Journal of Non-Timber Forest Products 27(4), pp.191-196, 2020
REVIEW ARTICLE

JOURNAL OF NON-TIMBER FOREST PRODUCTS

How Commercially important Tree Gum Exudates can be differentiated

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ARTICLE INFO

Keywords

Adhesiveness, Adulteration, Chemical test, Exudates, Latex, Mucilage, Optical rotation, Viscosity

Citation:

Sinha, S.K., Gunaga, R.P., Ahlawat, T.R., Sankanur, M.S., Mehta, A.A. and Hegde, H.T., 2020. How Commercially important Tree Gum Exudates can be differentiated. *Journal of Non-Timber Forest Products,* 27(4), pp.191-196.

ABSTRACT

The commercially important tree gum exudates produced in India are gum Arabic, gum ghatti and gum karaya or Indian gum tragacanth. These gums, available in the market, are often adulterated by many other natural gums which may be inferior in quality. Therefore, identification of these gums is very essential to minimize the adulteration by comparing their physical and chemical properties. The study shows that among these properties, solubility, viscosity and colour can be used along with confirmatory chemical tests for differentiating commercial gums. The paper highlights the details of physical properties of the gums and chemical tests to differentiate between these gums.

INTRODUCTION

The chief source of plant originated natural gums is either from tree exudates or seed. These natural gums are commercially harvested mostly from the plant species of *Leguminosae, Combretaceae* and *Sterculiaceae* (Raj, Haokip & Chandrawanshi, 2015; Thombare et al., 2018a). Tree gum exudates are secondary metabolic products mainly produced as a result of adverse climatic conditions, disease and external injuries to the bark or wood by insects or animals (Rout, 2014). Tree species known to exudate gums in India are *Acacia senegal* (True gum Arabic), *Acacia nilotica* (Babool), *Acacia catechu* (Khair), *Anogeissus latifolia* (Dhawda), *Sterculia urens* (Karaya), *Bombax ceiba* (Semul), *Cochlospermum religiosum* (White silk cotton), *Lannea coromandelica* (Jhingan), *Azadirachta indica* (Neem), *Terminalia tomentosa* (Sadad), *Butea monosperma* (Palas), *Buchanania lanzan* (Chironji), *Prosopis juliflora* (Vilayati babool), *Anacardium occidentale* (Cashew Nut), *Pterocarpus marsupium* (Bijasal), *Acacia tortilis* (Israeli babool), *A. leucophloea* (White-bark acacia), *A. farnesiana* (Sweet acacia) and *Moringa oleifera* (Drumstick) (Arora & Ramawat, 2014; Thombare et al., 2018a). Among these tree species, gum arabic (*Acacia senegal* and other similar species of *Acacia*), gum ghatti (*Anogeissus latifolia*) and gum karaya (*Sterculia urens*) or Indian gum tragacanth are commercially important tree gum exudates produced in India.

The average annual production of gum exudates from plants was approximately 930 tonnes (excluding resins, gum-resins and guar gum-a seed gum) during 2011 to 2018. Out of which, the share of karaya gum, ghatti gum and gum Arabic including other gums, production was about 17%, 30% and 52% respectively (Sharma, 2020; Yogi & Kumar, 2020). These natural gums are used in several industrial applications such as food, pharmaceuticals, pulp and paper, textiles, cosmetics, adhesives, paints, petroleum industry, leather industry, lithography and other miscellaneous applications (Krishnamurthy, 2010a; Shrivastava & Ray, 2015; Thombare et al., 2018a; Iravani, 2020). Most of the tree gum exudates are edible and used as substitutes or adulterants of gum Arabic, gum ghatti and gum karaya. When these adulterated gums are available in the market, then it becomes difficult to distinguish pure source of gum. Keeping this in view, the present review was carried out to differentiate the commercially important tree gum exudates *viz.,* gum Arabic including similar *Acacia* gums, gum ghatti, gum karaya or Indian gum tragacanth based on their physico-chemical characterization from each other.

Plant exudates

Different types of plant exudates such as gum, resin or oleo-resin, gum-resin or oleo-gum resin, mucilage and latex are represented in the following flowchart.

