Paper No. 01

Paper Title: Food Chemistry

Module-07: Pectins and Gums

Hydrocolloids or gums are a diverse group of long chain polymers characterized by their property of forming viscous dispersions and/or gels when dispersed in water. These materials were first found in exudates from trees or bushes, extracts from plants or seaweeds, flours from seeds or grains, gummy slimes from fermentation processes, and many other natural products. Occurrence of a large number of hydroxyl groups noticeably increases their affinity for binding water molecules rendering them hydrophilic compounds. Further, they produce a dispersion, which is intermediate between a true solution and a suspension, and exhibits the properties of a colloid. Considering these two properties, they are appropriately termed as 'hydrophilic colloids' or 'hydrocolloids'.

Hydrocolloids have a wide array of functional properties in foods including; thickening, gelling, emulsifying, stabilization, coating and etc. Hydrocolloids have a profound impact on food properties when used at levels ranging from a few parts per million for carrageenan in heat-treated dairy products to high levels of acacia gum, starch or gelatin in jelly confectionery. The primary reason behind the ample use of hydrocolloids in foods is their ability to modify the rheology of food systems. This includes two basic properties of food systems that is, flow behavior (viscosity) and mechanical solid property (texture). The modification of texture and/or viscosity of food systems helps modify its sensory properties, therefore hydrocolloids are used as significant food additives to perform specific purposes. It is evident that several hydrocolloids belong to the category of permitted food additive in many countries throughout the world. Various food formulations such as soups, gravies, salad dressings, sauces and toppings use hydrocolloids as additives to achieve the preferred viscosity and mouth feel. They are also used in many food products like icecreams, jams, jellies, gelled desserts, cakes and candies, to create the desired texture.

In addition to the functional attributes, future acceptance and, possibly, positive endorsement may derive from the recognition that fibers contribute many physiological benefits to the natural function and well-being of the body. The aim of this chapter of the book is to highlight the importance of the hydrocolloids in food industry.

Pectins and Gums

Pectins and gums are important polysaccharides in foods because of their functional properties. They are widely used as gelling agents, thickeners, and stabilizers. They are constituents of plant tissue and are large, complex molecules whose exact nature is not certain. However, enough is known to understand some of their properties and to make use of their functional properties to produce convenience and special texture foods.

Pectic Substances

Pectic substances including protopectin, pectinic acid, and pectic acid are an important constituent of plant tissue and are found mainly in the primary cell wall. They also occur between cell walls, where they act as intercellular cement. Although their exact nature is not clear, they can be considered as linear polymers of d-galacturonic acid joined by α-1,4-glycosidic linkages, as shown in Figure 7.1. Some of the acid or carboxyl (COOH) groups along the chain are esterified with methanol (CH3OH) as shown.

Each glycosidic linkage is a ***cross-planar*** bond, because it is formed by reaction of one hydroxyl group located above the plane of the first ring with another hydroxyl group located below the plane of the second ring. The configuration of these bonds causes twisting of the molecule, and the resulting polymer can be linkened to a twisted ribbon. Cross-planar bonds are not readily digested in the human digestive tract, and so pectins are classified as soluble fiber.

