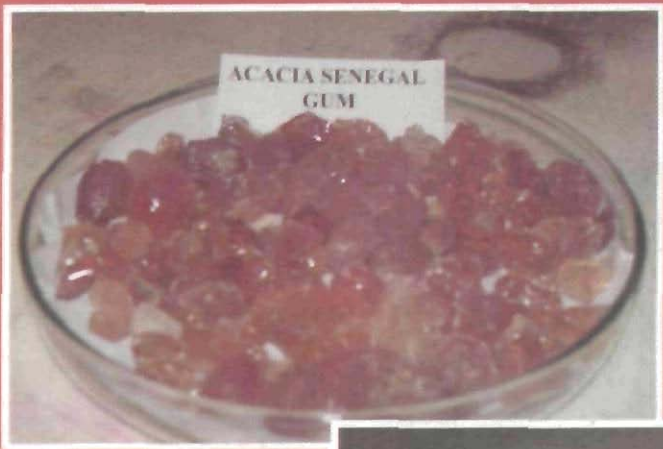
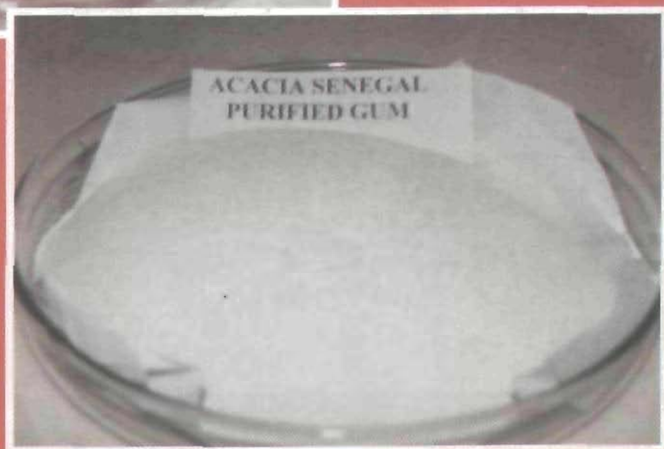
On Refining Gum Arabic





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Introduction

Acacia gum also known as gum Arabic is exuded as a semi-liquid from the stems and branches of *Acacia senegal* (L) Willdenow or closely related species of *Acacia* (fam. Leguminosae). The gum collects as a spherical tear, which expands as more gum is exuded in the inner core of the tear. The gum is soft and tacky as it exudes from the tree, but within a short time it becomes hard. Gum Arabic as found in nature is a mixed calcium, magnesium and potassium salt of a polysaccharidic acid (Arabic acid). It is composed of six carbohydrate moieties (galactopyranose, arabinopyranose, arabinofuranose, rhamnopyranose, glucuropyranosyl uronic acid and 4-O methyl glucuropyranosyl uronic acid) and also contains a small proportion of protein as an integral part of the structure.

Chemical composition

Acacia gums generally are not a discrete chemical species, but are complex polysaccharides consisting of several sugars. The gum contains a small amount (1–3%) of protein as an integral part of the structure. The gums from *Acacia senegal* are complex polysaccharides and contain a small amount of nitrogenous material that cannot be removed by purification. Their chemical compositions vary slightly with source, climate, season, age of the tree, etc., but typical analytical data are given in Table 1. The carbohydrate structure consists of a core of β (1, 3)-linked galactose units with extensive branching at the C6 position (Fig 2). The branches consist of galactose and arabinose and terminate with rhamnose and glucuronic acid. The gum consists of three broad molecular fractions, which differ principally in their size and protein contents(Fig 1). The main component, which corresponds to about 90% of the total, has a molecular mass of $\sim 2.5 \times 10^5$ and contains very little protein. A second component ($\sim$ 10% of the total) has a molecular mass of $> 1 \times 10^6$ contains $\sim$ 10% protein, which comprises mainly of hydroxproline, proline and serine which has wattle blossom-type structure typical of arabinogalactan protein complexes, where large carbohydrate blocks ($2\text{-}3 \times 10^5$) are attached to a *common polypeptide chain(Fig 3). The third component is only present at levels of $\sim$ 1% and has a* molecular mass of $\sim 2.5 \times 10^5$ containing 46- 50% protein. Its amino acid profile is different from the other protein –rich component (Table 2). Features of the molecular structure of gum Arabic taken as a whole are shown by all three fractions. The molecule has a core of β 1, 3 and 1,6 linked D-galactopyranose with branches at O -6 on the 1, 3 linked residues. The branches consist of L-arabinofuranose, L – arabinopyranose, L- rhamnose and D-galactopyranose. It also contains about 2% proteinaceous material which forms an integral part of the structure.

