Investigation of some physico-chemical properties of Elaeagnus L. GUM

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Abstract. As is known, most polysaccharides have biological activity, play important roles in life processes, and are widely used in healthcare, food processing, and cosmetic production due to their therapeutic effects and relatively low toxicity. Among polysaccharides, this class's representatives do not have a biological activity to some pathogens of diseases but have a huge potential to use them in various sectors of the national economy, such as in the food industry, cosmetics, and pharmaceuticals. One such polysaccharide is the gum obtained from the plant *Elaeagnus L.* germinating in the Xinjiang Uygur Autonomous Region of China and Central Asia. The local people call it jidah. This article is devoted to the extraction, purification, the determination of the monomeric composition, molecular weight, viscosity, spectral analysis, and some chemical properties of the polysaccharide obtained from the gum of the named plant *Elaeagnus L.*

1 Introduction

Polysaccharides are a huge class of natural polymers whose molecules comprise various monosaccharide residues. These monosaccharides are linked to each other due to glucosidic bonds [1]. It should be noted that when nucleotides in nucleic acids, amino acids in proteins are bound in only one way, monosaccharide units in polysaccharides can be bound by different points, forming a branched or linear structure [2].

The resources of polysaccharides are huge. They can occur in plants due to photosynthesis, fungi, algae, bacteria, etc. At the cellular level, polysaccharides are responsible for reserve components in the cytoplasm (for example, in starch) or for the structural components of membranes or cell walls of organisms (for example, in cellulose). The basic structure of polysaccharides obtained from natural products is extremely complex and diverse, but the basic structure of the macromolecule chain consists of glucose, fructose, xylose, mannose, galactose, etc. Or a polymer consisting of two or more monosaccharides (for example, galactomannan, pectin). The structure of their branched chains is diverse, representing a huge variety. Although studies on polysaccharides have been started later

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than proteins, nucleic acids, or lipids, polysaccharides are causing more and more research interest because of their important physiological functions and wide application in various branches of the economy [3, 22].

Natural gums are obtained as natural exudates of different tree species and exhibit unique properties in various applications, including pharmaceutical, food, adhesive, paper, textile, and other industries [4]. For example, *Albizia zygia* and some *Albizia Lebbeck* gums are useful as a natural emulsifiers for some foods and pharmaceuticals and as a substitute for Arabic gum in the mining and metallurgical industries [5-6]. In the froth flotation of base and platinum group metal ores, guar gum is used as a depressant for naturally hydrophobic waste minerals such as talk. Guar gum is of primary importance for controlling the release of drugs in the gastrointestinal tract. Such as carriers for colon targeted drugs, anti-cancer drugs in treating colorectal cancer, and oral rehydration solutions in treating cholera in adults [7]. Guar gum is also used in transdermal drug delivery systems, as a synthetic cervical mucus and viscosupplementation agent in osteoarthritis treatment.

Gmelin gums have been reported to be useful in the pharmaceutical and food industries. They have the potential to control drug release and in modifying the texture of some food [8].

This article is devoted to the study of some properties of gum obtained from the bush *Elaeagnus L.* The gum is formed as a release on the surface of the plant's stem. It has been used for centuries by the women of Xinjiang as a condenser fixer for hair. There is a version that it strengthens the roots of the hair.

It is possible to use gum *Elaeagnus L*. to obtain a ceramic mass with a uniform distribution of components with an optimal consistency in producing composite materials with micro- and nanometals and in the transformation of graphite[9,10]. In addition, using this gum, it is possible to obtain different compositions with various dispersed nanofillers, such as modified kaolin and carbon, which can be used to produce paint and varnish or rubber materials [11,12].

We have studied the methods of extraction of polysaccharide from this gum *Elaeagnus L.* purification, determination of monomeric composition, molecular weight, change in solution viscosity under different conditions, UV and IR spectra of polysaccharide.

2 Results and discussion

2.1 Physical and chemical properties

Figure 1 shows photographs of samples of the initial and purified gum *Elaeagnus L*. Table 1 presents some of the physicochemical properties of the resulting polysaccharide from the named gum. The crude gum is a translucent, hard, and brittle mass from yellow to dark brown. The crude and purified gum does not have any taste or smell. The yield of the purified polysaccharide from the gum is 89%. The gum dissolves in cold and hot water. It is insoluble in alcohols, acetone, chloroform, ethyl acetate, and hydrocarbons.