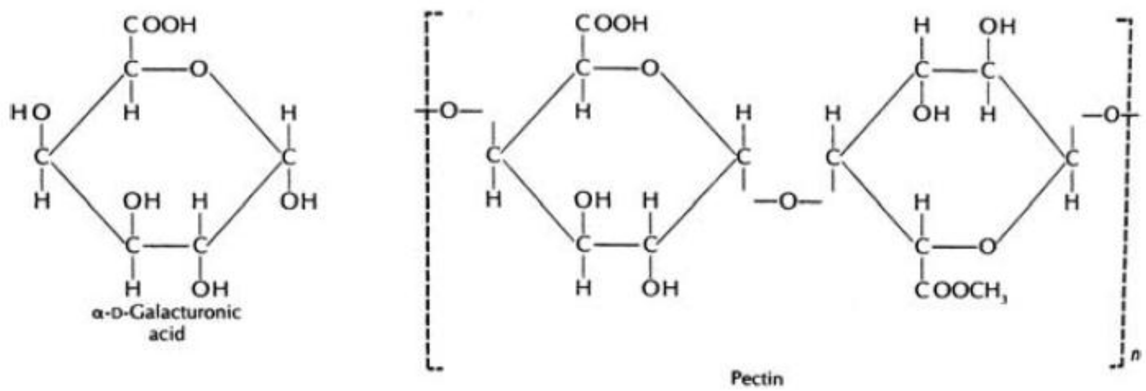

Figure 7.1. Basic Structure of pectic substances

Pectic substances may be grouped into one of the three categories depending on the number of methyl ester groups attached to the polymer. ***Protopectin*** is found in immature fruits and is a high-molecular-weight methylated galacturonic acid polymer. It is insoluble in water but can be converted to waterdispersible pectin by heating in boiling water. It cannot form gels. ***Pectinic acid*** is a methylated form of galacturonic acid that is formed by enzymatic hydrolysis of protopectin as a fruit ripens. High-molecular-weight pectinic acids are known as pectins. Pectinic acids are dispersible in water and can form gels. ***Pectic acid*** is a shorter-chain derivative of pectinic acid that is formed as fruit overripens. Enzymes, such as polygalacturonase and pectinesterase, cause depolymerization and demethylation of the pectinic acid, respectively. Complete demethylation yields pectic acid, which is incapable of gel formation.

Pectins

Pectins are high-molecular-weight pectinic acids and are dispersible in water. Some of the carboxyl groups along the galacturonic acid chain are esterified with methanol. The degree of esterification in unmodified pectins ranges from about 60% in apple pulp to about 10% in strawberries. (Pectins can be deliberately deesterified during extraction or processing.) According to the degree of esterification, pectins are classified as ***high methoxyl*** or ***low methoxyl*** pectins. The two groups have different properties and gel under different conditions. ***Low-methoxyl pectins***. Low-methoxyl pectins contain mostly free carboxyl groups. In fact, only 20–40% of the carboxyl groups are esterified. Therefore, most of them are available to form cross-links with divalent ions such as calcium, as shown in Figure 7.2.

If sufficient cross-links are formed, a three-dimensional network can be obtained that traps liquid, forming a gel. Low-methoxyl pectins thus can form gels in the presence of divalent ions without the need for sugar or acid. ***High-methoxyl pectins***. High-methoxyl pectins contain a high proportion (usually 50–58%) of esterified carboxyl groups. Most of the acid groups therefore molecules for each other must be ***increased***. This can be achieved by addition of sugar and acid.

Sugar competes for water, thus making less water available to associate with the pectin molecules. This reduces the attractive forces between the pectin and water molecules.

Acid adds hydrogen ions, reducing the pH. (The pH must be below 3.5 for a gel to form.) Carboxylic acids contain a ***carboxyl group*** (COOH), are weak acids, and are not fully ionized in solution; the un-ionized form of the acid exists in equilibrium with the ionized form.