Received: 30-03-2021; Revised: 14-08-2021; Accepted: 18-08-2021

Plant exudates	Gum	Oleo-resin	Oleo-gum resin	Mucilage	Latex
Nature	Polysaccharides/ pathological products	Terpenoid or phenolic compound	Mixture of polysaccharides and terpenoid or phenolic compounds	Polysaccharides or combination of mixed monosaccharides and uronic acids/ Non-pathological products	Complex mixture of terpenoids, phenolics, protein and alkaloids
Solubility	Soluble or swell up in water and insoluble in oils or organic solvents	Insoluble in water, but soluble in organic solvents	Soluble in water and organic compounds	Not readily soluble in water but forms colloidal solution in water with slimy masses	Soluble in lipids

Flow Chart : Types of Plant exudates

Gums are mainly non-starch polysaccharides and considered as pathological products formed by injury to plants by any means (FAO, 1995; BeMiller, 2001; Bhosale, Osmani & Moin, 2014). These are commonly soluble in water or swell up by absorbing water to form viscous jelly like suspension and generally insoluble in oils or organic solvents like hydrocarbons, ether or alcohol. *Resins or Oleo-resins* are complex mixture of volatile (essential oil) and non-volatile terpenes (rosin), and/or phenolic compounds along with fatty substances (Dilworth, Riley & Stennett, 2017). These are insoluble in water, but soluble in organic solvents. *Gum-resins* are intermediate compound composed of gums and resins in different proportions. Gum-resins containing essential oils as one of constituents are called *oleo-gum resins* and these are soluble in water and organic compounds depending upon the proportion of gums and resins (Sinha et al., 2016, 2020; Thombare et al., 2018a). *Mucilages* are polysaccharides or combination of mixed monosaccharides and uronic acids formed within cell by normal metabolic process of plant without any external injury. These are not readily soluble in water but form colloidal solution in water with slimy masses (Bhosale, Osmani & Moin, 2014). *Latex* is a milky white coloured fluid mainly composed of complex mixture of terpenoids, phenolics, protein and alkaloids (Agrawal & Konno, 2009). It is phytochemically more different than gums, resins and mucilages and generally soluble in lipid (FAO, 1995).

Edible tree gums and their substitutes

Many tree gum exudates are non-toxic, edible, pleasant and sweet in taste and some may be astringent and bitter (Krishnamurthy, 2010b). Hence, these tree exudates are directly or indirectly used in many food stuffs and confectionery. The most popular tree gum exudates commercially available in the market are gum Arabic, gum ghatti, and gum tragacanth. Additionally, Hog gum and Kino gums are also known and available in the market.

Acacia senegal, a native tree of Sudan and Arabia, is a true source of gum Arabic commercially used in food industries. The good substitutes for this gum available in the market are *Anogeissus latifolia* and many *Acacia* species such as *A. catechu*, *A. nilotica*, *A. farnesiana* and *A. tortilis* (Sao, 2012; Thombare et al., 2018a). However, gum exudates of *Lannea coromandelica*, *Azadirachta indica*, *Anacardium occidentale*, *Acacia leucophloea* and *Prosopis juliflora* (Mesquite gum) are used as poor substitutes or adulterants for gum Arabic (Thombare et al., 2018a).

Anogeissus latifolia is a source of ghatti gum or dhawda gum used in certain food applications. It has remarkable commercial position in the market due to its moderate viscosity, intermediate between gum Arabic and gum tragacanth (Shrivastava & Ray, 2015). Since, this gum is moderately soluble in water and also swells to form dispersions, therefore it is not as useful in food industries as other gums (Saha et al., 2017). It is also a good substitute for gum Arabic in almost all applications, where moderate viscosity is required (Krishnamurthy, 2010b). Gum exudate of *Terminalia tomentosa* is a substitute for this gum and sold in the name of ghatti gum or mixed with ghatti gum for trade (Thombare et al., 2018a; 2018b).

Astragalus gummifer, a shrub native to South-west Asia, is a true source of gum tragacanth used mainly as a natural emulsifier and thicknessing agent in drugs and food industries (FRI, 1972; Saha et al., 2017). In India, the best substitute for this gum is *Sterculia urens*, popularly known as gum karaya, katira gum or Indian gum tragacanth. This gum is similar in properties to true gum tragacanth as it swells in water to form gel. Initially it was sold as an adulterant of true gum tragacanth in U.S.A., but it has gained unique commercial importance since 1920 (Krishnamurthy, 2010a). Now, India is the leading producer and exporter of gum karaya in the world. The other substitutes of gum tragacanth are gum exudates of *Cochlospermum religiosum* and up to some extent Hog gums from *Bombax ceiba* and *Moringa oleifera* (FRI, 1972).

