

## Roles of Polysaccharide Gums in the Food and Beverage Industries: A Review

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### ABSTRACT

*Polysaccharides have been used in the food business for a variety of beneficial purposes over the years. The food and beverage businesses must satisfy customer demands while using natural components that perform their technological functions in processed foods. This puts them in increasingly difficult situations. Polysaccharides have numerous useful food uses as stabilizers, thickening agents, and emulsifiers that could be used as additives in the relevant food sectors. In the context of food industry innovation, this review discusses understanding regarding the functions and uses of polysaccharide gums.*

**Keywords:** polysaccharide gums; application; industry.

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### INTRODUCTION

Polysaccharide gums are derived from many sources and have several uses in the food and beverage industry as thickening agent, stabilizers, gelling agent, texture modifiers, etc. Due to their flexibility, polysaccharides are frequently employed in the creation of food items. Its chemical structures are directly related to its wide range of uses. The characteristics of polysaccharides or glycoconjugates can be determined by the characterization of structural molecules. The food industries are the companies responsible for transforming agricultural raw materials into edible food items. The food sector is a developing industry that is always seeking ways to innovate and enhance. Gums may provide the food industry with several options for innovation. Food coloring, juice concentrates, artificial sweeteners, and more sophisticated preservatives are just a few of the innovations made in the food processing sector.

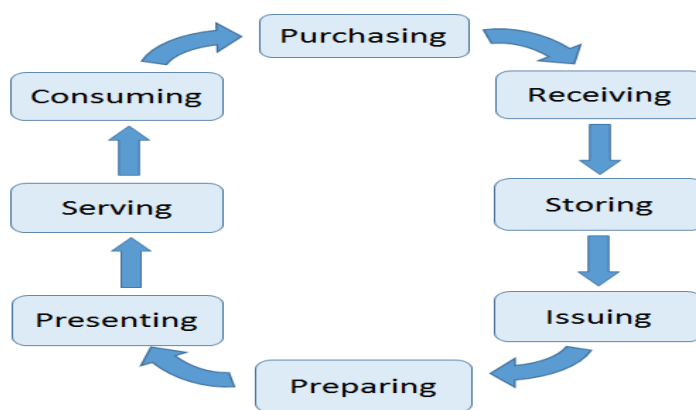
### The food and beverage industries

Numerous individuals disregard the significance of the food and beverage businesses to their daily lives. Without the food and beverage industry, the world would be significantly poorer and more starving. The food and beverage sector consists of all industries that turn raw agricultural products into finished food items. It is one of the oldest, largest, and most diversified industries. The food and beverage industries are always searching for methods to satisfy their consumers' desires by developing new goods and enhancing old ones at the lowest feasible cost and at the highest possible volume.

The food and beverage sector includes establishments like restaurants, food production plants, catering services, food delivery services, fast food restaurants, etc. The manufacture, transportation, and serving of food and drinks are all possible jobs in this sector. In order to produce more food items with added value, the industry is concentrating on employing technology and mechanical manipulation of basic food resources. Since ancient times, the food

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and beverage sectors have been setting the path for growth with their discoveries and advancements. The services of food and beverage industries involves a multitude of operations which start from the purchase of raw materials, making the food and beverage, making sure the record of materials are kept, maintaining service quality incessantly, managing of various catered events and finally, to decide future outcomes by analyzing business outcomes.



**Figure 1.** Flow chart of food and beverage industry

### Polysaccharide gums

Gums are often recognized as non-starchy, commercially significant, water-soluble polysaccharides. They may be referred to as hydrocolloids when utilized as ingredients in processed foods. Gums that dissolve in water, also called hydrocolloids, can be used as dietary thickeners, fibers, gelling agents, texture modifying agent, emulsifiers, coating agents, encapsulating agents, stabilizers and as films. (1; 2). Gums have a variety of functions that they add to a system when they are incorporated with a product. The physical and chemical characteristics of a gum, which can be determined by the composition and molecular structure of a gum, dictate the functions that gum will provide to a system into which it is introduced. The shape of a gum molecule is determined by the characteristics of the aqueous environment in which it exists, including pH, the types and concentrations of salts or other solutes, temperature, shear, and their organic framework.