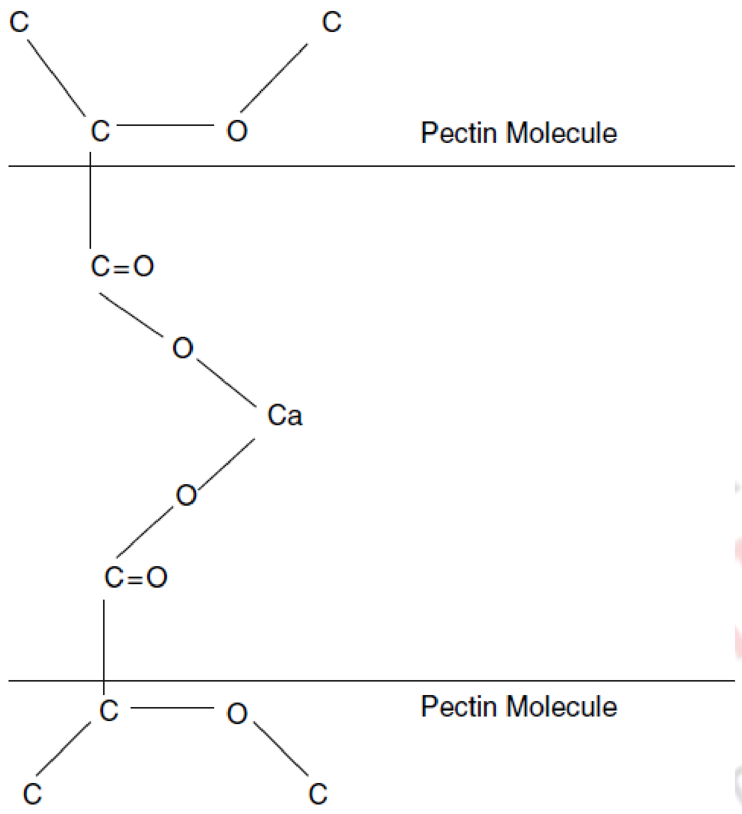

Figure 7.2. Cross-links in low-methoxy pectin

When hydrogen ions are added, they react with some of the ionized carboxyl groups to form undissociated acid groups. In other words, the equilibrium is shifted to the left and more of the carboxylic acid is present in the un-ionized form. Thus, when hydrogen ions are added to pectin, the ionization of the acid groups is depressed and the charge on the pectin molecules is reduced. As a result, the pectin molecules no longer repel each other. In fact, there is an attractive force between the molecules and they align and interact at specific regions along each polymer chain to form a three-dimensional network. These regions of interaction are called ***junction zones***, shown diagrammatically in Figure 7.3. However, there also are regions of the pectin chains that are not involved in junction zones because they are unable to interact with each other. These regions form pockets or spaces between the junction zones that are able to entrap water. Hence, a gel is formed, with water trapped in the pockets of the three-dimensional pectin network.

Exactly how the junction zones form is not certain, but hydrogen bonds are thought to play an important role. The ***steric fit*** of the molecules (in other words, their ability to fit together in space) also is important. Pectin molecules contain minor components such as rhamnose and other neutral sugars that are bound to the main galacturonic acid chain by 1-2-glycosidic links. These sugars cause branches or kinks in the molecules and make it difficult for them to align and interact to form junction zones. However, there are regions of the pectin chains that do not contain these neutral sugars and it is these regions that are thought to form the junction zones. High-methoxyl pectins form gels in this way. Low-methoxyl pectins require divalent ions to gel and intermediate pectins require sugar, acid, and divalent ions to gel.

