Hydrocolloids: Structure, preparation method, and application in food and pharmaceutical industries

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Abstract

Hydrocolloids are hydrophilic biopolymers with high molecular weight that act as thickeners, gelling agents, and foam and emulsion stabilizers. Also hydrocolloids act as inhibitors of the growth and expansion of ice crystals in frozen materials, and inhibitors of the growth of sugar crystals in different industries. Hydrocolloids are used not only to improve the rheological and textural properties of food products, but also are used as fat substitutes. Also hydrocolloids are used in the production of low-calorie foods and also their beneficial nutritional properties (non-absorbable fiber in the human body) causes their extensive application in the food industry. Although the use of hydrocolloids in food systems is low and in concentrations of one percent and less, but the presence of hydrocolloids has an important effect on the texture and organoleptic properties of diet foods. Food hydrocolloids or gums are high molecular weight hydrophilic biopolymers that are used as functional compounds in the food industry. Hydrocolloids are the most widely used additive in the food industry that have a variety of properties and applications, including dietary fiber as well as gluten and fat substitutes. Hydrocolloids are obtained from plants, animals, microorganisms, and modified biopolymers. Zedo gum is one of the plant hydrocolloids and secreted from almond tree which is native to Iran and has many medicinal and nutritional, food and industrial applications. The purpose of this article is to review hydrocolloids and their application in food, pharmaceutical and agricultural industries. Therefore, this article discusses the structure, origin, preparation methods, extraction and the applications of hydrocoloids in various industries.

1. Introduction

Hydrocolloids are a large and heterogeneous group of polymeric materials that mainly contain polysaccharides and some proteins. Hydrocolloids are a diverse group of long-chain polymers that are easily dispersed in water and are completely or partially soluble and prone to swelling in water. Hydrocolloids alter the physical properties of a solution by gel formation, or thickening, emulsifying, coating, and stabilizing. Among carbohydrates or polysaccharides, there are hydrocolloids such as starch, agar, various gums, etc. Hydrocolloids can have different sources: They are made naturally from plants, animals, algae, and even some of them by microorganisms. They can also be semi-synthetic, such as cellulose derivatives. Hydrocolloids form gel by contact with water and microscopic dispersion. They are hydrophilic, and hence they are also called hydrophilic colloids (Phillips and Williams, 2009; Amiri et al., 2021; Asadzadeh and Pirsa, 2021). Gelatin protein, due to its excellent hydrophilicity and multi-dispersion properties, is accepted as an exceptional member of this polysaccharide club, and therefore hydrocolloids are widely used as additives of important foods. Hydrocolloid is defined as a colloidal system in which colloidal particles, or hydrophilic polymers are dispersed in water (Saha and Bhattacharya, 2010). Depending on the amount of water available, the hydrocolloid can take on a variety of forms, such as gel, aqueous or solid. Hydrocolloids can be irreversible (single state) or reversible. Agar, for example, is a reversible hydrocolloid of seaweed extract that can be present in the gel and solid states and oscillates alternately between the two states by adding or removing heat. Many hydrocolloids are derived from natural sources. For example, agar and carrageenan are extracted from seafood or gelatin is produced by hydrolysis of cow protein and pectin is obtained from citrus peels. Hydrocolloids are used in the food industry and mainly to influence the viscosity of products such as sauces. Other applications of hydrocolloids include advanced dressings in the treatment of skin wounds (Saha and Bgattacharya, 2010; Bixler and Porse, 2011).

In general, hydrocolloids are compounds that are used to modify tissue, control crystallization, prevent dehydration or synergy, coat aromatic and flavor materials, increase physical stability, form films (Jabraili et al., 2021), produce gel structure and increase the consistency of liquid, semi-liquid and Semi-solid materials. Many of them are not metabolized in the human body and have low energy and can be used as useful compounds in diet foods. Large molecules of hydrocolloids are able to significantly affect and control the rheological and textural properties of their content systems at relatively low and low concentrations, by proper interaction with a large number of water molecules. These compounds increase the viscosity by absorbing water and thus increase the stability of some food systems (Milani and Maleki, 2012; Li and Nie, 2016).

2. Classification And Commercial Evaluation Of Hydrocolloids

Traditionally, most hydrocolloids fall into the category of polysaccharides and are classified according to this source. Therefore, karya gum, tragacanth gum, qati gum, Arabic gum and other plant gums are included in the collection of secretory gums from trees. Agar, alginate, carrageenan, forceseran, fosuidan are in the category of seaweed and gelatin and chitin are in the category of animal hydrocolloids. In another clasification, all these categories fall into three categories: 1) natural gums found in nature, 2) modified (semi-synthetic) gums made from natural gums based on chemical modifications, and 3) synthetic gums that are produced based on chemical synthesis (Milani and Maleki, 2012). Based on the ionic structure, hydrocolloids are grouped in two groups: 1) non-ionic gums and 2) anionic gums. Non-ionic gums include xanthan, guar gum, and carob bean gum, while carrageenan, gum Arabic, caraway gum, and gelan gum are anionic gums.

There are many hydrocolloids in nature that are part of the structure or storage source of plant tissues, but a limited number of them are of commercial importance. Common commercial hydrocolloids include starch, pectin, inulin, gelatin, agar, xanthan, guar, carrageenan, alginate, carob bean gum, gum Arabic, gellan gum, methylcellulose (MC), carboxymethylcellulose (CMC), and hydroxymethyl ethyl cellulose (HMC). Xanthan increases dough stability, increases water absorption and preserves the gel, and xanthan gum is important during dough preparation. The cheapest hydrocolloids are plant secretory gums because they require less processing. Arabic, Karaya and Tragacanth gums are mostly used in industry. Hydrocolloids extracted from seaweed are more expensive gums because they require a costly collection and drying process (Ranjbar-Mohammadi, 2016; Glicksman, 2020).

3. Functional Properties Of Hydrocolloids In Food Processing

Hydrocolloids are used for various food processing. Hydrocolloids are used as thickeners in soups, broths, salad dressings, sauces and condiments. Also hydrocolloids are used as a gel maker in puddings and jellies, as an emulsifier in ice cream, yogurt and butter, as a fat substitute in meat and dairy products, as coating agent in confectionery and fried foods, as an organic adhesive in bread glaze, as a clarification in beverages, as causing turbidity in fruit juices (Milani and Maleki, 2012).