All gums have the potential to make aqueous and water systems thicker, although they may impart varied rheological qualities to the thickened systems. Certain gums do specific functions more effectively than others. Gums are likewise primarily constituted of complex carbohydrates that dissolve easily in water and can create gels and mucilages (3). Gums from plants are useful for the production of various items, ranging food, medicine, care products, clothing, as well as textiles. (4). Gums that are produced naturally are progressively being utilized in place of manufactured products since they are affordable, safe, harmless, and readily accessible (5).

### Characterization of gums

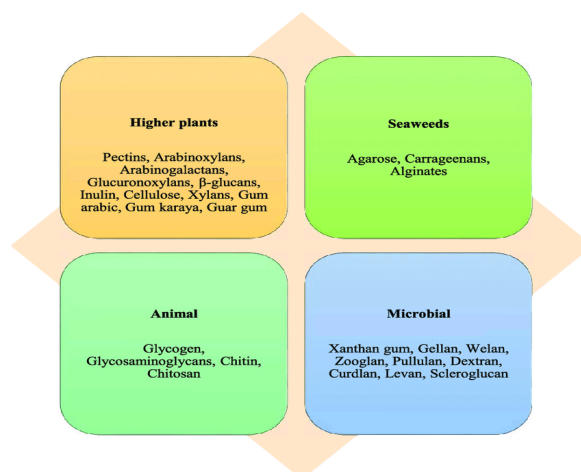
According to the type of information produced, analytical methods for characterization can be divided into different categories.

1. Structural: Gums are polysaccharides which consist of sugars. Therefore, chromatography (TLC/HPLC) may be used to validate the presence of various sugars, and the structure can be determined using Nuclear Magnetic Resonance, FTIR and mass spectroscopy.
2. Purity: Phenols, glycosides, steroids, saponins, carbohydrates, terpenes, amino acids, oils and fats, tannins, flavonoids and alkaloids are analysed to assess the gum's pureness.

3. Impurity Profile: Impurity test can be analysed using appropriate methods.
4. Physicochemical Properties: The odour, swelling index, form, pH, texture, touch, solubility, flavor, loss on dehydration, hygroscopic nature, color, porosity, and surface tension are all determinable. The viscosity of gums is very high. Consequently, the rheological characteristics of excipients are crucial when determining their importance commercially.
5. Toxicity: The OECD-recommended fixed-dose approach can be used to determine the gum's acute toxicity. (6).

### Classification of polysaccharide gums based on their origin

Polysaccharide gums can be obtained from marine origin, plant origin, animal origin, microbial origin, or modified gums. Alginic acid, agar, laminarin and carrageenans are examples of marine- or seaweed-derived gums. Gums gotten from animals consist of hyaluronic acid, chitin, chitosan, and chondroitin sulfate. Baker's yeast glycan, Xanthan, krestin, dextran, schizophyllan, scleroglucan and lentinan are examples of gums derived by microorganisms. Modified gums include methylcellulose (MC), carboxymethylcellulose (CMC), hydroxypropylmethylcellulose (HPMC), hydroxypropylcellulose, (HPC) and modified starches. Plant-derived gums are further classified as shrub or exudates from trees, such as tracaganth gum and gum arabic; extracts, such as pectin and larch gum; gums from seeds, such as guar gum and locust bean gum; and tubers and roots, such as potato starch (7; 8; 9; 10; 11; 12; 13; 14; 15). Among these sources, plant gums contribute the greatest amount of gum (16; 5)



**Figure 2.** Classification of polysaccharide gums based on their origin

### Gum and water thermodynamic relationship

The interactions of polysaccharides with water are strongly associated with the roles obtained from the chemical and physical characteristics of a gum. Curves known as moisture sorption isotherms can portray the connection between the amount of moisture in a product as well as its equilibrium relative humidity at a fixed temperature (17; 18). Actually, the thermodynamic features of sorption, for instance, the water-solute affinity and spontaneity of the sorption process, give an improved knowledge of the product's water-solute equilibrium (19). In addition, they aid in defining the entropy of water-solute systems (20).