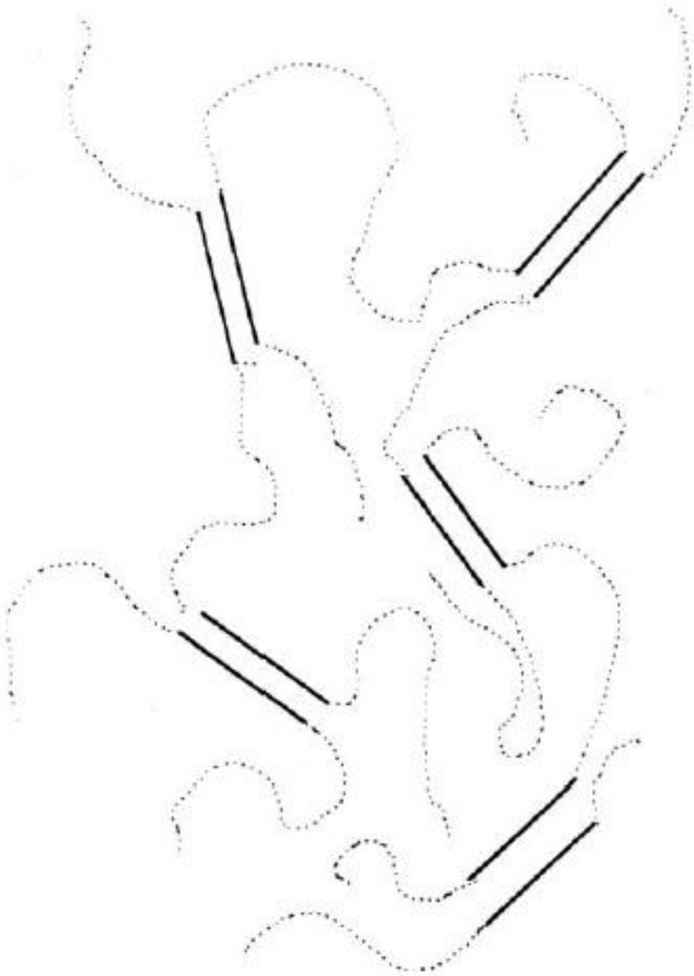

Figure 7.3. Junction zones in a pectin gel.

Pectin Sources

Pectins with a high-molecular weight and a high proportion of methyl ester groups have the best jelly-forming ability. The pectin content of fruits is variable and depends not only on the type of fruit but also on its maturity or ripeness. Purified pectin is made from apple cores and skins (apple pomace) and from the white inner skin (albedo) of citrus fruits. It is available in either liquid or granular form. The granular products have a longer shelf life than the liquids. Low-methoxyl pectin can be obtained by demethylating pectin with enzymes, acid, or alkali until it is 20–40% esterified. Because these pectins gel with divalent ions and need no sugar, they can be used commercially for the production of low-calorie jams, jellies, or desserts. They also have been introduced to the retail market so that such low-calorie products may be made at home.

Gums

Gums are a group of complex hydrophilic carbohydrates containing thousands of monosaccharide units. Galactose is the most common monosaccharide found in gums; glucose is usually absent. Gums are often referred to as ***hydrocolloids***, because of their affinity for water and their size; when added to water, they form stable aqueous colloidal dispersions or sols. The molecules are highly branched and as a result most gums are unable to form gels. However, they are able to trap or bind large amounts of water within their branches. Aqueous dispersions therefore tend to be very viscous, because it is difficult for the molecules to move around freely without becoming entangled with each other.

Gums are classified as soluble fiber because they undergo little digestion and absorption in the body. Therefore, they supply relatively few calories to the diet, as compared with digestible carbohydrates such as starch. Gums are common in a wide range of food products, including salad dressings, sauces, soups, yogurt, canned evaporated milk, ice cream and other dairy products, baked goods, meat products, and fried foods. They are used as thickening agents in food products, replacing starch. They also are used to assist in the stabilization of emulsions and to maintain the smooth texture of ice cream and other frozen desserts. They are common in reduced fat products, because they are able to increase viscosity and help to replace the texture and mouthfeel that was contributed by the fat. Gums are obtained from plants and can be separated into five categories: seed gums, plant exudates, microbial exudates, seaweed extracts, and synthetic gums derived from cellulose.

Seed Gums

The seed gums include guar and locust bean gums. These gums are branched polymers containing only mannose and galactose. Guar gum contains a mannose/galactose ratio of 2:1, whereas the ratio is 4:1 in locust bean gum. Guar gum is soluble in cold water, whereas locust bean gum must be dispersed in hot water. Neither gum forms a gel when used alone. However, they may be used synergistically with other gums to form gels.

Guar gum forms gels with carrageenan and guar gum. It is used to stabilize ice cream and it also is found in sauces, soups, and salad dressings. The presence of guar gum in the intestine seems to retard the digestion and absorption of carbohydrates and slow absorption of glucose into the bloodstream. Use of guargum in foods therefore may be useful in treating mildcases of diabetes (4). Locust bean gum typically is used as a stabilizer in dairy and processed meat products. It also may be used synergistically with xanthan gum to form gels.