Specifications

To prevent adulteration by non-Acacia gums such as Combretum and Abizi and to achieve uniform definition, the WHO/FAO Joint Expert Committee on Food Additives (JECFA), prepared its specifications at the 51st JECFA (1998) which was approved by the Codex Committee for Food Additives and Contaminants in 1999, the main points are as follows:

Synonyms	Gum Arabic (*Acacia senegal*), gum Arabic (*Acacia seyal*), *Acacia* gum; Arabic gum; INS No. 414
Definition	Gum Arabic is a dried exudate obtained from the stems and branches of *Acacia senegal* (L.) Willdenow or *Acacia seyal* (fam. Leguminosae). Gum Arabic consists mainly of high-molecular weight polysaccharides and their calcium, magnesium and potassium salts, which on hydrolysis yield arabinose, galactose, rhamnose and glucuronic acid. Items of commerce may contain extraneous materials such as sand and pieces of bark, which must be removed before use in food

C.A.S. number	9000-01-5
Description	Gum Arabic (*A. senegal*) is a pale white to orange-brown solid, which breaks with a glassy fracture. The best grades are in the form of whole, spheroidal tears of varying size with a matt surface texture. When ground, the pieces are paler and have a glassy appearance. Gum Arabic (*A. seyal*) is more brittle than the hard tears of gum Arabic (*A. senegal*). Gum Arabic is also available commercially in the form of white to yellowish-white flakes, granules, powder, roller dried, or spray-dried material. An aqueous solution of 1 g in 2ml flows readily and is acid to litmus.
Functional uses	Emulsifier, stabiliser, and thickener
Characteristics Identification	
Solubility	One gram dissolves in 2ml of water; insoluble in ethanol
Gum constituents	Proceed as directed under Gum Constituents Identification (FNP 5) using the following as reference standards: arabinose, galactose, mannose, rhamnose, galacturonic acid, glucuronic acid and xylose. Arabinose, galactose, rhamnose and glucuronic acid should be present. Additional spots corresponding to mannose, xylose and galacturonic acid should be absent.
Optical rotation	Gum from *A. senegal* Gum from *A. senegal*: aqueous solutions are levorotatory, Gum from *A. seyal*: a Gum from *A. seyal*: aqueous solutions are dextrorotatory Test a solution of 10 g of sample (dry basis) in 100 ml of water (if necessary, previously filtered through a No. 42 paper or a 0.8 mm millipore filter), using a 200-mm tube.
Purity Loss on drying	Not more than 15% (105^0, 5 h) for granular and not more than 10% (105^0, 4 h) for spray dried material. Unground samples should be powdered to pass through a No. 40 sieve and mixed well before weighing.
Total ash	Not more than 4%.
Acid-insoluble ash	Not more than 0.5%
Acid-insoluble matter	Not more than 1%
Starch or dextrin	Boil a 1 in 50 solution of the sample, cool and add a few drops of Iodine T.S. No bluish or reddish colour should be produced
Tannin-bearing gums	To 10 ml of a 1 in 50 solution of the sample, add about 0.1 ml of ferric chloride TS. No blackish colouration or blackish precipitate should be formed
Microbiological criteria	Salmonella Spp.: negative per test E. coli: negative in 1 g
Lead	Not more than 2 mg/kg. Prepare a sample solution as directed for organic compounds in the Limit Test and determine by atomic absorption spectroscopy.

Functional Properties of Gum

Gum Arabic readily dissolves in water to give clear solutions ranging in colour from very pale yellow to orange-brown and with a pH of ~4.5. The highly branched structure of *Acacia senegal* gum gives rise to compact molecules with a relatively small hydrodynamic volume and as a consequence gum solutions become viscous only at high concentrations. 30% gum Arabic solutions have a lower viscosity than 1% xanthan gum and sodium carboxymethylcellulose at low shear rates. In addition, gum Arabic is Newtonian in behaviour with viscosity being shear rate independent.

The other major functional characteristic of gum Arabic is its ability to act as an emulsifier for essential oils and flavours. It is now known that the protein-rich high molecular mass component adsorbs preferentially onto the surface of the oil droplets. It is envisaged that the hydrophobic polypeptide chains adsorb and anchor the molecules to the surface while the carbohydrate blocks inhibit flocculation and coalescence through electrostatic and steric repulsions. Since only part of the gum is involved in the emulsification process, the concentration required to produce an emulsion is much higher than for pure proteins. For example, in order to produce a 20% orange oil emulsion then gum Arabic concentrations of ~ 12% are required. Once formed the emulsions can remain stable for long periods of time.