The differential enthalpy or isosteric heat of sorption quantifies the quantity of heat that is absorbed or emitted during the sorption process at a pressure that is constant and measures the binding force between the product's water and solutes. (21). On addition of the latent heat of vaporization of free water, the integral isosteric heat of sorption which is the total amount of energy required to transport the molecules of water from the solid surface to vapor state or vice versa (20) is obtained (22). In addition, the differential entropy of a material is proportional to the number of sorption sites that are available, which corresponds to a certain energy level, and shows the motion state of the molecules of water existing in the product. (21). Entropy refer to

the amount of disorder and randomness in the motion of molecules of water and it is utilized to explain how water sorption occurs in biological materials. (23).

To construct a procedure and qualitatively comprehend the water state at a particular food surface, thermodynamic factors, such as enthalpy and entropy, are required. Changes in enthalpy determines the interface between the water molecules and the adsorbent's energy fluctuations. Entropy, in contrast, is linked with the attraction or repulsion of forces and, thus, the spatial structure of the water-adsorbent connection. Consequently, the entropy of the water-absorbent system characterizes its order or disorder (24). Gibbs free energy, on the other hand, is affected through the thermodynamic variables enthalpy and entropy and signifies the energetic spontaneity of the water-adsorbent interaction, hence supplying process energy. If the value of this property is negative, the process is spontaneous; otherwise, it is not. In complex systems, such as foods and polysaccharides, the Gibbs-free energy is dependent on pressure, temperature and also on the concentration of each component (20).

### **Food and beverage industries' use of gum**

Numerous segments of the food and beverage industry make substantial use of gums. They are commonly used to alter the texture of processed foods. They are utilized to thicken liquids and foods with a high moisture content. In addition to keeping potentially dry or brittle foods soft and flexible, they keep foods stable by preventing foods from separating, particularly when they include both fat and water.

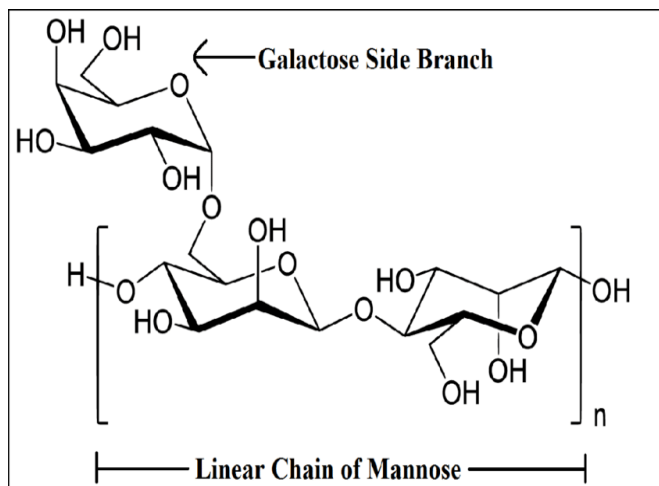
They can be used in chocolates and jellybeans with a high amount of sugar and low humidity to avoid crystallization of sugar, in salad dressings as thickening agents, emulsifiers and stabilizing agents (25), and within frozen products such as ice cream and popsicles as stabilizers (26). They can also be employed to preserve vital chemicals such as vitamin C, enhance the solubility of dehydrated substances like spray-dried juices and act as microencapsulants for oils, flavors and colors (27). In addition to their usage as taste fixatives and emulsifiers in wine clarity, they are also present in drinks and meat products (28; 29).

Tara gum is frequently used in dairy beverages to stabilize casein aggregation, hence enhancing phase separation. The product's stability and sensory acceptability are enhanced because tara gum are good stabilizing agent and decreases accessibility to casein molecules (30). It is utilized in wastewater treatment, nanoemulsion manufacturing, and micro and nano encapsulation of probiotics, dyes, essential oils, among other applications (31; 32; 33; 34; 35; 36).