Plant Exudates

The plant exudates include gum arabic, which comes from the acacia tree, and gum tragacanth. These are complex, highly branched polysaccharides. Gum Arabic is highly soluble in cold water and is used to stabilize emulsions and to control crystal size in ices and glazes. Gum tragacanth forms very viscous sols, and is used to impart a creamy texture to food products. It also is used to suspend particles and acts as a stabilizer in products such as salad dressings, ice cream, and confections.

Microbial Exudates

Xanthan gum, gellan gum, dextran, and curdlan are all gums produced using fermentation by microorganisms. Of these, *xanthan* is the most common. Xanthan forms viscous sols that are stable over a wide range of pH and temperature. It does not form a gel, except when used in combination with locust bean gum. It is used in a wide range of products as a thickener and stabilizer and suspending agent. Most salad dressings contain xanthan gum.

Seaweed Polysaccharides

The ***seaweed polysaccharides*** include the agars, alginates, and carrageenans. Unlike most other gums, they are able to form gels under certain conditions. **Carrageenan** is obtained from red seaweeds, especially from Irish moss. It occurs as three main fractions, known as kappa, iota, and lambda carrageenan. Each is a galactose polymer containing varying amounts of negatively charged sulfate esters. Kappa carrageenan contains the smallest number of sulfate esters, and therefore is the least negatively charged. It is able to form strong gels with potassium ions. Lambda carrageenan contains the largest number of sulfate groups and is too highly charged to form a gel. Iota carrageenan forms gels with calcium ions. The carrageenan fractions generally are used in combination. Several different formulations are available, containing different amounts of the individual fractions, and food processors are able to choose formulations that best fit their needs.

The carrageenans are used to stabilize milk products such as ice cream, processed cheese, canned evaporated milk, and chocolate milk, because of their ability to interact with proteins. The carrageenans also may be used with other gums, because of their ability to cross-link with them.

Agar also is obtained from red seaweeds. It is noted for its strong, transparent, heat-reversible gels; that is, agar gels melt on heating and reform when cooled again. Agar contains two fractions - agarose and agaropectin - both of which are polymers of β-d- and α-l-galactose. Agaropectin also contains sulfate esters.

The **alginates** are obtained from brown seaweeds. They contain mainly d-mannuronic acid and l-guluronic acid and they form gels in the presence of calcium ions. Calcium alginate gels do not melt below the boiling point of water; thus, they can be used to make specialized food products. Fruit purees can be mixed with sodium alginate and then treated with a calcium-containing solution to make reconstituted fruit. For example, if large drops of cherry/alginate puree are added to a calcium solution, convincing synthetic cherries are formed. Reconstituted apple and apricot pieces for pie fillings also can be made by rapidly mixing the sodium alginate/fruit puree with a calcium solution and molding the gel into suitable shapes.

Synthetic Gums

Cellulose is an essential component of all plant cell walls. It is insoluble in water and cannot be digested by man, so it is not a source of energy for the body. It is classified as insoluble fiber. The polymer contains at least 3000 glucose molecules joined by β-1, 4-glycosidic linkages. Long cellulose chains may be held together in bundles forming fibers, as in the stringy parts of celery. Synthetic derivatives of cellulose are used in foods as *nonmetabolizable* bulking agents, binders, and thickeners. *Microcrystalline cellulose,* known commercially as Avicel (FMC Corp.), is used as a bulking agent in low-calorie foods. It is produced by hydrolysis of cellulose with acid.

Carboxymethyl cellulose (CMC) and *methyl cellulose* (MC) are alkali-modified forms of cellulose. The former is the most common and it often is called simply *cellulose gum*. It functions mainly to increase the viscosity of foods. It is used as a binder and thickener in pie fillings and puddings; it also retards ice crystal growth in ice cream and the growth of sugar crystals in confections and syrups. In dietetic foods, it can be used to provide the bulk, body, and mouthfeel that normally would be supplied by sucrose. *Methyl cellulose* forms gels when cold dispersions are heated. It is used to coat foods prior to deep fat frying, in order to limit absorption of fat. Two other forms of modified cellulose include *hydroxypropyl cellulose* and *hydroxypropylmethyl cellulose*. These also are used as batters for coating fried foods.