3.1. Stabilizing properties of hydrocolloids

One of the reasons for the widespread use of hydrocolloids is due to their consistency. Thickening or increasing the viscosity is a key property in the use of hydrocolloids as emulsifiers, stabilizers and structural agents in foods. Consistency is created above a critical concentration known as the overlap concentration. Because these concentrations of hydrocolloids act like a Newtonian fluid, but above this concentration the hydrocolloids behave like a non-Newtonian fluid. One of the important components used in ketchup sauce as a diluent liquid is hydrocolloids that play an important role in controlling viscosity (Saha and Bhattacharya, 2010; Dickinson, 2009).

3.2. Gel-forming property

Although all hydrocolloids increase viscosity, a small number of them can form gels. Gel-forming hydrocolloids include agar, alginate, carrageenan, pectin, gelatin, gellan, forceselan, modified starch, methylcellulose, etc. This property of hydrocolloids is used in products such as jellies, jams, puddings. An undesirable phenomenon in the gel structure is the phenomenon of dehydration (synergy). To prevent this phenomenon, other hydrocolloids are used together with the desired gum because they have an intensifying effect on each other. In some hydrocolloids, the reversible changes from solid to gel occur with increasing and decreasing temperature, which is related to forces or non-covalent bonds such as hydrogen bonds or hydrophobic reactions (Saha and Bhattacharya, 2010; Liang et al., 2012).

3.3. Replacement of fat with hydrocolloids

Fats in most foods cause the desired texture, taste and appearance. Ice cream, frozen desserts, salad dressings, puddings, sauces, and other emulsion-based foods are relatively high in fat and calories. Some hydrocolloids can replace fat in food. These hydrocolloids perform all the functions of fats in food. Some of these hydrocolloids include inulin, pectin, guar gum, tragacanth, xanthan, kapaya-carrageenan, sodium alginate, carob bean gum, etc. One of the hydrocolloids used to reduce fat is inulin. Inulin as a dietary fiber has beneficial effects on health and has probiotic properties. Inulin is also used as a low-calorie sweetener, fat substitute and tissue modifier. As a fat substitute, inulin is widely used in meat and dairy products (Phillips and Willians, 2000; Azmoon et al., 2021).

3.4. Application of hydrocolloids in encapsulation

Hydrocolloids are used as the coating or wall of the capsule because they are edible, biodegradable, and insulated between the inside and outside of the capsule. One of the reasons for the use of capsule technology is the protection of sensitive bioactive substances such as probiotics against inactivation.

Probiotics are living microorganisms that are very sensitive to environmental conditions such as temperature, oxygen, acidity and bile salts. Another reason for using capsule technology is to prevent evaporation or reduction of volatile substances such as aromas and essential oils. For this purpose, protein-hydrocolloid complex is usually used (Milani and Maleki, 2012; Zandi et al., 2017; Karimi Sani et al., 2021; Rasul et al., 2022).

3.5. Ability of hydrocolloids to form packaging films

Ordinary plastics do not decompose in nature due to the presence of large molecules as well as strong hydrogen-carbon bonds in their structure. Starch is a hydrocolloid that is readily available and has important applications in bioplastics. There must be enough moisture to use starch in food packaging (Hosseini et al., 2021). The emollients such as glycerol and sorbitol are used in bioplastics as plastisizer. Softened starch is a good alternative to polystyrene. Cellulose is another biodegradable hydrocolloid that can be dissolved in a mixture of sodium hydroxide and carbon disulfide and then placed in sulfuric acid to form cellophane films (Pirsa, and Chavoshizadeh, 2018). The combination of hydrocolloids can also be used to make bioplastics such as gelatin, sodium alginate (Shabkhiz et al., 2021), chitosan (Pirsa and Mohammadi, 2021), cellulose, and starch. Because hydrocolloids are hydrophilic, packaging based on these materials is a weak barrier to water vapor, and these packages are sensitive to moisture. However, if these hydrocolloids are used in the form of gels, they can delay the loss of moisture during the short shelf life. A combination of carboxymethylcellulose (CMC) and polyvinyl pyrrolidane (PVP) can be used in the form of hydrogels for packaging (Pirsa, 2021). This packaging shows characteristics such as transparency, flexibility and good mechanical properties (López-Castejón et al., 2016).

3.6. Adhesion properties of hydrocolloids

Many hydrocolloids are known as organic adhesives such as Chitosan, pectin, dextran, gum Arabic, and Talha gum. Gum Arabic can be added to bread crumbs as an edible organic glue to increase the stickiness of bread, beef, and chicken and fish cutlets. Hydrocolloid adhesives have been widely considered in the pharmaceutical sciences due to their edible, non-toxic, hydrophilic and wet properties. Hydrocolloids act as both a biotransmitter and a protective layer. Adhesive mucosal hydrocolloids can increase the duration of drug contact with the mucosal layer in the mouth and gastrointestinal tract. In food products, mucous adhesive hydrocolloids are also used to control the delivery of a specific component such as seasoning, flavor or nutritional additives to the body (Dickinson E., 2009).

3.7. Nutritional value of hydrocolloids

Researchers have studied hydrocolloids in terms of nutritional value as well as their effect on common disease. One of the hydrocolloids studied is guar gum. Guar gum is a type of galactomannan. Galactomanans come in a variety of compounds, including carrots, coffee beans, soybeans, sugar beets, and coconut kernels. A diet containing guar gum has many benefits for the body, including delaying gastric emptying, slowing the rate of postprandial hyperglycemia, and improving colon function. Today, there is a wide range of hydrocolloids with nutritional and physiological effects that are being used extensively. These hydrocolloids include beta-glucan, pectin, inulin, gum Arabic, Chitosan. The health effects of these hydrocolloids are related to regulating appetite, improving intestinal function, reducing the risk of osteoporosis, and preventing coronary heart disease, type 2 diabetes, and colon cancer (Milani and Maleki G., 2012; Gidley, 2013).