### **The food and beverage industries applications of some polysaccharide gums**

Guar gum is produced from guar or Indian cluster bean and can be used in stabilizing, emulsifying, and thickening the texture of foods such as yoghurt, almond milk, etc. Additionally, it functions as a binder in gluten-free recipes. Guar is harvested from *Cyanopsis tetragonolobus* seeds, a commercially grown legume in Pakistan and India. Guar gum is identified as a galactomannan. It has a molecular weight of around 220,000 Daltons. It is composed of a Dmannse units on a straight chain linked by  $\beta$ -D-1,4- connections, and a D-galactose side chain is attached to almost alternating mannose unit (37). The mannose to galactose ratio is known to be 2:1 for a while, the exact sequence of galactose residues remains unknown.

When hydrated in cold water, guar gum has the capacity to produce a viscous colloidal dispersion (38). On heating, the gum's hydration level increases. In solution, guar gum is employed as a viscosity booster, stabilizer, and water binder. It is used to enhance the texture of bakery items, pie and pudding fillings, ice cream, soft cheeses, infant foods, tinned foods, instant mixes, as well as in pet foods, soups, and sauces (39; 40).



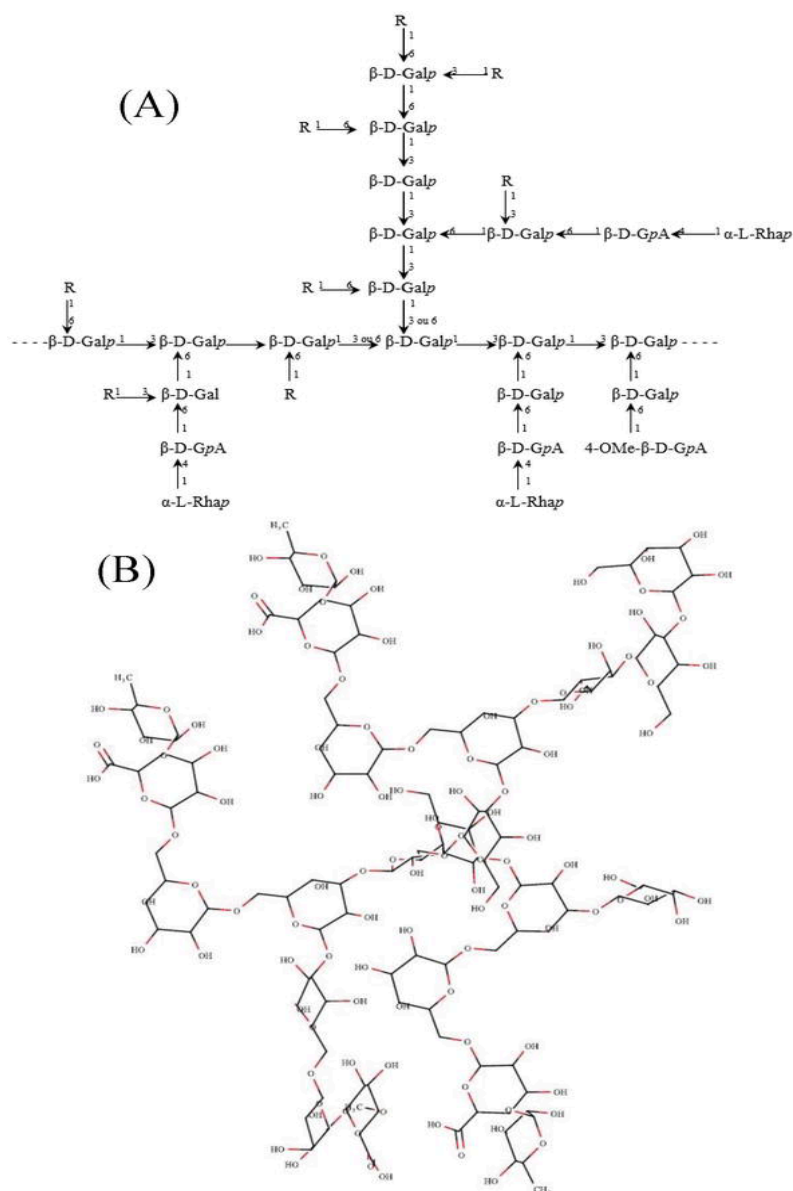
**Figure 3.** Structure of guar gum

### Acacia gum (gum arabic)

Gum Arabic has many uses in the food sector, it is used to emulsify and stabilize flavored goods, such as microencapsulated citrus flavors, as well as health foods. Gum Arabic is employed to coat in confectionery and pastry products and as a suspending agent in soft beverages (41). Acacia gum is included in essential oils, dairy and soybean products, tinned foods, soft beverages, cough syrups and marshmallows because it keeps together mixes that would not normally combine well. Historically, gum Arabic can be employed in the binding and also as a medium for coloring agents and inks. It is derived from the acacia tree's sap.