Functional properties

1 Viscosity enhancing or thickening properties

The foremost reason behind the ample use of hydrocolloids in foods is their ability to modify the rheology of food system. The modification of texture and/or viscosity of food system helps to modify its sensory properties, and hence, hydrocolloids are used as important food additives to perform specific purposes. The process of thickening involves nonspecific entanglement of conformationally disordered polymer chains; it is essentially polymer-solvent interaction. Hydrocolloids that have been used as thickening agents are shown in Table 1. The thickening effect produced by the hydrocolloids depends on the type of hydrocolloid used, its concentration, the food system in which it is used and also the pH of the food system and temperature.

	Film forming material		Principal function
Polysaccharide	Agar		Gelling agent
	Alginate		Gelling agent
	Carrageenan		Gelling agent
	Cellulose derivatives	CMC HPC HPMC MC	Thickener Thickener and emulsifier Thickener Thickener, emulsifier and gelling agent
	Chitosan		Gelling agent Antimicrobials
	Gum	Arabic gum Guar gum Xanthan gum	Emulsifier Thickener Thickener
	Pectin		Gelling agent
	Starches		Thickener and gelling agent
protein	Gelatin	Bovine gelatin Fish gelatin Pig gelatin	Gelling agent Gelling agent Gelling agent

Table 1. Hydrocolloidal materials that have been studied extensively for the formation of edible films and coatings in foods.

2 Gelling properties

Swollen particulate forms of gelled hydrocolloids are particularly useful as they combine macroscopic structure formation with an ability to flow and often have an attractive soft solid texture, which is especially sought in food applications, all at high water contents (>95%). There is a potential opportunity for particulate hydrocolloid systems to replace chemically cross-linked starches based on appropriate structuring, processing, and molecular release properties without the need for chemical treatment. The characteristics of gel particles, and the application for which they are used, will depend on the type of hydrocolloid, the network formation mechanism and the processing method used for particle formation.

3 Surface activity and emulsifying properties

The functionality of hydrocolloids as emulsifiers and/or emulsion stabilizers correlates to phenomena such as: retardation of precipitation of dispersed solid particles, decreased creaming rates of oil droplets and foams, prevention of aggregation of dispersed particles, prevention of syneresis of gelled systems containing oils and retardation of coalescence of oil droplets. It is believed that gums will adsorb (onto solid or liquid surfaces) very slowly, weakly and with very limited surface load if at all. The hydrocolloids were classified according to their activity at the interface. Gum Arabic is probably the most studied hydrocolloid that proved significant surface activity. Gum arabic is the only gum adsorbing onto oil-water interfaces and imparting steric stabilization. Other gums such as galactomannans, xanthan, pectin, etc. have been known to reduce surface and interfacial tensions, to adsorb onto solid surfaces and to improve stability of oil-in-water emulsions. Micro crystalline cellulose (MCC) is an example of a hydrocolloid with no solubility in water that adsorbs mechanically at the interface.

4 Gums as edible films and coatings

An edible film is defined as a thin layer, which can be consumed, coated on a food or placed as barrier between the food and the surrounding environment. The most familiar example of edible packaging is sausage meat in casing that is not removed for cooking and eating. Hydrocolloids are used to produce edible films on food surfaces and between food components. Such films serve as inhibitors of moisture, gas, aroma and lipid migration. Many gums and derivatives have been used for coating proposes. They include alginate, carrageenan, cellulose and its derivatives, pectin, starch and its derivatives, among others. Since these hydrocolloids are hydrophilic, the coatings they produce have nature limited moisture barrier properties. The Hydrocolloid edible films are classified into two categories taking into account the nature of their components: proteins, polysaccharides or alginates. Hydrocolloidal materials, i.e. proteins and polysaccharides, used extensively for the formation of edible films and coatings are presented in Table 1.