3.8. Prebiotic effect of hydrocolloids

Bacteria such as *Bifidobacteria*, *Lactobacillus* and *Streptococcus thermophilu*s, called probiotics, are living microorganisms that can affect the health of the consumer if used properly. Probiotics have effects such as reducing the duration of rotavirus diarrhea and preventing gastrointestinal diseases such as gastritis. Prebiotics are food compounds that are consumed by beneficial intestinal microbes and stimulate these microbes, thereby increasing the body's immunity to fight pathogens. In order to be included in a prebiotic diet, a food compound must meet the following four conditions: 1- The desired food composition should not be absorbed or hydrolyzed in the upper part of the gastrointestinal tract, 2- The desired food composition should be selectively fermented and decomposed in the colon by certain beneficial bacteria, 3- It should improve the microbial flora of the colon, and 4- Increase beneficial effects on host health. In the group of hydrocolloids, inulin has been further studied as a prebiotic. Inulin is accepted as a food ingredient in all countries and is used in industry without any restrictions. The glucoside bonds present in inulin make it resistant to hydrolysis by human small intestinal enzymes. As a result, inulin is protected from the risk of digestion in the upper gastrointestinal tract and reaches the microbes that live in the large intestine (colon) and is broken down and fermented by them (Milani and Maleki G., 2012; Kassem et al., 2021).

3.9. The effect of hydrocolloids on controlling blood sugar and preventing diabetes

The function of foods in changing blood sugar after eating is different. Blood sugar index and blood sugar are two criteria for measuring blood sugar. A diet low in blood sugar index and blood sugar plays an important role in preventing type 2 diabetes, cardiovascular disease, obesity, colon cancer and breast cancer. Diabetes is a common disease in which the body's blood sugar rises due to impaired absorption of glucose by the body's cells. This disorder is caused by a lack of the hormone insulin. Digestion of available carbohydrates by the gastrointestinal tract raises blood sugar. Hydrocolloids have different effects on the digestion and absorption of these available carbohydrates. Guar gum acts as an inhibitor, preventing the processing and digestion of available carbohydrates, thereby reducing the rate of glucose uptake into liver cells. Guar gum improves the sensitivity of the hormone insulin. On the other hand, guar gum increases the viscosity of ready-to-digest food and causes a slow flow in the digestive system instead of turbulent flow, resulting in carbohydrate fragments being exposed to mucosal cells and then absorbed by the liver cells (Phillips and Willians, 2000; Tan et al, 2019; Pirsa et al., 2018).

3.10. The effect of hydrocolloids in the prevention of colon cancer

Hydrocolloids have a digestive function that is far more important than their function. Colon cancer is the second leading cause of cancer death. High-fiber diets prevent colon cancer by lowering the colon pH, absorbing or diluting fecal carcinogens, reducing the passage of material through the colon, improving bile acid metabolism, and increasing the production of short-chain fatty acids. Inulin produces short-chain fatty acids. Among these fatty acids, butyric acid nourishes mucosal cells, promotes cell division, and stops the cell cycle. Increased proliferation of colon cells is a risk factor for cancer. All colon cells die after a while in a controlled cycle called apoptosis. It is the balance between cell proliferation and cell death that determines whether or not cancer develops (Wen et al., 2019).

3.11. Dietary hydrocolloids

All of these substances (hydrocolloids) have hydrophilic molecules that can be combined with water to form viscous solutions or gels. The nature of the molecules greatly affects the properties of the gums. Linear polysaccharide molecules take up more space and are more viscous than highly branched molecules with the same molecular weight. These compounds can be a good substitute for fat due to their ability to form gels, increase viscosity, stabilizing power, emulsifying and bulking (Williams and Phillips, 2009; Gidley, 2013).

3.12. Surface activity and emulsifying properties of hydrocolloids

The function of hydrocolloids as emulsifiers or emulsion stabilizers is related to some phenomena such as delay in precipitation of dispersed solid particles, decrease in the rate of creaming of oil droplets and foams, prevention of accumulation of dispersed particles, prevention of synergy of gel-containing systems and delays in the integration of oil droplets. It has been well proven that Arabic gum, is an excellent emulsion, and the properties of oil-in-water emulsions are an excellent example of its use in cloud emulsions. Microcrystalline cellulose is also able to stabilize strong oil emulsions in water (Dickinson, 2009; Garti and Leser, 2001).

4. Types Of Hydrocolloids And Their Application

Hydrocolloids extracted from different parts of plants include cellulose, pectin, starch, various types of gums such as gum Arabic and so on are plant-origin colloids. Gelatin, casein, egg white protein, soy protein are animal origin colloids. Hydrocolloids derived from algae include agar, carrageenan, and alginate. Microbial origin hydrocolloids include xanthan, dextran, etc. Modified or semi-synthetic hydrocolloids include methylcellulose, ethylcellulose, carboxymethyl Cellulose, propylene glycol alginate, modified starch (Dickinson, 2009; Pirsa and Aghbolagh Sharifi, 2020; Asdagh et al., 2021).

4.1. Hydrocolloids application in the food industry

Hydrocolloids are used in food for two main reasons: consistency and gel formation. Hydrocolloids are used in the food industry as thickening and gelling additives. Depending on the type of hydrocolloid used, concentration, pH, temperature and the type of foods, shelf life increases, and food quality improve. As a thickener in soups, sauces, additives and salad dressings, among other foods, various types of gum are used, such as arabica, guar or Guarana and carob, etc. Xanthan and starch are also thickeners.

Hydrocolloids such as pectin, alginate, agar, jelly and carrageenan is used as gelling agents, mainly in jellies, jams, low-sugar gelatins and ice cream. Like agar in plants, cooking to avoid the use of ordinary gelatin in the preparation of which the material contains animal origin (Milani and Maleki, 2012). In the food industry, a variety of hydrocolloids are used, including the following list (Fig. 1). Hydrocolloids affect solubility, viscosity, rheology, melting behavior, body emulsification, creaming, heat transfer, transport of vitamins and lipophilic flavors, taste and nutritional value (Saha and Bhattacharya, 2010).

4.1.1. The effect of hydrocolloids on the rheological properties of bread

Hydrocolloids increase the viscosity and thus the stability of some food systems by absorbing water. In this regard, they are widely used in many food products. Hydrocolloids are commonly used to improve tissue, strengthen the gluten network, soften, and delay stagnation. Due to the fact that bread plays a very important role in the household food basket. Hydrocolloids change the structure of starch, which reduces the distribution and storage of water in starch and the strength of bread texture (Dickinson, 2009; Liu et al., 2017).

4.2. Hydrocolloids as films and edible coatings

Edible film is defined as a thin layer that can be consumed, covered or placed on a food as a barrier between food and the environment. Hydrocolloids are used to produce edible layers on food surfaces and between foods. Such films act as a barrier to moisture, gas, and lipid migration. Many gums and derivatives have been used in the proposed coatings. They include alginate, carrageenan, cellulose and its derivatives, pectin, starch and its derivatives and so on. Because these hydrocolloids are hydrophilic, their application as coating agents have some limitations. Oral hydrocolloid films are classified into two categories according to their nature and components: proteins and polysaccharides or alginates (Arslan et al., 2019; Pirsa et al., 2022; Yorghanlu et al., 2021).

