ISSN : 0974 - 7478 Volume 9 Issue 4

Macromolecules

An Indian Journal

Microreview

MMAIJ, 9(4), 2013 [111-116]

Karaya gum: General topics and applications

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ABSTRACT

In recent years, there has been increasing interest for the use of hydrocolloids, particularly for the gums, these fact due to need to incorporate new natural sources from plants that for their physical, chemical and biological properties are excellent component to development of better drugs and food. Karaya gum is the most important hydrocolloid from India, this gum is an exudates from *Sterculia urens* tree, in despite of actually there are reports about their applications, structure and physical properties, these information is disperse. The main of this paper is provide an overview about the origin, the mechanic and rheological properties, chemical and structure and the several uses in food and pharmaceutical industries as drug delivery system and thickener, gelling, emulsifier, stabilizer and encapsulating agents.

KEYWORDS

Karaya gum;
Hydrocolloids;
Physical and chemical properties;
Applications.

INTRODUCTION

Gums are one of the cheapest and more abundant raw materials, commonly produced of superior plants as a result of their protection mechanisms after a wound[1,2].

Gums are polysaccharides built from multiple simple-sugars units named monosaccharides, this are linked by intermolecular glycosidic bounds to produce big molecules. These polymers can form complexes with different metals to form salts with calcium, potassium, magnesium and more complex substances known as polyuronides. Gums are highly water-soluble; this property gives them the name of "hydrocolloids". Most of these forms tridimensional structures linked as molecular nets named gels[2].

Gums are used as texture modifiers, dietetic fiber, gelling agents, emulsifiers, stabilizers, thickeners, capsule-form agents and drug delivery process[1,3–5]. In the last years its utility has raised considerably in food industry and in drug-delivery systems; actually are the principal components in liquid and semi-solid food[6].

Gums are classified according to its source. Like shown in TABLE 1, there are three main groups: natural, semi-synthetic and synthetic gums[2,7,8].

For gum selection process, know its chemical composition is essential because obtaining source, extraction method and additional process depends on it. These are decisive factor to understand physical properties rheologic and gelling behavior, attributes that are of great importance to define the uses for the gum[17,18]. Researchers have been working with gums because they are bio-safe and bio-degradable, on other hand they can be used to elaborate drug-delivering matrix by their high water-produced swelling, availability, thickening properties in oral-administrated liquids, dispersible in tablets and low cost[1,2,19,20]. In the group of natural polymers we can found the gum karaya.

KARAYA GUM

The karaya gum, also known as sterculia, kadaya, katilo, kullo and kuterra, is native from India that is the main producer and exporter[21].

Since 1911, the Food and Agriculture Organiza-

TABLE 1 : Gums classification

Source			Common Name	Functions	Reference
Naturals	Plant Exude	*Acacia Senegal*	Gum arabig	Texture modifier gelling agent stabilizer emulsifier	8
		Astragalus Gummifer	Gum tragacanth	Bifunctional emulsifier Thickener	6 8 9
		Sterculia urens	Gum karaya	Emulsifier Thickener Dental adhesive	6 10
		Anogeissus latifolia	Gum Ghatti	Emulsifier Die fixer	11 12
		Ceratonia siliquia	Carob	Thickener Gelling agent Stablilizer Suspension Agent Water linker	8
	Seed	*Cyamopsis tetragonolobus*	Gum Guar	Thickener Gelling agent Stablilizer Emulsifier Adhesive Water linker Cristallyze prevention Flocculant	7 8 13
		Prosopis	Mesquite gum	Stablilizer Emulsifier Surface tensión reducer	6
Naturals		*Caesalpinia spinosa*	Gum Tara	Stablilizer Thickener	14
	Seaweed extracts	*Gelidium cartilagineum*	Agar	Texture modifier Thickener Gellifier Stablilizer Turbidity modifier	8
		Macrocystis pyrifera	Sodium alginate	Suspension agent Mucoadhesive microespheres Gellifier Emulsion stabilizer	14 7
		Chondrus crispus	Carrageenan	Thickener Stablilizer	8
	Others	Citrus aurantium	Pectin	Thickener Texture modifier	1
			Starch	Gelatinization	8
Semi-sinthetics	Cellulose derivatives	Chemical modifications	Carboxymethyl celulose	Thickener Gellifier Stablilizer	6
			Methyl celulosa	Heat gellifier	
			Hydroxypropylmetthyl Cellulose	Heat gellifier	
	Microbian Gums	*Xanthomonas campestris*	Gum xantana	Colloidal suspension stabilizer Enzymatic-degradation resistant adhesive	15 16 6
		Leuconostoc mesenteroides	Dextran	Blood plasma substitute	6
		Pseudomonas elodea	Gellan	Gellifier	

tion (FAO) has recognized to karaya gum as a food additive with the number E-416[22].