Grude sample of gum

Purified sample of gum

Fig. 1. Photographs of crude and purified samples of *Elaeagnus L*. gum

Table 1. Some physical and chemical properties of original gum

Parameters	Properties
Color	Light yellow to dark brown
Smell	Odorless
Taste	Without taste
pH (25 °C)	6.8-7.0
Yield (%, w/v)	89
Swelling capacity	4.2-4.8
Solubility in cold water	soluble
Solubility in hot water	soluble
Acetone	Insoluble
Chloroform	Insoluble
Ethyl acetate	Insoluble
Hydrocarbons	Insoluble
Salinity	00
Melting point (°C)	170-183
Nitrogen (%)	0,32
Ash content (%)	0,37
Moisture content (%)	11,63
Fibre content (%)	00
Carbohydrate (%)	88

These results correspond to the physicochemical properties of many plant gums [13, 14].

The low nitrogen content (0.32%) in the gum composition corresponds to the nitrogen content in the Arabica gum (0.26-0.39%) [15] and has a relatively close value with other gums (0.21 to 0.35%) [16-18].

The moisture content of *Elaeagnus L.* (11.63 %) was relatively high, indicating that the gum has high water-absorbing or retaining capacities. It is the high ability of the gum to retain moisture that can be useful in cosmetics, especially for the face. In addition, the lack of taste and smell and the ability to form dense aqueous systems of low-concentration gum solutions allows its use as a food thickener. It should be noted that the presence of a dissolved form of gum in concentrated sugar solutions prevents the formation of premature crystallization of sugar, which is very important in producing high-sugar confectionery. The low ash content of the gum (0.37 %) also suggests that it has much more organic content than inorganic constituents.

2.2 Monomer composition of polysaccharide

Table 2 below shows the monomeric composition of *Elaeagnus L.* and Arabica gums.

Table 2. Comparative monomeric composition of gums

Monomers (%)	*Arabic* gum	*Elaeagnus L.*gum
D-Galactose	43	22,7
L-Arabinose	30	41,8
L-Rhamnose	13	8,7
D-Glucuronic acid	13	3,5
D-Mannose	-	1,2
uncertain	-	22,1

As seen from the table, in the macromolecule of the polysaccharide gum *Elaeagnus L.*, the content of the residues of D-glucuronic acid is almost four times less than that of the arabica gum. Therefore, the aqueous solution of *Elaeagnus L.* gum has an almost neutral

medium. On the other hand, the change in pH does not significantly affect the relative viscosity of the solution. As is known, if there are free carboxyl groups in the macromolecule of water-soluble polymers, a change in the pH of the solution would lead to a change in the relative viscosity of the solution. In our studies, increasing the pH of the solution to pH 10 did not lead to a significant change. This allows us to conclude that the carboxyl group of glucuronic acid is not in free form.
The composition of *Elaeagnus L.* gum is still different from arabica by its insignificant content in D-mannose. The remaining comonomers of galactose, arabinose, and rhamnose are present in the *Elaeagnus L.* gum and differ only in percentage.
The absence of toxicity, odor, color, and taste makes it possible to use this gum in food products as a thickener or a modifier of food consistency.

2.3 Spectroscopic Study

The UV spectrum of the sample of the purified gum is shown in Figure 3. The results show that the gum contains no proteins, which corresponds to the data in Table 1.