4.3. Application of hydrocolloids in laboratories, pharmacies, and medicine

Hydrocolloids such as agar are used in the preparation of various types of microbial culture medium. It forms the basis that gives these media a different texture, which resists sterilization temperature without changing them. Sephadex hydrocolloid is commonly used as a tool for various chromatography and gel filtration steps. This allows proteins and other biological molecules to be separated or refined based on their different sizes or molecular weights. In dentistry under certain conditions, alginate and agar hydrocolloids are good materials for tooth repair. In medicine, hydrocolloids such as dextran, hydroxyethyl starch, gelatin, etc. are used in injection fluids and volume-expanding solutions to treat hypovolemia. Hydrocolloids, such as gums, are used in the manufacture of bioadhesives for surgical bandages, dressings, or dressings used to treat pressure sores and wounds. It acts as a water-retaining fiber, which makes it possible to use it in drugs such as laxatives (Saha and Bhattacharya, 2010; Osmalek et al., 2015).

5. Hydrocolloid Types

5.1. Cellulose based hydrocolloids

5.1.1. Carboxymethylcellulose (CMC)

Carboxymethylcellulose is one of the most important and widely used gums that is soluble in water. This gum is obtained from the process of esterification and atrification performed on cellulose and has various types. Sodium carboxymethylcellulose is the more complete name of this substance. Generally it is known by shorter names such as CMC. Carboxymethylcellulose is used in many industries like the dairy and ice cream industries or water-based adhesives and the drilling industry. Cellulose is a natural polymer that converts to CMC after several reactions during the synthesis process. This gum is one of the most widely used hydrocolloids in many products, from ice cream and fruit drinks to a variety of glues. Carboxymethylcellulose is made from cellulose, a natural polymer that is abundant in nature. Forests are one of the great sources of cellulose that is easily available to us. Because there is a large amount of cellulose in the trunks of trees, cellulose can be extracted from the wood of trees through the extraction process. Another source for cellulose is cotton, which is the most commonly used to extract alpha cellulose. Carboxymethylcellulose has a wide range of applications, including the confectionery and chocolate, bread and bakery industries, dairy products and dairy desserts, fruit juices and beverages, ice cream, sauces and some applications of industrial carboxymethylcellulose, adhesives, paints and resins, drilling, and petrochemicals (Sharifi and Pirsa, 2021; Michelin et al., 2020; Pirsa, 2021).

5.1.1.1 CMC application in food industry

Carboxymethylcellulose can act as a thickener, emulsifier, retainer and water absorber, stabilizer and rheology agent, and because of these properties, CMC can be used instead of gelatin and other materials. Not only it is economically viable, it also preserves the true taste and freshness of the food and ultimately increases the shelf life of the food. Carboxymethylcellulose is now one of the most essential food additives, widely used in high quality ice cream (to resist melting), sweets, biscuits, cakes, cookies, candies, juices, liquid beverages, dairy products and meat products, frozen foods, instant pastas, canned and fruit compotes. One of the important applications of CMC is the stability and protection of proteins, especially bran proteins. In addition, since CMC is a low-calorie polysaccharide, it is used in diet and low-calorie foods such as diet breads, diet drinks and diet sauces (Arancibia et al., 2016).

5.1.1.2. CMC application in pharmaceutical and cosmetic industries

Properties such as particle suspension, color retention, skin protection, uniform dispersion, dirt and stain removal, concentration, stabilization, lubrication and uniformity have led to the use of carboxymethylcellulose in cosmetic and pharmaceutical applications. Carboxymethylcellulose is used in hand creams and lotions due to the flavor, polish and stabilizing properties of the suspension. Also, it is used in the production of toothpaste, due to the emulsion stabilization, creating a uniform layer and thickening. Other applications of this substance include its use in shampoos due to the stabilizing properties of the foam produced and the significant increase in the hydrophilicity of the detergent, as well as its use in medicinal tablets due to its hydrophilicity and swelling action (Gutiérrez et al., 2012).

5.1.1.3. Carboxymethylcellulose dissolution methods

For easier dissolution of CMC, two methods are suggested. The first and most common method is to add an ether cellulose to water at the same time as stirring and forming a vortex. The rate at which gum is added to water must be controlled to the extent that the particles have a chance to absorb and dissolve in the water. On the other hand, if the addition rate is too slow, with the formation of the initial viscosity, the remaining materials remain unresolved. The second method is mostly used when CMC in the final product formulation is combined with other dry powder materials (for example with sugar). In these cases, it is better to first mix the powder materials and then dissolve them in water according to the first method. Using this method, the speed and solubility of this substance in water increases (Gutiérrez et al., 2012: Wu et al., 2020).

5.1.2. Microcrystalline cellulose (MCC)

Microcrystalline cellulose is a pure product of cellulose polymers and is made from natural cellulose. It is an odorless and tasteless crystalline powder. MCC products are available in the pharmaceutical and pharmaceutical disintegrant industries. The free MCC concentrates the water phase between the oils and prevents the blood cells from approaching them. Intrinsic properties of water-dispersed colloidal MCC products have been used to simulate fats in various food applications including ice cream, salad dressing, dressings and sauces. It can be used as a food raw material in the food industry and dietary fiber, it is an ideal food supplement for food hygiene. In the coating industry using thixotropy and its thickening can be used as a water-stabilizing dye and emulsifier in cosmetics. In the production of damp synthetic leather as a thickening and filler, is used (Hosseini et al., 2011).

5.1.2.1. Characteristics of microcrystalline cellulose

MCC is a thizotropic colloid that appears to have a high concentration and high viscosity, but in reality, it flows easily when an external force is applied. The colloidal viscosity can be 3000 ~ 5000 mPa per second when its concentration is 3%. The colloid has hot and cold stability. Although cellulose is made up of glucose, the body cannot digest beta glucose, its caloric value is zero, so microcrystallized cellulose in the human body is not absorbed by the body only with foods that are not moving together (Hosseini et al., 2011). MCC is used in low-calorie ice cream (instead of part of milk fat), salad dressing (instead of part of milk fat), rich fiber bread (powder) and in cosmetics as raw materials (moisturizer, skin care).