According to standard CODEX STAND 192-1995, food additive means any substance not normally consumed as a food by itself and not normally used as a typical ingredient of the food, whether or not it has nutritive value, the intentional addition of which to food for a technological (including organoleptic) purpose in the manufacture, processing, preparation, treatment, packing, packaging, transport or holding of such food results, or may be reasonably expected to result (directly or indirectly), in it or its byproducts becoming a component of or otherwise affecting the characteristics of such foods. The term does not include contaminants or substances added to food for maintaining or improving nutritional qualities[23].

Origin and production

The karaya gum is obtained as the exudates from *Sterculia urens*, a large and bushy tree that belongs to the family Sterculiaceae, that usually grows in dry and rocky forest regions in central and northern of India, more than fifty percent of the gum is produced in the state of Andhra Pradesh, however others sources are from *S. setigera* in Senegal and Mali, and minor supplies form *S. villosa* in Sudan, India and Pakistan. *Sterculia* trees can grow up to 10 meter tall depending on the species and it can be used near of five times during its life time, with a total yields between 1-5 Kg by season. A very important fact is that the gum production is handcraft process. Local population obtained the gum by incisions or tapping of the trunks and the exudation begins immediately and continues for several days, the bulk exudes is dried in hot and dry climate, broken, cleaned to remove bark and foreign matter and classified according to the quality and stored. The highest quality of raw gum is collected during the hot months of April, May and June. The grades used in international trade are superior (No.1, 2 and 3) and siftings. Superior No. 1 gum is used in food and pharmaceutical preparations because have high viscosity, clear color, good solubility and moisture retention. The gum is offered as granules or powder. World production is around 3000 tons by year, near of half comes from India and the rest comes from North Africa. The major imported countries are USA, France en UK. The price by tone is in the range 2250-6000 US dollar depending of the quality[6,20,24,25].

Physical properties

Karaya gum has a fine dust appearance, a pink-grey color and slightly acetic flavor and smell; combined with some compounds as glycols, has the capacity to form soft films when is plastified with those compounds[6].

A technique used to develop pharmaceutical products is spray-drying. Is well known that the materials used in this method as a behavior amorphous or crystalline[26]. This behavior is associated to glass temperature transition and environmental conditions[27].

Glass transition temperature is a relevant factor because is linked to viscosity and this one is related to the product yield and storage. Is well known that if an amorphous material is heated at a temperature 20 °C higher than its glass transition temperature became potentially gummy and sticky[28]. Differential Scanning Calorimetry (DSC) is an analytical technique used to perform compatibility studies been this the preferred method to pre-formulation of pharmaceutical products.

Rheological properties

Karaya gum is the less water-soluble integrant of the gums group and produce solutions in very low concentration (<0.02% in cold water and 0.06% in hot water), this is due the acetyl groups in the structure of the gum. Viscosity of karaya gum in 0.5% dispersions has a value near the 120-400 centipoices (cPs) and in 3% dispersion is about 10,000 cPs[6]. This fluids has a non-newtonian pseudoplatic-type behavior because its viscosity is inversely proportional to the shear rate [29]. In low-concentration solutions, viscosity grows linearly in a concentration-dependent fashion until reach 0.5% of karaya gum concentration. In powdered form, viscosity decreases with increasing age (IMESON, 2011).

pH stability

pH has an important role in karaya gum dispersions stability. These preparations are relatively stables at acid pH values; 1% dispersion is stable at pH range of 4.5-4.7. Viscosity is diminished when an acid or an alkali is added to the dispersion and it can be raised if gum is totally hydrated before make any pH adjust. At pH values above 8, karaya gum can suffer irreversible conversions, dispersion characteristics are damaged because the gum lose its acetyl groups[30]. Due its high concentration of uronic acid, karaya gum dispersion are resistant to acidic conditions and it can resist hydrolytic activity of a concentration of 10% of hydrochloric acid.

Heat stability

Dispersion of karaya gum are thermolabils; during heating, polymer conformation changes, resulting in an increased solubility and a permanently decreased viscosity. In cold water, dispersions can be as concentrated as 5% while in hot water and low pressures concentrations about 18 and 20% can be reached[6,7].

Behavior in water

Karaya gum has a strong capacity to fix with water molecules, gum particles are not fully solubilized, instead it present a phenomenon called swelling that consist in an increment in total volume with relation to dry mass that can be about the 60 times the original volume.

