoluble in acid, max) 14.0%, 7.0%; gum (min), 65.0%, 75.0%; viscosity at 27°C(min), 1000, 2500 cps. Analysis of a food grade gum gave: moisture, 10-15%, protein, 5-6; crude fibre, 2.5; ash, 0.5-0.8; and polysaccharide, 78-82%.

Chemical nature: The analysis of the composition of typical guar gum gave: Galactomannan, 75-85%; moisture, 8-14%; protein (N x 6.25), 5-6%; fibre, 2-3% and ash, 0.5-1%. The gum has been shown to be a linear chain of (1→4)-linked β-D-mannopyranosyl units with single α-D-galactopyranosyl units connected by (1→6) linkages to, on the average, every second main chain unit. The ratio of D-mannosyl to D-galactosyl unit is 1.8:1.

Molecular weight: The average molecular weight of guaran is reported as 220,000. The results from size exclusion chromatography and low-angle laser light scattering show the average molecular weight to be in the range $1-2 \times 10^6$.

Derivatives: Several chemical derivatives are made out of guar gum. Commercially important derivatives include carboxymethyl, hydroxyalkyl and quaternary amine derivatives.

Solubility & Viscosity: Guar gum and its derivatives swell and/or dissolve in polar solvents that form strong hydrogen bonds e.g. water, liquid ammonia, hydrazine, formamide, ethylene diamine. Non solvents are nonpolar such as hydrocarbons, alcohols, ketones, high-mol-wt glycol, ethers and dimethyl sulfoxide. The rate of dissolution and viscosity development generally increases with decreasing particle size, decreasing pH and increasing temperature.

Guar gum has the highest solution viscosity of all natural gums, being 5,000-6,000cps for 1% aqueous solution. Viscosity is not only influenced by purity but by processing techniques. The gum shows pseudoplastic or 'shear thinning' behaviour in solution. The degree of pseudoplasticity increases with concentration and molecular weight. Solutions of guar gum do not exhibit yield stress properties.

Aqueous solutions of guar gum form gels when treated with cross linking agents under controlled pH conditions. Effective cross linking agents include borates and transition metal ions. Calcium salts will also cause gel formation under alkaline conditions. Crosslinking increases guar gum's resistance to hydrolysis at high temperatures.

The presence of 0.001 to 0.05 % dissolve guar gum can reduce fluid friction by 20 to 70%. Guar gum products show excellent resistance to shear degradation. Salt tolerance is one of the unique properties of guar gum. Viscosity of 1% guar gum solution in 25% NaCl (pH 5.5) is reported as 6300 cp.

Guar gum and its derivatives are able to adsorb onto hydrophilic solid matter, particularly mineral particles. Cationic guar gum derivatives are flocculants for organic matter such as sewage and cellulose fibre that are negatively charged.

Film Formation & Adhesive properties: Guar gum films have high tensile strength, are brittle and do not elongate under stress. Film flexibility can be improved by using hydrophobic guar gum derivatives or plasticizers, such as glycerol or polyglycols. Guar gum was used as a binder for briquetting fine coal with sawdust, iron ore raw material powder and pulverized coke *etc.*

Miscellaneous: Guar gum is stable over a wide pH range, and due to its non-ionic nature there is little change in solution viscosity in the pH range 1-10.5. This non-ionic nature also leads to a compatibility with salts over a wide concentration range. Guar gum products can be hydrolyzed by acids. Guar gum is easily depolymerized by certain enzymes. Thermal degradation occurs when guar gum solutions are heated to very high temperature. The solution will lose viscosity when heated to 80-90°C for extended period of time. The microwave (MW) induced hydrolytic degradation of the guar gum solution was found dependent on the length of MW exposure. The powdered commercial grades of guar gum and its derivatives are all stable in the dry form.

Uses

Guar gum and its derivatives are among the most important **water-soluble** polymers. Guar gum mainly functions as thickener, emulsifier, stabilizer, **binding agent**, gelling agent, natural fiber, flocculant, fracturing agent etc. and used in **paper, textile, oil and gas, explosives, mining, food, pharmaceutical and cosmetic industries.**

In paper making – as a wet-end additive added to the pulp suspension just before the sheet-formation.

Textile – in printing and dyeing as thickeners to control the mobility of dyestuffs

Oil and gas – as additive in drilling oil-well for water-loss control, viscosity control, flocculation, suspension of drilling-muds, turbulent-friction reduction, or mobility control.

- as aqueous fracturing fluid.

Mining – as a flocculant to produce a liquid-solid separation by filtration, settling, and clarification of mineral slurries.

- as a depressant for talc or insoluble gangue minerals mined along with the valuable minerals.

Explosive- as gelling agent for gel sausage type explosives and pumpable slurry explosives.

- as water blocking agent in nitro-glycerine, slurry explosives, ammonium nitrate and dynamite explosives

Food

In frozen food products – guar gum reduces crystal formation; act as a binder & stabilizer to extend shelf life of ice cream.

In baked food products – provides unparallel moisture preservation to the dough and retards fat penetration in baked foods

In dairy products – it improves texture, maintains uniform viscosity and color.

In sauces & salad – as a water binder and reduces water and oil separation.

In confectionary – controls viscosity, bloom, gel creation, glazing and moisture retention.

In beverages – provides viscosity control and reduces calories value.

In pet food – forms gels and retains moisture, acts as a thickening, **stabilizer and** suspending agent.

Pharmaceutical – in gelling/viscosifying/thickening, suspension, **stabilization, emulsification, preservation, water retention / water phase control, binding, clouding/bodying, process aid, pour control for suspensions, anti-acid formulations, tablet binding & disintegration agent, controlled drug delivery systems, slimming aids, nutritional foods etc.**

-as a non-caloric source of soluble dietary fibre

Cosmetic – as a thickener, protective colloid and conditioner in hair/skin care products, creams, shampoos and lotions. Also used in toothpaste and shaving cream.

Other uses are in wildfire control, in latex paints for rheology control and stabilization, as thickeners, antisag additives, and water-binding agents in spray textures, in the production of reconstituted tobacco sheets. Guar gum has been used for the treatment of certain physiological disorders of the gastrointestinal tract, and in treatment of hypercholesteremia.

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