5.1.3. Hydroxypropyl methylcellulose (HPMC)

Hydroxypropyl methylcellulose (HPMC) belongs to the group of cellulose ethers in which the hydroxyl groups are replaced by one or more groups in the cellulose ring. HPMC is a hydrophilic (water-soluble) polymer, biodegradable and biocompatible that has a wide range of applications in the delivery of medicine, paints, cosmetics, adhesives, coatings, agriculture and textiles. HPMC is also soluble in polar organic solvents and allows the use of aqueous and non-aqueous solvents. It has a unique solubility in hot and cold organic solvents. HPMC has a high organic solubility and thermal flexibility compared to other methyl cellulose counterparts. Hydroxypropyl methylcellulose is synthesized via methylcellulose by the action of alkali oxide and propylene. The product is a water-soluble cellulose ether derivative that contains both methoxy and hydroxypropyl groups. It is used as a thickener, stabilizer and emulsifier (Bahrami et al., 2019). HPMC widely is used in building materials, coatings, synthetic resins, ceramics, medicine, food, textiles, agriculture, cosmetics, tobacco and other industries (Bahrami et al., 2019).

5.1.4. Hydroxypropyl cellulose (HPC)

HPC is a derivative of cellulose that dissolves in both water and organic matter. Hydroxypropyl cellulose is used as a common additive and preservative in ophthalmology and lubricants. Hydroxypropyl cellulose is an ether derivative of cellulose in which some hydroxyl groups of the repeating unit are hydroxy-propylated glucose to form $-OCH_2CH-(OH)-CH_3$ groups using propylene oxide. Hydroxypropyl cellulose is crystalline, for proper solubility in water hydroxypropyl cellulose must have a replacement number of 4 mol. Hydroxypropyl cellulose has a combination of hydrophilic and hydrophobic groups, so it has a lower critical dissolution temperature of about 45 °C. At temperatures below the critical dissolution temperature, hydroxypropyl cellulose is soluble in water and insoluble at temperatures above this value (Chen and Lai, 2008).

5.1.4.1. Application of HPC

Hydroxypropyl cellulose is used in the manufacture of artificial tears, as a lubricant for artificial eyes, as a thickener, a low-level binder and an emulsion stabilizer. In pharmacy, hydroxypropyl cellulose is used as a binder in tablets. Hydroxypropyl cellulose is used as a screening matrix for DNA isolation (Chen and Lai, 2008).

5.1.5. Ethyl cellulose

Ethyl cellulose is a compound of cellulose derivatives in which some of the hydroxyl groups present in the repeated glucose units are converted to the ethyl ether group. Ethylene cellulose is structurally similar to cellulose and cellulose acetate, except that the ethoxy group ($O-CH_2-CH_3$) has replaced the hydroxyl functional group (-OH) (Hosseini et al., 2011). Applications of this substance include pharmaceutical, cosmetic, nail polish, vitamin coatings, printing inks, special coatings and food packaging, also ethyl cellulose is used as a thin coating in the paper and as an emulsifier in the food industry (McKeen, 2012). Fig. 2 shows chemical and physical structure of five types of cellulose based hydrocolloids. Table 1 reports the new research on the five types of cellolose based hydrocolloids.

Table 1. New researche on the five types of cellulose based hydrocolloids

Celloluse based hydrocolloids	Field of application	Novelty	Characteristics of product	Reference
Carboxymethylcellulose (CMC)	Application of CMC in the preparation of active film	New CMC/curcumin and zinc oxide composite	Antioxidant Antiabcterial Active film	(Roy and Rhim, 2020)
Microcrystalline cellulose (MCC)	Application of MCC on emulsified sausages	Simultaneus effect of CMC and MCC on functional characteristics	Improving functional characteristics	(Schuh et al., 2013)
Hydroxypropyl methylcellulose (HPMC)	Application of HPMC in encapsulation of ferulic acid	Simultaneus application of maltodextrin and HPMC in encapsulation	Encapslation efficiency and quality	(Yu et al., 2021)
Hydroxypropyl cellulose (HPC)	Application of HPC in topical gels	Dynamic rheology as a quantitative method	Real-time tracking of excipient solvation in non-aqueous gels	(Potuck et al., 2019)
Ethyl cellulose	Application of ethyl cellulose nanofibers in food preservation	Prepration of zein-ethyl cellulose hybrid nanofibers by electrospinning method	Electrospinning method and food preservation	(Niu et al., 2020)

5.2. Pure herbal based hydrocolloids

5.2.1. Pectin

Pectin obtained from citrus peel is one of the various and valuable hydrocolloids. Due to its ability to create gels and excellent texture, it is widely used in the fruit processing and confectionery industries, as well as in the dairy industry, for example in acidified beverages and beverage yogurts. On the other hand, it is also used as a thickener in certain medicinal applications (Pirsa et al., 2020; Liang and Luo 2020).

5.2.2. Alginate

Alginate is a natural hydrocolloid derived from brown seaweed. It is mainly used as an emulsifier, texture and thickener, as well as as a thermal stabilizer and freeze-thaw. In the food industry, it is also used to make gels and films, process meat and instant dairy desserts. In addition, it is used in the cosmetics, pharmaceutical, printing, construction, and pet food industries (Tong et al., 2008; Karimi Sani et al., 2019; Karimi Sani et al., 2020).

5.2.3. Agar

Agar has a naturally occurring, high molecular weight linear structure and is extracted from red algae. In the food industry, agar acts as a gel, firming and stabilizing tissue. Agar is commonly used in beverages, jellies and puddings, ice cream, chewing candies, canned food, meat products, fruit jams and dairy products (Rhim et al., 2011).

5.2.4. Carrageenan

Carrageenan is a hydrocolloid with unique properties extracted from special species of red seaweed. This substance plays an essential role in the food industry due to its ability to stabilize dairy products, control water content in meat products, stabilize ice cream texture or give the desired texture to confectionery products, water-based desserts and fruit preparation. Carrageenan, on the other hand, is a well-known additive in the pharmaceutical and cosmetic industries, where it can be used as a thickener or film-forming agent. There are three main types of commercial carrageenan identified. These are known as KAPPA, IOTA and LAMBDA, which are ideal molecules. Exploitation of these three basic types requires a precise technical understanding of the sources of seaweed, the process used for extraction and modification, as well as extensive knowledge about the application in various food products (Alavi et al., 2018; Daei et al., 2022). Fig. 3 shows chemical and physical structure of four types pure herbal based hydrocolloids. Table 2 reports new research on the four types of pure herbal based hydrocolloids.