5 Gums as fat replacers

The changes in modern lifestyle, the growing awareness of the link between diet and health and new processing technologies have led to a rapid rise in the consumption of ready-made meals, novelty foods and the development of high fiber and low-fat food products. Calorie dense materials such as fats and oils may be replaced with 'structured water' to give healthy, reduced-calorie foods with excellent eating quality. In particular, numerous hydrocolloid products have been developed specifically for use as fat replacers in food. This has consequently led to an increased demand for hydrocolloids. As an example, the Italian dressing includes xanthan gum as a thickener and the 'Light' mayonnaise contains guar gum and xanthan gum as fat replacers to enhance viscosity.

The traditional approach is the partial replacement of fat using starches which, when dissolved in water, create stable thermo-reversible gels. Soft, fat-like gels can be created by conversion modifications to the degree necessary to produce thermo-reversible, spreadable gels. Typically, 25–30% solids, i.e. starch in water, form an optimal stable structure for fat replacement. New generation fat replacers are tailored to mimic more closely the many and complex properties of fats or oils in a particular application. These are referred to as fat mimetics. Maximising the synergies of functional ingredients such as hydrocolloids generally in combination with specific starch fat mimetics can mean that 100% fat reduction is achievable.

Gums in the production of special products

1 Soft gelatin capsules

Liquid foods, as well as instant (soluble) coffee and other food powders, can be conveniently contained in a gelatin capsule. The interior of the capsule contains a suitable instant food which dissolves or disperses promptly upon addition of water. The capsule is maintained in a dry form in a suitable enclosure, such as a hermetically sealed bottle, blisterpack packaging or the like, until use. Soft gelatin capsules are commonly used in food supplements. Gelatin is the basic capsule shell component and it is formulated with suitable ingredients to encapsulate a wide variety of materials. Gelatin's special properties are of particular interest in foods since it acts as a barrier and protects liquid capsule contents from the outside environment. On the one hand, gelatin acts as a physical barrier to bacteria, yeasts and molds. On the other, it provides a low-permeability membrane to gases. The gelatin shell is transparent, can be formed in a wide range of sizes and shapes and dissolves quickly in hot water, releasing its encapsulated liquid. The advantages of encapsulation are: portion control, easy use and storage, extended shelf-life, improved aesthetic appeal, the variety of sizes available, disposability and edibility, improved product aromatics versus time, and biodegradability.

2 Liquid-core capsules

Liquid-core hydrocolloid capsules are liquids encapsulated in a spherical polymer membrane. Production of these capsules included suspending cells in a sodium alginate solution, forming small spherical calcium alginate beads by cross-linking with calcium salt, and reacting with polylysine to create a polylysine alginate membrane around the bead. In the final stage, the bead's core, composed of calcium alginate gel, was solubilized, thus forming a liquid-core micro-capsule containing cells.

3 Jelly-like foods

Natural gums are used in the confectionary industry. At one time, guar was used for production of jellies (candies) and marshmallows, and gum arabic was used gum drops. The gum within the formulation served to form *jelly*, but an additional function was to prevent sugar crystallization and to emulsify fat, keeping it evenly distributed within the product. The gum powder swells and gels when added to water and heated. Its gels are thermally irreversible and unaffected by further addition of water and can be produced over a pH range of 2.0-9.5 in the presence of many food additives. The gels may be used to make novel food products consisting of a jelly-like skin with a liquid core, and canned jellies. The concentration of the polysaccharide in water must be greater than 1.5% for gel stability and less than 0.6% for taste acceptability. The gels are freeze-thaw stable and may be used to make an ice confection contained in an elastic gel skin.