The gum exudate of *Pterocarpus marsupium* is known as Indian Kino or Malabar Kino used as main ingredient of aphrodisiac food item especially in preparation of an Unani recipe 'Kamar kas keladdoo' (Thombare et al., 2018a). In India, this gum is substituted by gum exudate of *Butea monosperma* which is known as Bengal Kino in trade. Another important edible gum exudate used in many beverages is *Buchanania lanzan* gum. It is similar in the properties to benzoin gum exuded from *Styrax benzoin*; however, it is supposed to be inferior in quality (Krishnamurthy, 2010b).

Physico-chemical characterization

The physico-chemical characteristics of commercially important tree gum exudates are summarized here.

Gum Arabic and similar *Acacia* gums

The true gum Arabic is obtained from *Acacia senegal* tree of Mimosaceae family (Ballal et al., 2005). It is similar in properties to the gum exudates of Indian gum Arabic (*Acacia nilotica*) and *Acacia catechu* (Khair). These two natural gums are the best substitutes for gum Arabic in India. In a broader sense, the gum Arabic is often considered as the gum from *Acacia* species (FAO, 1995).

Physical properties

The physical characteristics of these two Indian gum Arabic trees are represented in table 1 in comparison to true gum Arabic. The gum exudates of *Acacia nilotica* and *Acacia catechu* are pale-yellow to brown or dark brown in colour (Sao, 2012). The exudates of these two gums are odourless, sweet in taste, whereas the gum exudate of *Acacia senegal* is tasteless, odourless and pale to orange brown in colour (Johnson, 2005; Shrivastava & Ray, 2015). Both kinds of gum Arabic are almost completely soluble in water to give clear solution but these are insoluble in organic solvents. In 2% solution (on dry basis), the water solubility of *A. catechu, A. nilotica* and *A. senegal* gums are reported as 94.2%, 97.8% and 99.2% respectively (Sao, 2012). The molecular weight of gum exudate from *A. nilotica* (10^6) is higher than *A. senegal* (10^5) followed by *Acacia catechu* (10^4) (Sao, 2012). The viscosity of *A. senegal* and *A. catechu* gum exudates is similar, while the viscosity of *A. nilotica* gum is slightly higher. The adhesiveness of gums from *A. nilotica* and *A. catechu* is slightly lower than *A. senegal*. The optical rotation of gums is either dextrorotatory or laevorotatory in aqueous solution. Generally, the optical rotation of *Acacia* gum to be used for food and pharmaceutical purposes should be laevorotatory (Mhinzi, 2003). The optical rotation of *A. senegal* gum is laevorotatory, while the gum of *A. nilotica* is slightly dextrorotatory (Mhinzi, 2003; Sao, 2012). However, the information on optical rotation of *A. catechu* is rather scanty.

Chemical properties

Gum exudates of *A. senegal, A. nilotica* and *A. catechu* are complex polysaccharide mixed with calcium, magnesium,

Table 1. Physical properties of commercially important gums

Physico-chemical properties	True gum Arabic	Indian gum Arabic	Khair gum	Ghatti gum	Karaya gum (Indian tragacanth)	True gum tragacanth	Reference
Source	*A. senegal*	*A. nilotica*	*A. catechu*	*Anogeissus latifolia*	*Sterculia urens*	*Astragalus gummifer*	Ballal et al., 2005; Kuruwanshi & Katiyar,2017; Bagheri et al., 2015; Shukla & Modi, 2020
Colour	Pale to orange brown	Pale-yellow to brown or dark brown	Pale-yellow to brown or dark brown	Yellowish-white to reddish brown	Pale yellow or gray to pinkish brown	Off-white to pale yellow	Shrivastava & Ray, 2015; Sao, 2012; Johnson, 2005; Kuruwanshi & Katiyar, 2017; EFSA, 2016; Mayes, 2010; Kulkarni & Shaw, 2016
Odour	Odourless	Odourless	Odourless	Odourless	Acetous or vinegary	Odourless	Shrivastava & Ray, 2015; Krishnamurthy, 2010b; Ballal et al., 2005; Kuruwanshi & Katiyar, 2017; Shukla and Modi, 2020; EFSA, 2016; Mayes, 2010
Taste	Tasteless	Sweet	Sweet	Tasteless	Acetous or vinegary	Tasteless	Shrivastava & Ray, 2015; Krishnamurthy, 2010b; Ballal et al., 2005; Kuruwanshi & Katiyar, 2017; EFSA, 2016; Mayes, 2010; Kulkarni & Shaw, 2016
Solubility	Completely soluble in water but insoluble in organic solvents	Completely soluble in water but insoluble in organic solvents	Completely soluble in water but insoluble in organic solvents	Partially soluble in water but insoluble in 90 per cent alcohol	Swells in normal water and forms gel	Swells and forms viscous solutions in normal water and hot water both	Sao, 2012; Mayes, 2010
MW	10^5	10^6	10^4	10^3 to 10^7	10^6 to 10^7	10^6 to 10^7	Sao, 2012
Viscosity (cP)	95 (30% solution)	120 (30% solution)	~95 (30% solution)	800-1000 (5% solution)	800-1200 (3% solution)	100 to 3500 (1% solution)	Sao, 2012; Saha et al., 2017; Thombare et al., 2018b
Optical rotation	Laevorotatory	Slightly dextrorotatory	-	Laevorotatory	-	-	Sao, 2012; JECFA, 1985