Uses of Gum Arabic

Gum Arabic is utilized in the food industry to set flavours, as an emulsifying agent, to prevent the crystallization of sugar in confectionary and as a stabilizing agent in frozen dairy products. It is also useful in the baking industry because of its viscous and adhesive properties, which are used to stabilize mousses, and as a turbidity agent in beer. Gum Arabic has found a new range of applications in the dietetic food and health sub-sectors because of its high fibre content.

In the pharmaceutical industry, Gum Arabic is utilized to stabilize emulsions, as a binding agent and for coating medications. It is also included in the mixtures for eye drops and cough syrups. In the cosmetic field, it is used as an adhesive when making face powders and masks but also used in making lotions creamy and smooth.

In the chemical industry, Gum Arabic is utilized as glue, as a colloid protector and as a preserving agent for inks. It is also used to sensitize lithographic plates, to stiffen cloth, coat certain paper types and for coating metals to prevent corrosion. It is equally utilized in manufacturing matchsticks and ceramics.

Impurities

The gum is soft and tacky as it exudes from the tree. During this period, the out layer of the gum tears becomes contaminated with foreign substances, such as fine sand, dirt, insects, pieces of bark and leaves, bacteria and the like. The contaminated out layer of the tear harden as a result of air oxidation and bears colour bearing impurities as well. Such contaminated gums are unfit for human consumption.

Purification of gum

Since gum Arabic is extensively employed in the food and pharmaceutical industry, it has been necessary to process the impure gum to render it acceptable for human use. For removal of suspended impurities, 10 g of crude gum is dissolved in distilled water (100 ml). Insoluble foreign substances like sand, dirt, bark and the leaf particles and the like are allowed to settle and separated from the solution

Table 1. Sugar and protein compositions of *A. senegal* and isolated fractions

Components	Whole gum	Fraction 1	Fraction 2	Fraction 3
% of total recovered		88.4	10.4	1.24
% galactose	36.2 ± 2.3	34.5 ± 2.2	29.3 ± 0.7	12.3 ± 0.5
% arabinose	30.5 ± 3.5	27.6 ± 1.9	31.4 ± 1.0	15.0 ± 1.3
% rhamnose	13.0 ± 1.1	11.8 ± 2.2	12.9 ± 1.0	6.7 ± 1.1
% glucuronic acid	19.5 ± 0.2	23.1 ± 0.4	17.6 ± 0.1	11.2 ± 0.3
4-O-methyl glucuronic acid	1.5	-	-	-
% protein	2.24 ± 0.15	0.35 ± 0.10	11.8±0.5	47.3 ± 3.0
Specific rotation/degrees	-30.0	-30.0	-37.5	-
Average molecular mass (Mw)	3.8×10^5	2.5×10^5	1×10^6	2.5×10^5

Source: Randall et al., 1989. Food Hydrocolloids, 3, 65-75.

by decantation and filtration. In order to remove colouring impurities, gum solution is passed through a column of activated charcoal. The column is first washed with distilled water to remove soluble impurities from the charcoal and then the gum solution is passed through the column. If required, the solution that passed through the column and collected is again passed through the charcoal bed of the column. The colourless solution is then spray dried, whereby a highly purified aseptic gum Arabic is formed. The spray dried gum can be packaged immediately to protect the gum from contamination. The elevated temperature employed during spray drying, kills many strains of bacteria.

Table 2. Amino acid composition of *A. senegal* and isolated fractions

	Whole gum	Fraction 1	Fraction 2	Fraction 3
Hydroxyproline	41.00	5.80	291.00	228.00
Aspartic acid	12.00	2.10	30.00	432.00
Threonine	12.00	2.60	67.00	168.00
Serine	22.00	5.40	115.00	324.00
Glutamic acid	6.20	3.10	7.20	324.00
Proline	13.00	2.90	55.00	216.00
Glycine	9.30	2.70	27.00	312.00
Alanine	4.90	1.90	7.80	192.00
Cystine	-	0.40	-	11.90
Valine	5.90	1.40	8.70	300.00
Methionine	0.30	0.08	-	6.00
Isoleucine	2.00	0.70	2.60	84.00
Leucine	12.00	2.00	51.00	300.00
Tyrosine	2.80	0.42	4.60	83.00
Phenylalanine	6.00	0.37	10.00	372.00
Histidine	8.80	1.20	51.00	132.00
Lysine	4.30	0.80	9.90	168.00
Arginine	1.50	2.20	1.20	47.00
% protein	2.00	0.44	9.18	46.70
Protein expressed as a % of the total protein in the whole gum	100.0	20.10	49.50	24.20

Source: Randall et al., 1989. Food Hydrocolloids, 3, 65-75.
Values quoted in nmol/mg gum (dry wt).