Chemical structure and composition

The gum karaya has a ramnogalacturonane-type partially-acetylated ramified structure and is commercially obtained form of and/or magnesium salt. Has a molecular weight of $16X10^3$ kDa and is composed for 55-60% of neutral monosaccharide units (galactose and ramnose), 8% of acetyl groups and 37-40% of acid residues (galacturonic and glucuronic acids). Gum main chain is formed by α-D-galacturonic acid and L-ramnose units. Side chains are linked to main chain by 1,2-β-D-galactose bounds or 1,3-β-D-glucoronic bound for galacturonic acid[31] (Figure 1).

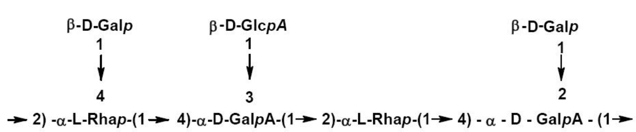

Figure 1 : Chemical structure of karaya gum.

Figure 2 shows the Fourier Transformed Infra Red (FTIR) spectrum of karaya gum. Signals in 1731 cm^{-1} and 1254 cm^{-1} indicates acetyl groups presence while signals at 1616 cm^{-1} and 1423 cm^{-1} are due the carboxylation of uronic acid residues. Signal at 3426 cm^{-1} indicates OH group presence[32].

Applications

The biological activities of karaya gum had been previously evaluated. The hypocholesterolemic properties were demonstrated by Behall, Lee, & Moser (1984). On the other hand, Afrose, Hossain, Maki, & Tsujii (2009), elaborated an comparative assay with several saponins and shown that karaya root saponins had better effects to reduce the blood and hepatic cholesterol, blood low density liprotein and atherogenic index and to increase the serum high-density lipoprotein and the high density lipoprotein/ cholesterol in comparison with other saponins from tea, soy bean and quillaja in rats feed with high-cholesterol diet.

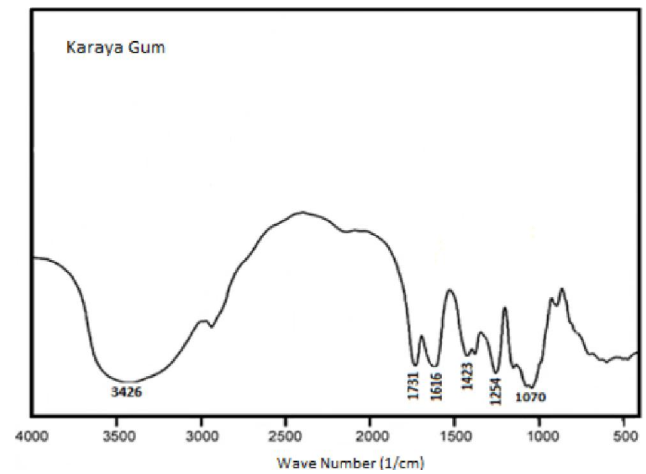

Figure 2 : FTIR spectrum of karaya gum

Karaya gum can also act as adhesive when is at a concentration between 20 and 50%, this permits that gels and pasts made with karaya gum can resist water lose when are diluted[35].

Karaya gums as wide applications in food and pharmaceutical industries[6,22,36,37]. Due its complex and ramified structure, its exhibits properties as emulsifiers, cohesive and adhesive, these properties are fundamentals in pharmaceutical industries. In the following table, some of the actual uses of karaya gum are showed (TABLE 2).

TABLE 2 : Applications of karaya gum.

Aplication	Reference
Food	
Lactic products, dressing, whipped cream and freezed dessert. Poorly used in carnic industry. Meringue manufacture.	8,38,39
Pharmaceutical	
Laxative elaboration	1,8,38
Dental adhesive,	40,41
Release matrix of diltiazem, quetiapine fumarate, Aceclofenac, metformin	42,43
Delivery of essential oil in patches.	44

TOXICITY

Karaya gums are generally recognized as safe (GRAS); the FDA recognizes it as safe after the realization of toxicological, teratogenic and mutagenic studies[45].

Dikshith et al. (1984) demonstrated that karaya gum have no harmful significative effects in vital organs or biochemical alterations in a study performed on male and female rats.

FINAL COMMENTS

Studies realized to this day have demonstrated that karaya gum is a multiple-applications food additive that can be used as stabilizer, emulsifiers and gelling agent. It has a great potency in pharmaceutical industry as adhesive, suspension, emulsifier and tablet agent. Use of gums is highly attractive due they are economic, easily available and are capable of been modified to obtain more accessible materials, presenting a wide advantage over synthetic materials.

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