potassium and sodium salts and also consist of small amount of proteins (Ali, Ziada & Blunden, 2009; Azam et al., 2011; Shrivastava & Ray, 2015). The pH value of *Acacia* gums varies from 4.81 to 6.41 (Yaumi et al., 2016). The chemical structure of gum Arabic generally consists of galactan backbone linked with 1-3β galactopyranosyl units, joined to the main chain by 1,6-linkage which is highly branched with side chains of L-arabinose, D-galactose, L-rhamnose and D-glucuronic acid (Sao, 2012; Idris, Williams & Phillips, 1998). The confirmatory test to identify gum Arabic including similar *Acacia* gums is given in table 2.

Table 2. Confirmatory chemical tests for commercially important gums

Gum	Chemical Test	Result	Reference
Gum Arabic and similar *Acacia* gums	10% copper sulphate + 10% sodium hydroxide (Cold)	Blue precipitate with colourless solution	Chowdhury, 2020
	10% copper sulphate + 10% sodium hydroxide (Boil)	Dark precipitate with pale blue solution	
Ghatti gum	10% copper sulphate + 10% sodium hydroxide (Cold)	Darker blue cloudy solution	Chowdhury, 2020
	10% copper sulphate + 10% sodium hydroxide (Boil)	Slight reduction in precipitate or forms no precipitate	
	Ferric chloride and Alcohol	Almost clear solution	
Karaya gum	Mucilage+20% HCl (Boil)	Pink colour after cooling	Chowdhury, 2020
	Mucilage + sodium hydroxide (Warm)	Gives brown colour	
Gum tragacanth	Mucilage + sodium hydroxide (Warm)	Gives yellow colour	Parry, 1918
	Mucilage + borax + ferric chloride	No clear precipitate but precipitate in clots when alcohol is added to the solution	

Gum Ghatti

The gum exudate of *Anogeissus latifolia* is known as gum ghatti or dhawda gum belonging to the family Combretaceae (Kuruwanshi & Katiyar, 2017).

Physical properties

The physical properties of gum ghatti in comparison to other gums are given in table 1. The exudate of gum ghatti is usually odourless, tasteless and yellowish-white to reddish brown in colour with glassy, amorphous and translucent appearance (Kuruwanshi, Katiyar & Khan, 2018; Shrivastava & Ray, 2015). It is partially soluble in water (80 to 90% solubility) to form colloidal solution and does not give clear solution (Sao, 2012). It is insoluble in 90 per cent alcohol. The molecular weight and viscosity of gum ghatti is intermediate to gum Arabic and gum tragacanth (Sao, 2012). The dispersion of this gum in water shows non-Newtonian behavior. The adhesive strength of this gum is better than *A. nilotica* and *A. catechu* (Sao, 2012). Ghatti gum does not form a true gel like gum tragacanth and used as a good substitute of gum arabic, where moderately high viscosity is required. The optical rotation of *Anogeissus latifolia* gum in aqueous solution is laevorotatory (JECFA, 1985).

Chemical properties

Gum ghatti is composed of calcium and magnesium salt of complex acidic polysaccharide and 2.7-3.6% protein with trace amount of fats (JECFA, 1985). The hydrophobic amino acids in gum ghatti are reported to be more than gum Arabic (Kang et al., 2015). The pH value of gum ghatti ranges from 4.92 to 5.11 (Thombare et al., 2018b). The chemical structure of this gum contains a backbone of 1, 6-β-D-galactopyranosyl units branched with side chains of mainly L-arabinofuranose and occasionally with L-rhamnopyranose, D-galactopyranose, D-glucopyranosyl uronic acid, D-glucopyranose and L-arabinopyranose residues (Deshmukh et al., 2012). This gum yields an aldehyde (28.2% on dry basis) known as furfural (Agrawal & Konno, 2009) The confirmatory test for identification of gum ghatti is represented in table 2.

