Karaya gum: General topics and applications

Gabriel A. Lujan-Medina, Janeth Ventura*, Ana Claudia Lara Ceniceros, Juan Alberto Ascacio Valdés, Daniel Boone-Villa, Cristóbal Noé Aguilar


E-mail: janeth_ventura@yahoo.com

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. © 2013 Trade Science Inc. - INDIA

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
Karaya gum: General topics and applications

**Microreview**

Karaya gum 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.

**TABLE 1 : Gums classification**

<table>
<thead>
<tr>
<th>Source</th>
<th>Common Name</th>
<th>Functions</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acacia Senegal</td>
<td>Gum arabig</td>
<td>Texture modifier gelling agent</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>stabilizer emulsifier</td>
<td></td>
</tr>
<tr>
<td>Astragalus Gummifer</td>
<td>Gum tragacanth</td>
<td>Bifunctional emulsifier</td>
<td>8</td>
</tr>
<tr>
<td>Sterculia urens</td>
<td>Gum karaya</td>
<td>Emulsifier Thickener</td>
<td>6</td>
</tr>
<tr>
<td>Anogeissus latifolia</td>
<td>Gum Ghatti</td>
<td>Dental adhesive</td>
<td>10</td>
</tr>
<tr>
<td>Ceratonia siliqua</td>
<td>Carob</td>
<td>Emulsifier Die fixer</td>
<td>12</td>
</tr>
<tr>
<td>Cyamopsis tetragonolobus</td>
<td>Gum Guar</td>
<td>Thickener Gelling agent</td>
<td>7</td>
</tr>
<tr>
<td>Prospis</td>
<td>Mesquite gum</td>
<td>Adhesive Water linker</td>
<td>8</td>
</tr>
<tr>
<td>Caesalpinia spinosa</td>
<td>Gum Tara</td>
<td>Cristallyze prevention</td>
<td>13</td>
</tr>
<tr>
<td>Gelidium cartilagineum</td>
<td>Agar</td>
<td>Suspensio agent</td>
<td>6</td>
</tr>
<tr>
<td>Macrocystis pyrifera</td>
<td>Sodium alginate</td>
<td>Emulsion stabilizer</td>
<td>14</td>
</tr>
<tr>
<td>Chondrus crispus</td>
<td>Carrageenan</td>
<td>Mucoadhesive microspheres</td>
<td>7</td>
</tr>
<tr>
<td>Citrus aurantium</td>
<td>Pectin</td>
<td>Geliffier Emulsion stabilizer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suspension Agent</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Water linker</td>
<td></td>
</tr>
<tr>
<td>Xanthomonas campestris</td>
<td>Gellan</td>
<td>Colloidal suspension stabilizer</td>
<td>6</td>
</tr>
<tr>
<td>Leuconostoc mesenteroides</td>
<td>Gum xantana</td>
<td>Enzymatic-degradation resistant adhesive</td>
<td>15</td>
</tr>
<tr>
<td>Pseudomonas elodea</td>
<td>Dextran</td>
<td>Blood plasma substitute</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat gellifier</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Heat gellifier</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Colloidal suspension stabilizer</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Enzymatic-degradation resistant adhesive</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Blood plasma substitute</td>
<td></td>
</tr>
</tbody>
</table>

**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-
Microreview

The FAO has recognized 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 centipoises (cPs) and in 3% dispersion is about 10,000 cPs [6]. This fluids has a non-newtonian pseudoplastic-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
Karaya gum: General topics and applications

Microreview

Conversions, dispersion characteristics are damaged because the gum loses its acetyl groups\(^{30}\). Due to its high concentration of uronic acid, karaya gum dispersion is resistant to acidic conditions and it can resist hydrolytic activity at a concentration of 10% of hydrochloric acid.

Heat stability

Dispersion of karaya gum are thermolabiles; during heating, polymer conformation changes, resulting in an increased solubility and a permanently decreased viscosity. In cold water, dispersions can be 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 rhamnogalacturonan-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 rhamnose), 8% of acetyl groups and 37-40% of acid residues (galacturonic and glucuronic acids). Gum main chain is formed by \(\alpha\)-D-galacturonic acid and L-rhamnose units. Side chains are linked to main chain by 1,2-\(\beta\)-D-galactose bounds or 1,3-\(\beta\)-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 chemical structures of karaya gum had been previously evaluated. The hypocholesterolemic properties were demonstrated by Behall, Lee, & Moser (1984). On the other hand, Afroze, Hassain, Maki, & Tsuji (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 lipoprotein 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.

The biological activities of karaya gum had been

<table>
<thead>
<tr>
<th>Application</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food</td>
<td></td>
</tr>
<tr>
<td>Lactic products, dressing,</td>
<td></td>
</tr>
<tr>
<td>whipped cream and frozen</td>
<td></td>
</tr>
<tr>
<td>dessert</td>
<td>8,38,39</td>
</tr>
<tr>
<td>Poorly used in carnic</td>
<td></td>
</tr>
<tr>
<td>industry</td>
<td></td>
</tr>
<tr>
<td>Meringue manufacture</td>
<td></td>
</tr>
<tr>
<td>Pharmaceutical</td>
<td></td>
</tr>
<tr>
<td>Laxative elaboration</td>
<td>1,8,38</td>
</tr>
<tr>
<td>Dental adhesive</td>
<td></td>
</tr>
<tr>
<td>Release matrix of diltiazem,</td>
<td>40,41</td>
</tr>
<tr>
<td>quetiapine fumarate</td>
<td>42,43</td>
</tr>
<tr>
<td>Aceclofenac, metformin</td>
<td></td>
</tr>
<tr>
<td>Delivery of essential oil in</td>
<td></td>
</tr>
<tr>
<td>patches</td>
<td>44</td>
</tr>
</tbody>
</table>

TABLE 2 : Applications of karaya gum.

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 pastes 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, it 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).
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.

REFERENCES.

[23] FAO; Food categories or individual food items in which the use of food additives is not acceptable, or where use should be restricted, are defined by this Standard. 1.4 M; CODEX STAN, (2009).
Microreview

1032 (2004).
[45] FDA; Database of Select Committee on GRAS Substances (SCOGS) Reviews Sterculia Gum (karaya gum), 13–14 (1973).