Acacia senegal provides the origin of gum arabic, is among the most known and commercially available gums (41). It consists of a primary chain produced of  $\beta$ -D-galactopyranose linked by bonds (1 $\rightarrow$ 3), alternating by highly branched bonds (1 $\rightarrow$ 6), and lateral chains made of 4-O-methyl-glucuronic acid which is 1.5 percent, glucuronic acid which is 17.5 percent, galactose which is 39 percent, arabinose which is 28 percent, and rhamnose which is 14 percent (42). Anderson; Hirst; Stoddart (43) suggested the arrangement shown in figure 4. The authors show that those represented by the radical "R" as possible replacement units: (L-Araf); (L-Araf 1 $\rightarrow$ 3 L-Araf); ( $\beta$ -L-Arap 1 $\rightarrow$ 3 L-Araf); (L-Araf 1 $\rightarrow$ 3 L-Araf 1 $\rightarrow$ 3 L-Araf); ( $\beta$ -L-Arap 1 $\rightarrow$ 3 L-Araf 1 $\rightarrow$ 3 L-Araf); ( $\beta$ -D-Galp 1 $\rightarrow$ 3 L-Araf). Arabinofuranoside is denoted by the symbol Araf, arabinopyranoside by the symbol Arap, and galactopyranoside by the symbol Galp. In Figure 4B, the radicals "R" are not present.

Gum Arabic stands out among natural hydrocolloids because of its very soluble in water in addition with the low viscosity of its concentrated solutions. Gum Arabic's solubility, viscosity, and protein concentration impart it with its well-known stabilizing and emulsifying properties (45).



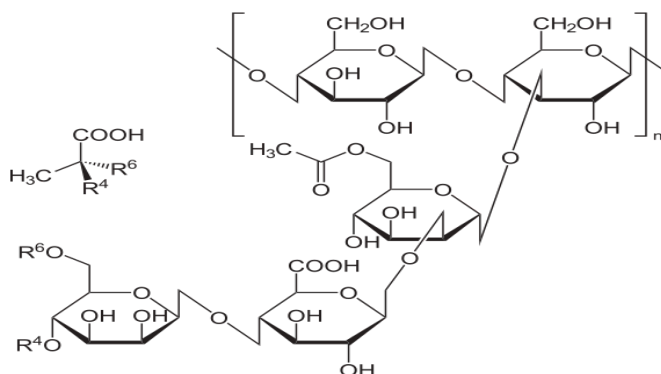
**Figure 4.** Gum Arabic structural piece (*Acacia senegal*). Referring to the fragment in (A), a scheme, and (B), a three-dimensional structure

### Xanthan gum

Xanthan gum is a stabilizer and thickener commonly found in gluten-free baked goods, as well as in ice cream, puddings, jams, sauces, and fillings for pastries. Xanthan gum has a non-gelling property and is one of the most often used gums in the food sector. Xanthan gum has been utilized to provide long-term stability, high viscosity, ice crystal management, heat shock protection, and improved transfer characteristics in the course of production in dairy products such as sour cream, ice cream, and sterile whipped cream. Xanthan gum aids in incorporation of air, smoothing and retention in baked foods. Xanthan gum can be blended with dry cake ingredients to provide even batter mixing and hydration, which is crucial to the general shelf-life and quality of the cake.