Gum Karaya

The true source of gum tragacanth is *Astragalus gummifer* (Bagheri et al., 2015); however, the gum exuded from the tree of *Sterculia urens* is commercially known as Indian gum tragacanth or gum karaya due to its similar gum properties (Shukla & Modi, 2020). In fact, this gum is inferior to true gum tragacanth (Krishnamurthy, 2010a.).

Physical properties

The physical properties of gum karaya are summarized in table 1 in comparison to true gum tragacanth. The gum exudate of *Sterculia urens* is translucent, pale yellow or gray to pinkish brown in colour, with acetous or vinegary odour and taste (EFSA, 2016). However, the gum obtained from *Astragalus gummifer* is odourless, tasteless, translucent and off-white to pale yellow in colour (Mayes, 2010; Kulkarni & Shaw, 2016). Gum karaya swells in normal water and forms thick, soft gel-like viscous colloidal dispersion due to the presence of acetyl group (Sao, 2012). This gum can swell more than 60 times of its original volume by absorbing water (Mayes, 2010). The viscosity of gum karaya decreases and solubility increases on heating and aging, as a result of the alterations of its polymer conformation (Mayes, 2010). The gum tragacanth swells and forms viscous solutions in normal water and hot water both (Sao, 2012). Its viscosity increases and solubility decreases on heating and aging. The molecular weight and viscosity of both gums are generally higher than *Acacia* gums and gum ghatti. The wet adhesive properties of gum karaya and gum tragacanth are stronger than gum ghatti and *Acacia* gums.

Chemical properties

Chemically, the exudate of gum karaya is composed of partially acetylated (8-14% acetyl groups) complex polysaccharides mixed with calcium and magnesium salts and 1% protein

(Mayes, 2010). The chemical structure of this gum consists of a backbone of D-galactose, L-rhamnose and D-glucuronic acid residues branched with glucuronic acid (Sao, 2012). This gum has high proportion of L-rhamnose (about 15%) and uronic acids (about 40%) in comparison to *Acacia* gums and ghatti gum (Mayes, 2010; Sao, 2012). The gum tragacanth is a complex mixture of 60-70 per cent tragacanthic acid (bassorin), a water-swellable polymer and tragacanthin (8-10%), a water-soluble arabinogalactan polysaccharide along with calcium, magnesium and potassium salts, proteins (<4%) and traces of starch and cellulose. Tragacanthic acid consists of a backbone of 1, 4-linked α-D-galacturonic acid connected with the side chain of 1, 3-linked D-xylose,L-fucose or D-galactose, whereas, tragacanthin contains a backbone of 1, 6-linked D-galactose units attached with side chains of L-arabinofuranose residues (Mayes, 2010, Emam-Djomeh, Fathi & Askari, 2019). The normal pH of 1% gum karaya solution ranges from 4.5 to 4.7 due to the presence of uronic acid residues, while the pH of 1% gum tragacanth solution varies from 4.5 to 6.0 (Agrawal & Konno, 2009; Emam-Djomeh, Fathi & Askari, 2019). The confirmatory test for identification of gum karaya and true gum tragacanth are given in table 2.

CONCLUSION

Plant gum exudates are complex polysaccharides mixed with calcium, magnesium, potassium and sodium salts, proteins and traces of fats, starch and cellulose molecules. The commercially important tree gum exudates are gum Arabic and its similar *Acacia* gums, gum ghatti and gum karaya or Indian gum tragacanth. These natural gums can be differentiated from each other by comparing their physico-chemical properties such as colour, odour, taste, solubility, viscosity, pH and heat stability, optical rotation, adhesiveness, chemical composition and structure and by carrying out confirmatory chemical tests or reactions. Among these properties, solubility, viscosity, colour and chemical tests are the major physico-chemical methods used to differentiate the commercially important gums.

ACKNOWLEDGEMENTS

We are grateful to funding agency the *ICAR, New Delhi* and *World Bank* for financial support under the National Agricultural Higher Education Project (NAHEP) sub-project Centre for Advanced Agricultural Science and Technology (CAAST) for sanctioning of the project entitled "Establishment of Secondary Agriculture Unit for Skill Development in Students and Farmers at NAU, Navsari".

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