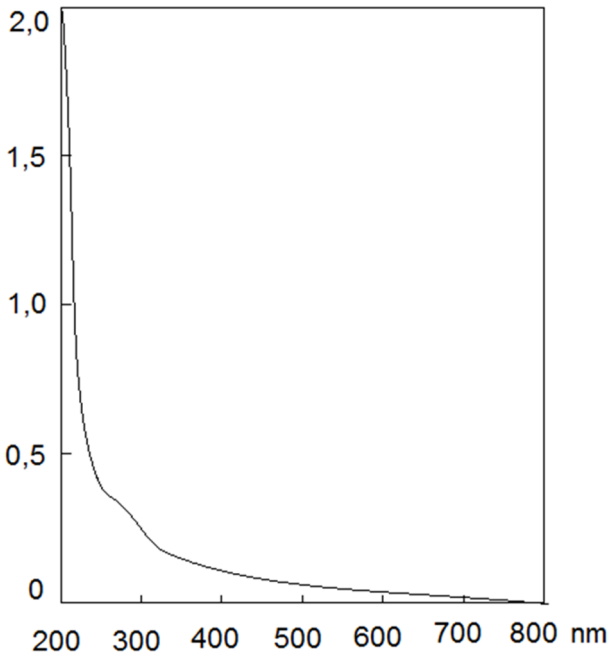
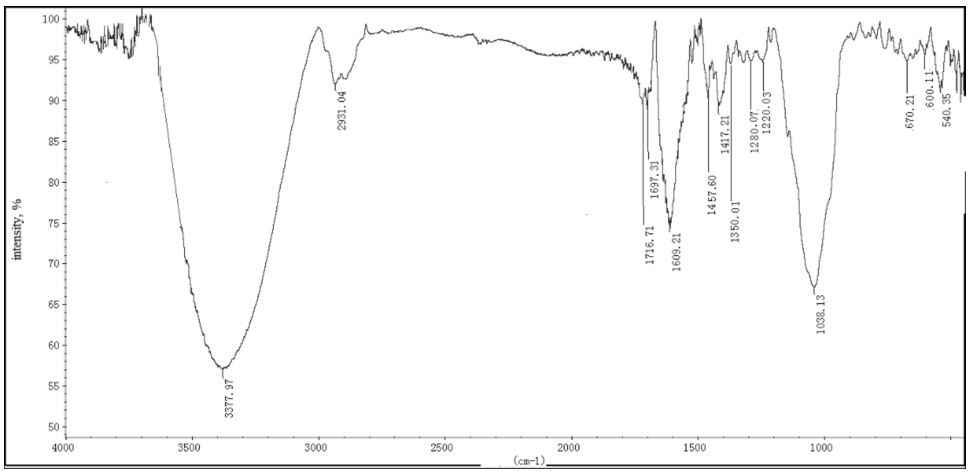
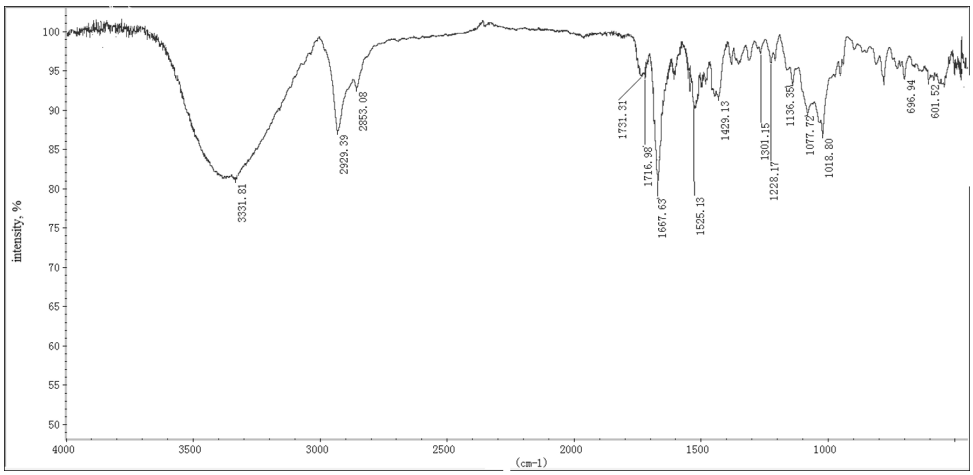


Fig. 3. UV spectrum of purified gum *Elaeagnus L*

Figure 4 shows the purified gum's IR spectra and the gum's spectrum after hydrolysis in an acidic medium. As the results show, the spectra of the initial and hydrolyzed gums differ, which proves the hydrolysis reaction and change of the structure of the macromolecule.



IR spectrum of purified gum



IR spectrum of hydrolyzed gum

Fig. 4. IR spectra of purified gum and gum spectrum after hydrolysis in acidic medium.

The spectrum displayed features typical of polysaccharides. Thus OH stretch vibration was found at 3377 cm^{-1}. The peak obtained at 2931 cm^{-1} is due to stretching modes of CH bonds of a methyl group (CH_3). Also, the peaks obtained at 597 and 670 cm^{-1} are CH bend due to alkyne.