4 Fruit products

A combination of compression and shearing forces is used to extract juice from fruits or vegetables. For pulp production, and in the case of grapes, tomatoes or other soft fruits, are heated, if necessary, to soften their tissues and pulp is forced through the perforations of the pulping equipment's screen, the size of which determines the consistency of the resultant product. Unique uses of such fruit products (i.e. juice, pulp or puree) for production of soft viscous, fruit-based, membrane-coated items by a membrane were described decades ago. For example fruit juice, pulp or puree containing soluble Ca salt is extruded to form drops which are coated with a thin skin of alginate or pectate sol. The coated drops are exposed to an aqueous setting bath containing a soluble Ca salt. Drops of aqueous fruit material are coated with an aqueous alginate or pectate solution and applied in a solution containing Ca or Al ions to gel the surface.

5 Frozen product

Frozen desserts are mixtures of ice crystals in flavored liquid syrup. The most common frozen dessert is ice cream. During the last 50 years, a huge change in the texture of icecream products has occurred. Gum karaya can be used as a stabilizer in ice cream, ice milk, mellorine and related products. In ice pops and sherbets, formation of large ice crystals and syneresis can be prevented by including 0.2-0.4% gum karaya. Combinations of 0.15% gum karaya and 0.15% LBG can be used successfully for ice pop stabilization. Karaya, as well as carrageenan, can be used as a binder and emulsifying agent in quantities of less than ~1%. The binders are used to absorb the water resulting from the ice during chopping. Sodium CMC in its highest purified form is used in many food applications. In frozen desserts (such as ice cream), cellulose gum inhibits the formation of ice crystals. Gum arabic, because of its water-absorbing properties, gum inclusion inhibits the formation and growth of ice crystals. Other stabilizers, such as carrageenan and locust bean gum, can be used for the same purposes. Guar gum is used in the food industry for its ability to bond and immobilize large amounts of water. This property contributes to inhibition of ice crystal formation, product texture, stabilization of product consistency to changes in temperature, and viscosity.

Frozen doughs are widely used in industrial bakeries to make baking more profitable. However, loaf volumes are usually smaller and quality poorer for breads baked from frozen doughs, especially in those with low fat content. Addition of hydrocolloids such as CMC, alginate, and different blends in quantities of up to 1.5% yielded higher total dough water content without changing baking properties.

6 Candies

Candies are popular products among children and adults and their versatility is visually alluring as well as pleasing to the consumer. The confectionery industry uses gum arabic to a great extent, for crystallization prevention, as an emulsification agent of fat and as a glaze in candies, chewing gum. Gum arabic serves to coat the center of sugar-coated tablets. It is the main ingredient in gumdrops (regular and dietetic) and other chewy-type gums, where pectin or modified starches can also play a major role. The incorporation of sorbitol, mannitol and gum arabic can produce dietetic candies. The higher the gum Arabic content, the softer and chewier the candy.

7 Fabricated foods

Using fish, meat, fruit or vegetables as main ingredients within a matrix, which is usually produced from a gum, can create fabricated foods. Gums were incorporated into meat products to achieve better control of their texture, improve sliceability and increase yield. In some meat products, hydrocolloids are responsible for the undesirable broad dark striations (called tiger stripping), running parallel to the meat fibers. The swelling ability of the type of carrageenan used influences its activity within the product. Semi-refined carrageenan (less swelling) improved performance in injected poultry by reducing the incidence of tiger stripping without reducing purge controls.

Fabricated fruit is easily manufactured with alginates. A gel is readily formed when a soluble calcium salt is added to a sodium alginate solution. This gel is stable over a wide range of temperatures, has excellent syneresis control, and is irreversible to heat. Possible uses for this fabrication concept include imitation cocktail cherries; imitation glazed fruit pieces for cakes, breads, cookies, ice cream and candy products; icing; and gelled products containing pureed fruit.

Conclusion

Pectins and seaweed polysaccharides are useful for various food products because of their gelling ability. In general, gums are important because they form very viscous solutions, but most do not gel. All these carbohydrates are important to the food industry because of their functional properties and their ability to produce foods with special textures. Used in a wide range of food products as gelling agents, thickeners, and stabilizers, their availability has increased the choice and quality of many convenience foods. Synthetic derivatives of cellulose are important as nonmetabolizable bulking agents, thickeners, and stabilizers in a wide range of calorie-reduced foods.