Table 2. New research on the four types of pure herbal based hydrocolloids

Pure herbal based hydrocolloids	Field of application	Novelty	Characteristics of product	Reference
Pectin	Food products coating	Application of pectin coating in egg coating	Improving egg quality and minimizes the breakage and porosity of eggshells	(Dávalos-Saucedo et al., 2018)
Alginate	Essence encapsulation	Application of carrageenan alginate and Shellac gum for encapsulation of peppermint essential oil	Encapsulation efiiciency peppermint essential oil preservation	(Foglio et al., 2021)
Agar	Formulation of guava by agar and gellan gum	Application of agar and gellan gum in the formulation	Improving texture, microstructure and volatile profile of guava	(da Costa et al., 2020)
Carrageenan	Low-fat whipping cream formulation	Application of k-carrageenan in the formulation	Improving characteristics of low-fat whipping cream	(Ghribi et al., 2021)

5.3. Hydrocolloids based on plant gums

5.3.1. Guar gum

Guar gum is one of the most widely used hydrocolloids in the food and non-food industries. This natural gum is soluble in hot and cold water and increases viscosity. Guar gum is extracted from the beans of this substance, which the center of India is the main cultivation of this plant and it is also known as Guarana. This substance has food and industrial uses, which is also known in food grades with E412 (Martin C., 2006).

5.3.1.1. Properties and applications of guar gum

Guar gum is a plant native to India, this gum is extracted from guar beans, and it can be dissolved in hot and cold water (Martin C., 2006). Because it is a natural gum, it has a significant advantage over other synthetic hydrocolloids. This hydrocolloid is rich in fiber and can decrease blood sugar. Also, some research shows that this substance also decreases blood cholesterol. Excessive consumption of this substance is not recommended for human health (Martin C., 2006). Guar gum is used in ice cream, sauces (hot and cold), dairy drinks, non-dairy drinks, soups, cakes and cookies (has a special application in cakes), confectionery and chocolate industry, dairy stabilizer, ice cream stabilizer, and cosmetics (Martin C., 2006; Mudgil et al., 2014).

5.3.2. Locust bean gum

Locust bean gum is a natural hydrocolloid that is extracted from the seeds of the locust tree. It consists of a long chain of high molecular weight galactomannans, which provide high viscosity for food products. It is not only used as a thickener in countless products, but also has a synergistic effect with other hydrocolloids, including carrageenans. The combination of these two hydrocolloids increases their gel formation ability. Locust bean gum provides high viscosity, clarity and brightness, which are essential for products such as desserts. Locust bean gum is widely used as an additive in various industries such as food, pharmaceuticals, paper, textiles, oil well drilling and cosmetics. The industrial application of bean meatballs is due to its ability to form hydrogen bonds with water molecules. It is also useful in controlling many health problems such as diabetes, bowel movements, heart disease and colon cancer due to the function of dietary fiber. In the food industry, the combination of Locust bean gum with pea gum and other edible gums can act as a thickener, water carrier and adhesive. In the processing of Western meat products and sausages, Locust bean gum improves water binding capacity, meat tissue structure and freeze/thaw stability, it also helps the shelf life increasing. In flour products, it helps control the water absorption of the dough, improves the properties and quality of the dough, and increases the shelf life (Sadat Hosseini et al., 2016; Dionísio and Grenha, 2012).

5.3.3. Zedo Gum

Zedo gum is a polysaccharide secreted from the tree Amygdalus scoparia Spach. Zedo gum is composed of two components, soluble and insoluble, which have the property of solubility and swelling in water, respectively. The viscosity of gum depends on changes in temperature and pH. The highest viscosity is at pH 7.2 and at 24 °C. Also, the viscosity was changed by the presence of strong electrolytes. The ability to form an oil emulsion in water and its stability, increased with increasing gum concentration (Fadavi et al., 2014).

5.3.3.1. General applications of Zedo gum

Zedo gum is similar to gum Arabic, but Zedo is mostly used for industrial purposes and gum Arabic is used for food. Zedo cuts the mucus and is used to stimulate the appetite and crush bladder stones. Zedo gum industrial applications are very diverse. Zedo gum is used in textile, paper, glue, lithography, ink making industries as well as many cosmetic and food industries. This gum is used as an emulsifying and suspending agent along with tragacanth and gum Arabic is used in pharmacy. It is also used in the pill making due to its adhesive properties. The effective use of this gum in improving the rheological properties of Taftoon bread dough, as well as stabilizing the ash syrup system against precipitation, improving tissue properties, improving viscosity and reducing synergy in low-fat probiotic yogurt has also been proven (Pirouzifard et al., 2020).

5.3.3.2. Therapeutic application of Zedo gum

Zedo gum has warm and dry nature, and is used for the following therapeutic purposes: It is useful for relieving chronic coughs, clarifies the skin, increases eye vision, relieves itching of the eyelids, relieves pimples in children, stimulates appetite, treatment of swollen joints, anti-parasitic, analgesic for toothache, hair conditioner and skin glaze, crush bladder stones, relieve pulmonary embolism, treat shortness of breath, strengthen the mind.

5.3.4. Gum Arabic

Acacia gum, also known as gum Arabic, is a natural and plant-based extract of acacia trees. The protein part of gum Arabic is responsible for surface activity, foaming and emulsifying properties. Gum Arabic is also known by the letters azodatazi, acacia gum, barghand and fart. When superficial scratches are made of the branches of the acacia shrub, the shrub naturally secretes a kind of plant extract, which dries in the presence of air and gum Arabic are formed. The color of gum Arabic varies from white to brown, and the closer the color of this gum to white or yellowish white, the higher its quality (Ali et al., 209; Patel and Goyal, 2009; Ghasemizad et al., 2022).