Xanthan gum exists as an anionic polysaccharide which is formed by bacterium *Xanthomonas campestris* (46). It can be deduced from its chemical composition that xanthan has a cellulose backbone (47), that is a glucose molecules that has a branch at carbon-3 atoms and are joined by a 1,4-glycoside bond. D-mannopyranose-(2,1)-D-glucuronic acid-(4,1)-D-mannopyranose is present in the branches. Below 40% of the terminal mannose units contain a pyruvic acid group connected as a ketal at its 4 and 6 locations, while the inner mannose units are 6-Oacetylated.

The branching is asymmetrical, and some branches may not be present (48). The primary structure of xanthan gum is shown in figure 5 (49).



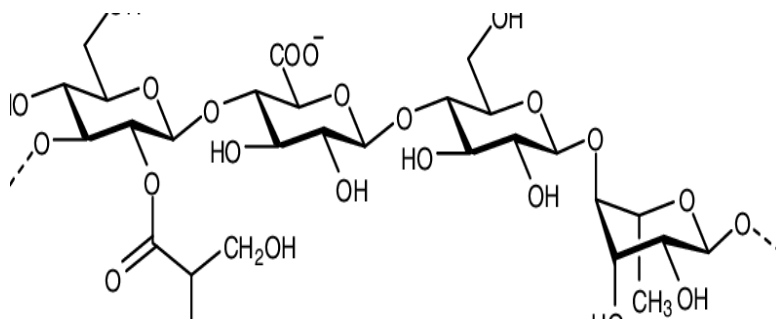
**Figure 5.** Primary structure of Xanthan gum

### Gellan gum

Gellan gum acts as a bulking emulsifying, stabilizing and thickening agents in food. It is commonly found in sauces, confectionery items, jams, baked products and ice cream. It exists typically in cosmetics and vegan meals. Gellan gums can be found in sugar confectionery, dairy products and dessert jellies as gelling agents.

It can be formed by the fermentation of *Sphingomonas paucimobilis* (formerly *Pseudomonas elodea*) (50; 51; 52). It is a linear heteropolysaccharide which comprises of repeating units of D-glucuronic acid (D-GlcA), L-rhamnose (L-Rha), and D-glucose, (D-Glc), and forming a tetrasaccharide structure  $\rightarrow 3\text{-}\beta\text{-D-Glcp-(1}\rightarrow 4\text{)-}\beta\text{-D-GlcpA-(1}\rightarrow 4\text{)-}\beta\text{-D-Glcp-(1}\rightarrow 4\text{)-}\alpha\text{-L-Rhap-(1}\rightarrow$  in the proportion of 2 to 1 to 1 (53). On the D-glucosyl residue next to the D-glucuronyl residue, O-Acetyl and L-glyceryl groups are present as side chains (54). Based on the degree of acylation and on the present ions, Gellan gum has different functionality. Low acyl or Kelcogel and high acyl or Kelcogel LT 100 are the two commercially available variants (55). Brittle gels can be created with low acyl gellan gum, whereas high acyl gellan gum is utilized to create elastic, gels. The qualities of classic gelatin dessert jellies can be improved with low-acyl gellan gum. Gellan gum is a substance that is used to create structured liquids (56).

Both types of gellan gum cannot be dissolved in cold water, however the gum powder may be easily dissolved in water by swirling and adding it gently.