C=O stretches due to acetyl groups were prominent at 1716, 1240, and 1130 cm^{-1}, respectively. Absorption bands at 1609 and 1038 cm^{-1} are typical for carboxylate groups of the galacturonic acid residues[19]. Other functional groups identified were CH_2 twisting vibration at 1350 cm^{-1} and OH stretch due to carboxylic acid at 1417 cm^{-1}.

2.4 Hydrolyze of gum

To study the change in gum in the body, hydrolysis of a 1% aqueous solution of gum in the stomach was simulated at pH = 2.2, 30, and 37.5°C. The flow of the hydrolysis process was observed by a change in the rotational viscosity of the solution along the course of the reaction.

As shown in Figure 6, the hydrolysis process depends on temperature. The change in temperature from 30 to 37°C accelerates the hydrolysis process. At a temperature of 37.5°C, hydrolysis is completed within one hour. Further increase in the reaction time to 18 hours does not lead to a change in the viscosity of the system. In other words, within one hour under these conditions, a part of the readily hydrolyzed bonds manages to split. This behavior of the gum solution allows us to conclude that the gum can be cleaved in a gastric juice at pH = 2.2 and 37.5°C or further in the intestinal tract. The absence of toxicity, odor, and color in the gum can enable it to be used in food products.

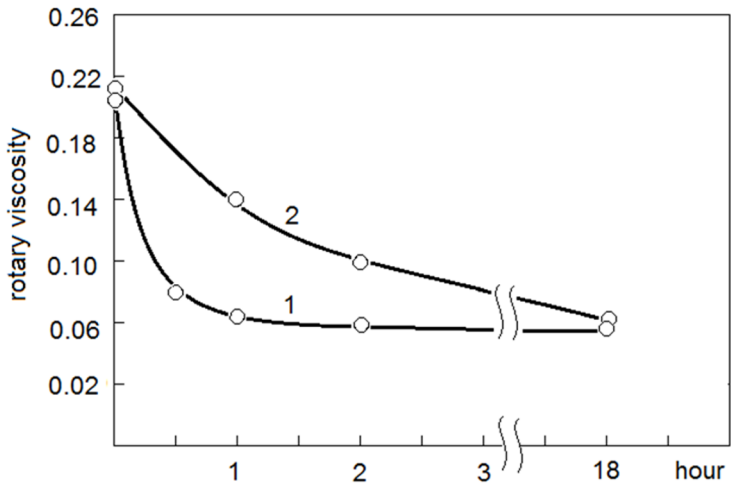


Fig. 6. Change in rotational viscosity of gum during hydrolysis, with 37.5 (1) and 30°C (2).

The IR spectrum of the acid hydrolysis of the gum shows (Figure 4) that an additional band OH band is formed in the range of 3331 cm^{-1}. For other groups, there is a shift in the absorption bands: the peak obtained at 2929 cm^{-1} is due to stretching modes of CH bonds of the methyl group. Also, the peaks obtained at 601 and 696 cm^{-1} are CH bend due to alkyne.

C = O stretches due to acetyl groups were prominent at 1716, 1298, and 1136 cm^{-1}, respectively. Due to the gum's hydrolysis, the absorption bands' intensity for the carbonyl groups sharply decreases, and they appear with some displacement at the 1667 and 1018 cm^{-1} range. This may be due to the partial withdrawal of the carbonyl-containing components from the gum macromolecule during hydrolysis.

CH_2 twisting vibration was identified at 1301 cm^{-1}, OH stretch due to carboxylic acid at 1429 cm^{-1}.

2.5 Some hydrodynamic properties of the gum solution

Low-concentrated aqueous solutions of the gum are viscous solutions. Viscosimetric studies have shown that a polyelectrolyte anomaly is not observed in dilute aqueous solutions of the gum. In other words, the gum macromolecules do not appear to contain free carboxyl groups, which are responsible for the appearance of a polyelectrolyte anomaly. Consequently, a change in the pH of the solution does not significantly affect the relative viscosity of the solution, as was observed in the experiments.

The molecular weight of the polysaccharide was determined by HPLC, and it was $1.6 \cdot 10^5$.

The rotary and kinetic viscosity of the 1.0 g / dl aqueous gum solution was determined at 25 and 40 ° C, and they were 258 mPa s and 124 mm2 / s, respectively.