5.3.4.1. Medicinal properties of gum Arabic

Gum Arabic is a rich source of fiber, so that 6 grams of gum Arabic can provide 21 to 29 percent of the fiber needed by women and 16 to 20 percent of the fiber needed by men. Gum Arabic reduces inflammation due to its adhesive properties. In traditional medicine, gum Arabic is used to treat sore throats and stomach upsets caused by inflammation. Gum Arabic powder can be used to make herbal toothpaste. This gum destroys dental plaque and has an effective role in preventing tooth decay and plaque on them. The properties of gum Arabic in lowering cholesterol can be attributed to the fiber in it. The body does not have the enzymes needed to break down soluble fiber, which absorbs water and forms a gel in the stomach. Fiber absorbs bile, which is secreted to help digest fats, and eventually fiber and bile are excreted in the feces. Bile is made of cholesterol, and if the liver needs to produce bile, it will absorb cholesterol from the blood, which will lower cholesterol levels. Another property of gum Arabic is the fight against oxidative stress. Oxidative stress means upsetting the balance between free radicals and antioxidants. Free radicals are highly reactive and are neutralized by antioxidants. But if the number of free radicals is high, these radical damage adipose tissue and DNA and increase the risk of cancer. Diarrhea is caused by bacteria, viruses or parasites that interfere with the functioning of the digestive system. Gum Arabic prevents the growth of these bacteria and thus helps treat this disease. Other properties of gum Arabic include home treatment of constipation. Constipation is caused by impaired bowel movements. Consumption of gum Arabic can improve bowel movement and thus help treat constipation. One of the most well-known properties of gum Arabic in traditional medicine is the treatment of sore throat and cough and is one of the most important ingredients used to prepare cough syrup. This gum has anti-inflammatory properties and prevents dry throat (Nour Elkhair et al., 2020; Williams and Phillips, 2021).

5.3.4.2. Industrial applications of gum Arabic

Gum Arabic is stable in acidic conditions and is used to make orange essential oils and cola to make carbonated beverages. In the food industry, gum Arabic is used to increase the viscosity of food and to stabilize flavoring components. Gum Arabic is used to make products such as chewing gum, pastilles, marshmallows and toffee. This gum also prevents the separation of fat or the growth of sugar crystals in confectionery products. Gum Arabic is used in watercolor paintings. This gum gives volume to the watercolor and makes the color transparent and shiny. Gum Arabic is used as a lubricant for printing ink. This product is used to make stamps; In fact, the sticky substance in postage stamps is gum Arabic. This gum is used to produce coal. It is one of the most important compounds in wax and is used in the textile industry to saturate the fabric (Nour Elkhair et al., 2020; Ali et al., 2013).

5.3.5. Tragacanth gum

Tragacanth is an anionic polysaccharide that is secreted from Asian species and Iran is the largest producer in the world. The most important feature of tragacanth is consistency and reduction of surface tension simultaneously. This substance has long been widely used in food, pharmaceutical, cosmetic, textile and medical industries. Air-hardened resin chips, which flow naturally or are obtained by cutting through the trunk. Tragacanth gum contains a water-soluble substance. Tragacanth has good water absorption, biodegradability and biocompatibility and high potential for chemical and physical modification, and due to its special monosaccharides, it has a special ability to be used in tissue engineering and gene and drug release (Azarikia and Abbasi, 2010; Asadzadeh and Pirsa, 2020).

5.3.5.1. Chemical-physical properties of tragacanth gum

Tragacanth is a large molecular polysaccharide composed of acidic and anionic monosaccharides with some calcium, magnesium and potassium salts and a small amount of protein. This gum consists of a soluble part and an insoluble part that swells in water (Azarikia and Abbasi, 2010). One of the most important physical properties of tragacanth is its stability against acidic environment, high viscosity, simultaneous consistency and reduction of surface tension, etc. The pH of the aqueous solution of tragacanth varies from 5 to 6. Tragacanth is a gum resistant to acidic environment and the viscosity of its solution does not change much between pH of 1 to 10. The thermal stability of tragacanth is lower compared to some gums and the onset of its thermal degradation is at a temperature of about 151 °C.

5.3.5.2. Common applications of tragacanth gum

Tragacanth gum has been used in many industries since ancient times, including food, cosmetics, textiles, ceramic tiles and paints. This gum is used in the food industry as a thickener, suspender and stabilizer in various products such as ice cream, beverages, sweets, chocolate, sauces and pastilles. On the one hand, tragacanth gum increases the viscosity of the aqueous phase and has a thickening property. On the other hand, it reduces the tension between the surface of the oil and the water in the suspension. Therefore, with the addition of this material, the need to add thickeners and surfactants is eliminated. Stability in acidic environment is the most important feature of tragacanth for use in the role of thickener and stabilizer in the food industry (Goudar et al., 2020).

5.3.5.3. Medical application of tragacanth gum

This gum has been used in traditional medicine as an ointment for burns and healing superficial wounds. Tragacanth stimulates the immune system and is recommended to strengthen the immune system of people who have undergone chemotherapy. It is also recommended for treating bladder infections and preventing the formation of kidney stones. It is recommended for the treatment of many infections, especially viral diseases as well as respiratory diseases. Tragacanth is used in toothpaste, creams and skin lotions and moisturizers in the role of suspender, stabilizer and lubricant, and in the printing, painting and paint paste industries in the role of stabilizer (Tavakol, 2016). Fig. 4 shows chemical and physical structure of five types of hydrocolloids based on plant gums. Table 3 reports new research on the five types of hydrocolloids based on plant gums.

Table 3. New research on the five types of hydrocolloids based on plant gums

Hydrocolloids based on plant gums	Field of application	Novelty	Characteristics of product	Reference
Guar gum	Low fat meatballs formulation	Simultaneous effects of carrageenam and guar gum on the low fat meatballs characteristics	Cooking and textual properties of low fat meatballs	(Ulu, 2006)
Locust bean gum	Formulation of dairy creams	Locust bean gum (LBG) and λ-carrageenan combinations application in food formulation	Rheological characterization	(Camacho et al., 2005)
Zedo Gum	Film preparation	Active film based on potato starch containing Zedo gum	Antioxidant/antimicrobial film	(Pirouzifard et al., 2020)
Gum Arabic	Formulation of pharmaceutical emulsions	Application of β-Lactoglobulin, gum Arabic, and xanthan gum for emulsifying sweet almond oil	Stabilization mechanisms of pharmaceutical emulsions	(Bouyer et al., 2013)
Tragacanth gum	Low-fat yoghurt formulation	The effect of hydrolysed tragacanth gum and inulin on the food quality	Probiotic viability and quality characteristics of low-fat yoghurt	(Ghaderi-Ghahfarokhi et al., 2021)

5.4. Microbial polysaccharids based hydrocolloids

5.4.1. Xanthan gum

Xanthan gum is an extracellular polysaccharide produced by the bacterium Xanthomonas. The primary structure of xanthan gum consists of a cellulose backbone of β-glucose-linked β-units substituted on glucose residues replaced by a side-chain trisaccharide. Xanthan gum can take on a helical structure. The lateral branches are almost parallel to the helical axis and stabilize the structure. Xanthan gum forms highly viscous solutions and, at sufficient concentrations of the polymer, exhibit weak gel-like properties. If xanthan mixed with watery food products, it can produce heat reversible gels (Torres et al., 2012; Meydanju et al, 2022).