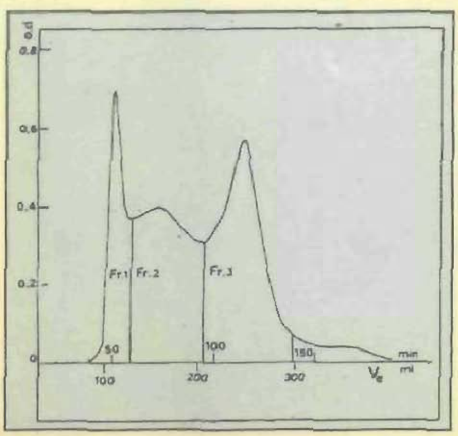

Figure 1. Gel-permeation chromatogram of *A.senegal* gum monitored by UV absorbance at 214 nm

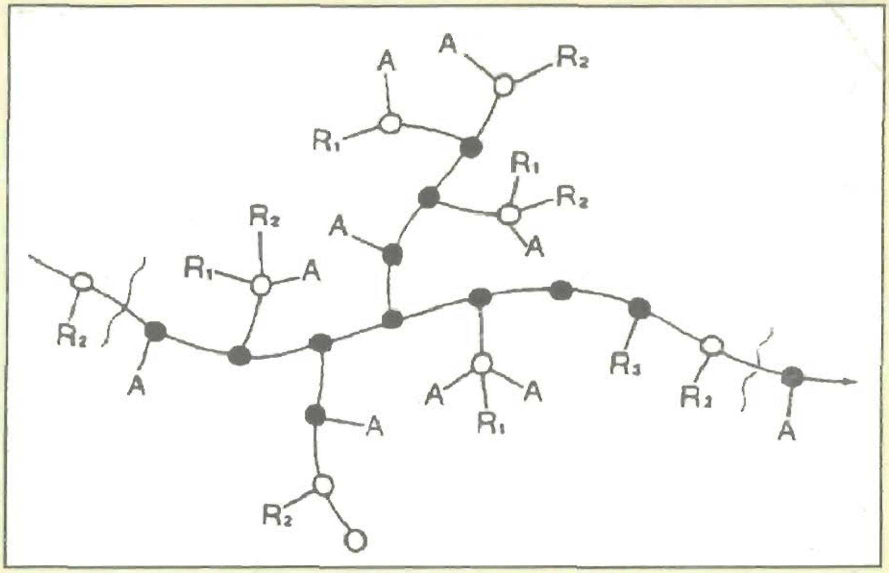

Figure 2. Possible structure for Carbohydrate component of *A. senegal* gum. A = arabinosyl; filled circles = 3-linked Galp (Galp attached); open circles = 6-linked Galp (Galp or *Glcp* attached), or end-group; R_1 = Rha •4GlcA (Rha occasionally absent, or replaced by Me, or by Araf); R_2 = Gal •3 Ara; R_3 = Ara •3 Ara •3 Ara.

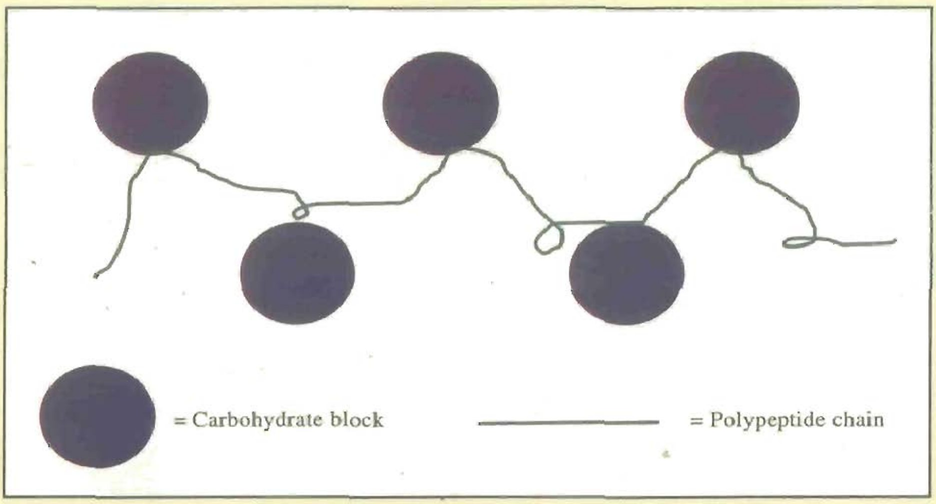

Figure 3. Wattle blossom-type structure of the high molecular mass fraction of A. senegal gum.

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