An aqueous gum solution was studied to determine the change in solution viscosity in the presence of sugar over a wide range of sugar concentrations (Figure 7). A change in the viscosity of water in the presence of sugar is given to compare the results.

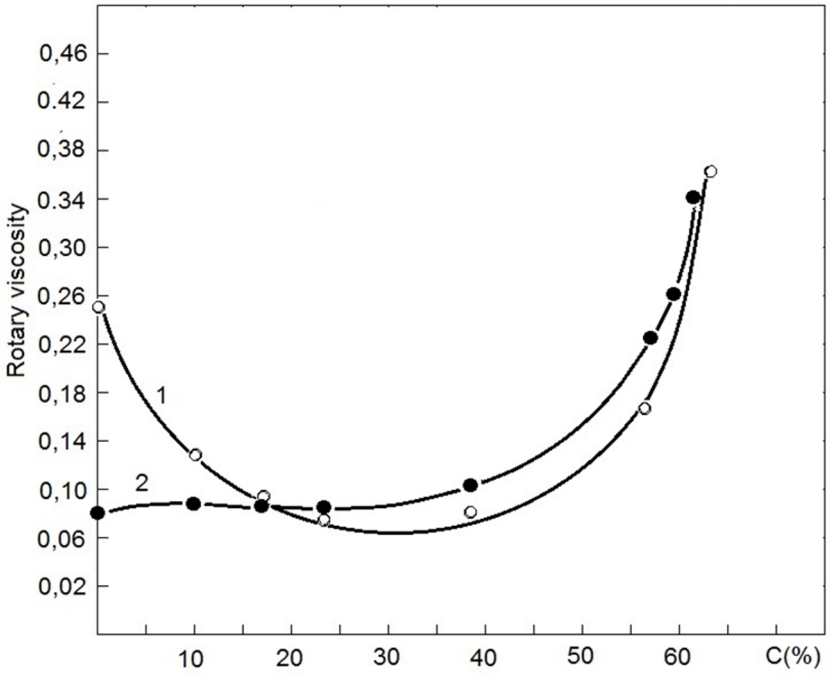


Fig. 7. Change in rotational viscosity of 1% gum solution (1) and water (2), depending on concentration of sugar in solution

As can be seen from the figure, adding sugar to 35% in the gum solution leads to a decrease in the viscosity of the solution. Especially a sharp decrease in viscosity is observed when adding sugar to 10% (Figure 7, 2-curve). This behavior of the gum is apparently due to a change in the conformation of the macromolecule of the gum in the presence of sugar. Small sugar content (up to 10%) is likely to promote the folding of the macromolecule of the polysaccharide, which is reflected in a decrease in the viscosity of the solution. At a sugar concentration in the solution range from 20 to 40%, the viscosity varies very smoothly, and starting from 45%, the viscosity of the solution sharply increases. But such an increase in viscosity in this region is explained only by increased sugar content. Because comparative experiments of aqueous solutions of sugar also show a similar picture (Figure 7, 2-curve). For aqueous solutions of sugar within the concentration of sugar from 0 to 40%, the viscosity remains almost constant. And in this case, when the sugar concentration reaches 45%, the viscosity begins to increase due to the high sugar content of the solution.

Based on the results obtained, i.e., an interesting change in the viscosity of the gum solution in the presence of another organic compound can make it possible to use it as a consistency modifier for various aqueous systems, ranging from food to cosmetic.

3 Experimental sections

3.1 Collection and Purification of Samples

Crude samples of *Elaeagnus. L*. Gum was obtained as exudates from the *Elaeagnus L*. tree in Xingjian, China. The gum was dried in an oven at 50ºC for 2 hours and ground with a grinder. After grinding the gum, it was passed through a 200 μm sieve and freed from various mechanical impurities. A 2% aqueous solution was prepared from the obtained cream-colored powder, and the gum dissolved very slowly for 4-5 hours. The solution has a weak yellow color. The solution was then passed through a 100 μm sieve. After that, the solution was treated with an oxidizer [20]. The solution became discolored and became transparent. The solution was then centrifuged for 5 minutes while the rotor was rotating at 5000 rpm. At the same time, very small organic and inorganic impurities settled on the bottom of the ampoule. The precipitate was removed, and the solution was precipitated into ethanol with a mechanical stirrer with a rotation speed of 120 rpm at room temperature. After precipitation and filtration of the gum, it was washed with alcohol several times. Then the gum was dried under a vacuum at 50°C for 2 hours. Thus the gum obtained was held in a desiccator.