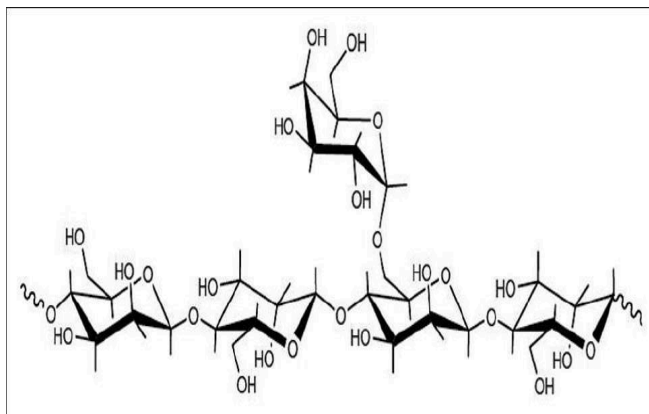


**Figure 6.** Structure of gellan gum

### Locust bean gum (carob bean gum)

Carob tree seeds (*Ceratonia siliqua* L.) are processed to extract a natural hydrocolloid called locust bean gum (seed coat) (57; 58). It is usually applied in sweetening of food and can be

used in replacement of chocolate because of its sweet flavor. It can be dissolved in hot water and has a long shelf life, making it appropriate for use in powdered hot chocolate mixtures. The quality of the gum can be made known by the degree and quality of the separation process (59). Together with Guar Gum, it consists of a neutral polysaccharides known as the galactomannan polysaccharides, (60) with a 1,4-linked  $\beta$ -D-mannopyranosyl backbone largely replaced with a single 1,6-linked  $\alpha$ -D-galactopyranosyl side group. (59; 60). Locust bean gum basic structural fragment of is presented in figure 7 (61).

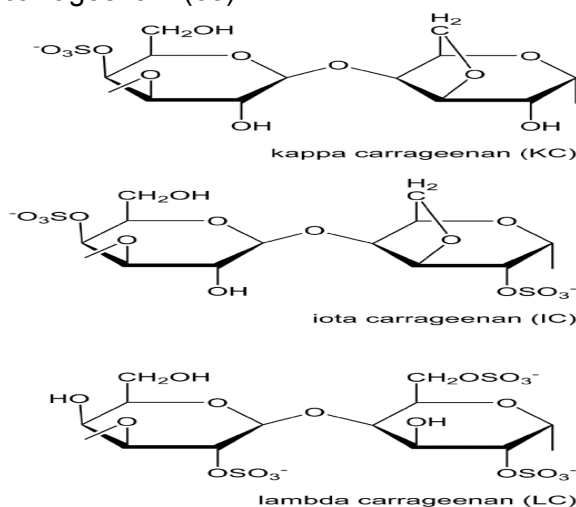


**Figure 7.** Locust bean gum has a linear polysaccharide structure (1-4)- $\beta$ -linked mannose unit backbone with single (1-6)- $\alpha$ -D-galactose units attached

### Carageenan

Carageenan gum is a polysaccharide which can be obtained from red algae and it is indigestible. It can be used in cottage cheese, ice cream, soy milk, yogurt and other processed foods to improve their texture by acting as a thickening and emulsifying agent. Carageenan gum has two classifications which include the undegraded (which can be used in food) and degraded (which cannot be used in food).

Carrageenan gum comprises of a disaccharide backbone comprising alternating 3-linked  $\beta$ -D-galactopyranose and 4-linked  $\alpha$ -D-galactopyranose units, also known as G and D units, according to Knutsen's nomenclature (62). According to the location of sulfation (S) (63), and the cyclization of the D units to form an anhydro ring (A), they may be identified. Industrial examples include kappa- carrageenan (G4S-DA), iota- carrageenan (G4S-DA2S), and lambda-carrageenan (non-gelling) (G2S-D2S,6S) (64). Figure 8 depicts the fundamental disaccharide units that provide diverse carrageenan. (65).



**Figure 8.** Structures of alternating units in carrageenans

## CONCLUSION

Gums, whether used alone or in combination, have an extensive range of applications and serves as a major contributor towards the enhancement of food processing and production. The applications of polysaccharide gums in the food industries are very diverse. They can be used in various sector of the food industries and can be used to improve taste, texture and also in stabilization. In light of this, it is crucial to promote the exploration of new sources of gums in order to learn more about their advantages and applications.

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