3.2 Physicochemical analyses

To characterize the gums, it was subjected to the following physicochemical tests.

3.2.1 Determination of Percentage Yield of the Purified Gums

To determine the percentage yield of the gum, crude and purified samples of the gum were weighed, and the percentage yield was calculated concerning the weight of the crude gum.

3.2.2 Determination of Percentage Moisture Sorption

To determine the water sorption capacity of the gum, dried evaporating dishes were weighed, and 2.0 g of the gum sample was weighed into the dish. The final weight of the dishes was noted and placed over water desiccators. After 5 days, the dish was transferred to another desiccator over activated silica gel (desiccant) for another 5 days. The percentage sorption was calculated by the difference in weight.

3.2.3 Determination of solubility

The solubility of the gum was determined in cold and hot distilled water, acetone, chloroform, ethyl acetate, ethanol, and hydrocarbons. 1.0 g of the sample was added to 50 ml of each solvent and left overnight. 25 ml of the clear supernatants were taken in small pre-weighted evaporating dishes and heated to dryness over a digital thermostatic water bath. The residue weights concerning the volume of the solutions were determined using a digital top loading balance (Sartorius CPA 1245) and expressed as the percentage solubility of the gums in the solvents.

3.2.4 Determination of Nitrogen

The nitrogen content of the gum was determined using the Kjeldahl method. The absence of proteins was evaluated by UV spectroscopy on a UV-2550 Shimadzu instrument.

3.2.5 Determination of pH

This was done by shaking a 1 % (w/v) dispersion of the sample in distilled and deionized water (pH=6.8) for 20 minutes, and the pH was read from a pre-calibrated pen-type pH meter (Model 8635) after inserting the probe of the meter into the sample.

3.2.6 Determination of Moisture Content

In the determination of the moisture content of the sample, the oven drying method was used as described in the AOAO [21] method.

3.2.7 Determination of Ash Content

The ash content of the sample was determined using the method recommended by AOAO [21].

3.2.8 Determination of Crude Fibre

The fiber content of the sample was determined using the method recommended by AOAO [21].

3.2.9 Determination of Carbohydrate

The total carbohydrate content was determined by the difference in the sum of the percentage moisture; ash was subtracted from 100.

3.2.10 Viscosity Measurements

The viscosity of the gum solution was determined in distilled water using a Cannon Ubbelohde capillary viscometer which was immersed in a precision water bath maintained at a specified temperature. Rotary viscosity was measured using NDJ-5S rotational viscometer.

3.3 FTIR Analysis

FTIR analysis of *Elaeagnus L.* gum was carried out using Thermo Scientific Nicolet 6700 FT-IR Spectrometer. The analysis was done by scanning the sample through a wave number range of 400 to 4000 cm^{-1}.

4 Conclusions

From the obtained results of the research, the following conclusions are formulated:

1. The monomeric composition of *Elaeagnus L* shrub gum was determined; the gum consists mainly of polysaccharide (89%), which consists of 22.7% D-galactose, 41.8 L-arabinose, 8.7% L-rhamnose, 3, 5% D-glucuronic acid and 1.2% D-mannose. The carboxyl group of glucuronic acid is not in free form.

2. *Elaeagnus L*, the gum is similar in composition to arabica and only has a slight content of glucuronic acid in the composition. The gum has no toxicity, odor, or color.
3. The process of assimilation of gum in the body was modeled, and it was proved that *Elaeagnus L*, the gum, can be absorbed in the human body at pH 2.2 and 37.5 ° C.
4. The molecular weight of the *Elaeagnus L.* bush gum polysaccharide was determined. Viscosimetric methods showed that a polyelectrolyte anomaly was not observed in the gum solution, which is explained by the absence of free carboxyl groups on the macromolecule.
5. The viscosity of the aqueous gum solution in the presence of sugar over a wide range of concentrations was studied. It is shown that the viscosity of the solution decreases sharply with the addition of sugar to 10%, which is explained by the folding of the polysaccharide macromolecules. An interesting change in the viscosity of a gum solution in the presence of another organic compound may make it possible to use it as a consistency modifier for various aqueous systems, from food to cosmetics.

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