5.4.2. Gellan gum

Gellan gum is a fermenting polysaccharide produced by the microorganism *Sphingomonas*. The molecular structure of gellan gum is a straight chain based on glucose replication. This gum is an anionic polymer made of beta-di-glucose, beta-di-glucuronic acid and alpha-l-rhamnose units at a ratio of 1:1:2. Based on the degree of substitution of the acyl group, gellan gum is classified into two groups: high acyl gellan gum and low acyl gellan gum. Gellan gum is a food additive and initially gellan gum was used as a thickener and stabilizer in the food industry and various products such as jams, jellies, dairy products and confectionery, etc. (Ferris et al., 2013).

5.4.2.1. Applications of gellan gum

The main applications of gellan gum include, the ability to form microgels and films, binding to the nutrient surface and the coating material for the coating. Gellan gum quickly forms a gel in the presence of cations, so this feature can be used to attach different seasonings and ingredients to the surface of food such as potato chips and crackers. The microgels obtained from the gels of gellan release aroma and flavor, have a good mouthfeel and clarity, and can stabilize the dispersions. In coated systems, due to the high resistance of gellan gum to heat and acid, the coated material is well protected against environmental factors. In this regard, gellan gum is a good option to protect the coated material against digestive conditions. Due to its high resistance to heat, salt and acid, this gum is one of the best hydrocolloids for use in acidic and high-salt foods as well as processed foods. This gum can also be used to encapsulate and deliver targeted nutrients (Silva-Correia et al., 2011).

5.4.3. Pullulan gum

Pullulan gum is a water-soluble mucopolysaccharide whose final product is a white solid powder. Due to its good film formation, fiber formation, gas barrier, adhesion, easy processing, non-toxic and other properties, it has been widely used in medical, food, and light industry, chemical and petroleum fields. Pullulan gum is an extracellular hemopolysaccharide of glucose that is produced by many species of glucose. Pullulan gum dissolves easily in hot or cold water to form a stable viscous state. Pullulan gum solution is stable over a wide range of pH and is also relatively stable to heat (Hassannia-Kolaee et al., 2016).

5.4.3.1. Application of Pullulan gum

Pullulan gum has important applications as adhesive ingredients for the pharmaceutical capsule and cosmetics industry, food quality improvers and thickeners, a water-soluble packaging material to prevent oxidation, low-calorie food raw materials for staple foods and sweets. Pullulan gum has good filmmaking properties, so it can be widely used to preserve agricultural products such as fruits, vegetables and eggs. Several studies have shown that pullulan gum, as a new type of seafood film retainer, can completely and effectively prevent the accumulation of TVB-N (Total Volatile Basic Nitrogen) in seafood, as well as its extremely protective effect in the evaporation of water in seafood (Hassannia-Kolaee et al., 2016). Pullulan gum is widely used in the food industry as a low-calorie raw material for staple foods and sweets, improving food quality and softening. Pullulan gum is a non-ionic, non-reducing, stable polysaccharide that dissolves easily in water and acts as a non-gelling, viscous, neutralizing and separating aqueous solution. Pullulan gum film is clear, colorless, odorless, non-toxic, hard, very oil resistant, and edible and can be used for food packaging. Its gloss, strength and corrosion resistance are better than amylose starch. Fig. 5 shows chemical and physical structure of 3 types of microbial polysaccharides based hydrocolloids. Table 4 reports new research on the three types of microbial polysaccharides based hydrocolloids.

Table 4. New research on the three types of microbial polysaccharides based hydrocolloids

Hydrocolloids based on plant gums	Field of application	Novelty	Characteristics of product	Reference
Xanthan gum	Thickened infant formula	Thickened infant formula prepared with xanthan gum	Rheological behaviors food	(Yoon, S.N. and Yoo, 2017)
Gellan gum	Low-fat and sodium-reduced meat batters formulation	Formulation of food with gellan gum and dicationic salts	Textural properties and microstructure of food	(Totosaus and Perez-Chabela, 2009)
Pullulan gum	Formulation of drugs	Formulation of floating matrix tablets of stavudine using pullulan gum	Evaluation of floating matrix tablets of stavudine	(Mahendar and Ramakrisha et al., 2009)

6. Conclusion

Hydrocolloids are compounds used to modify tissue, control crystallization, prevent dehydration, encapsulation aromatic and flavor substances, produce a gel structure, and increase the consistency of liquid, semi-liquid, solid, and semi-solid nutrients. Many of them are not metabolized in the human body and have low energy (calorie production) and can be used as useful compounds in diet foods. Hydrocolloids come in a variety of sources: plants, animals, algae, and some are even made by microorganisms, and many are derived from natural sources such as agar, carrageenan, and gelatin by hydrolyzing cow protein and pectin from the citrus peel. Hydrocolloids can be irreversible (single state) or reversible. Types of hydrocolloids include carboxymethylcellulose, microcrystalline cellulose, ethylene cellulose, hydroxypropyl methylcellulose, hydroxypropyl cellulose, carrageenan, pectin, guar gum, fiber, alginate, stepwise agar, agar gum, Xanthan gum, pullulan, gelan gum. Hydrocolloids are in two groups: non-ionic gums and anionic gums. Non-ionic gums include xanthan, guar gum, and carob bean gum, while carrageenan, gum Arabic, caraway gum, and gelan gum are anionic gums. Hydrocolloids are used as a coating or wall of the capsule because of their edible nature, biodegradability, and insulation between the inside and outside of the capsule. Hydrocolloids have gastrointestinal function, and prevent colon cancer, which is the second leading cause of cancer death. Hydrocolloids such as agar are used in the preparation of various types of microbial culture medium and are used as a tool in various stages of chromatography and gel filtration. In medicine, hydrocolloids such as dextran, hydroxyethyl starch, gelatin, etc. are used in injection fluids and volume-expanding solutions to treat hypovolemia. Hydrocolloids are used in the manufacture of bioadhesives for surgical bandages, dressings, or coatings used to treat pressure sores and wounds.

Declarations

Conflict of interest

There is not any Conflict of interest between authors.

The authors whose names are listed in the manuscript certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Figures

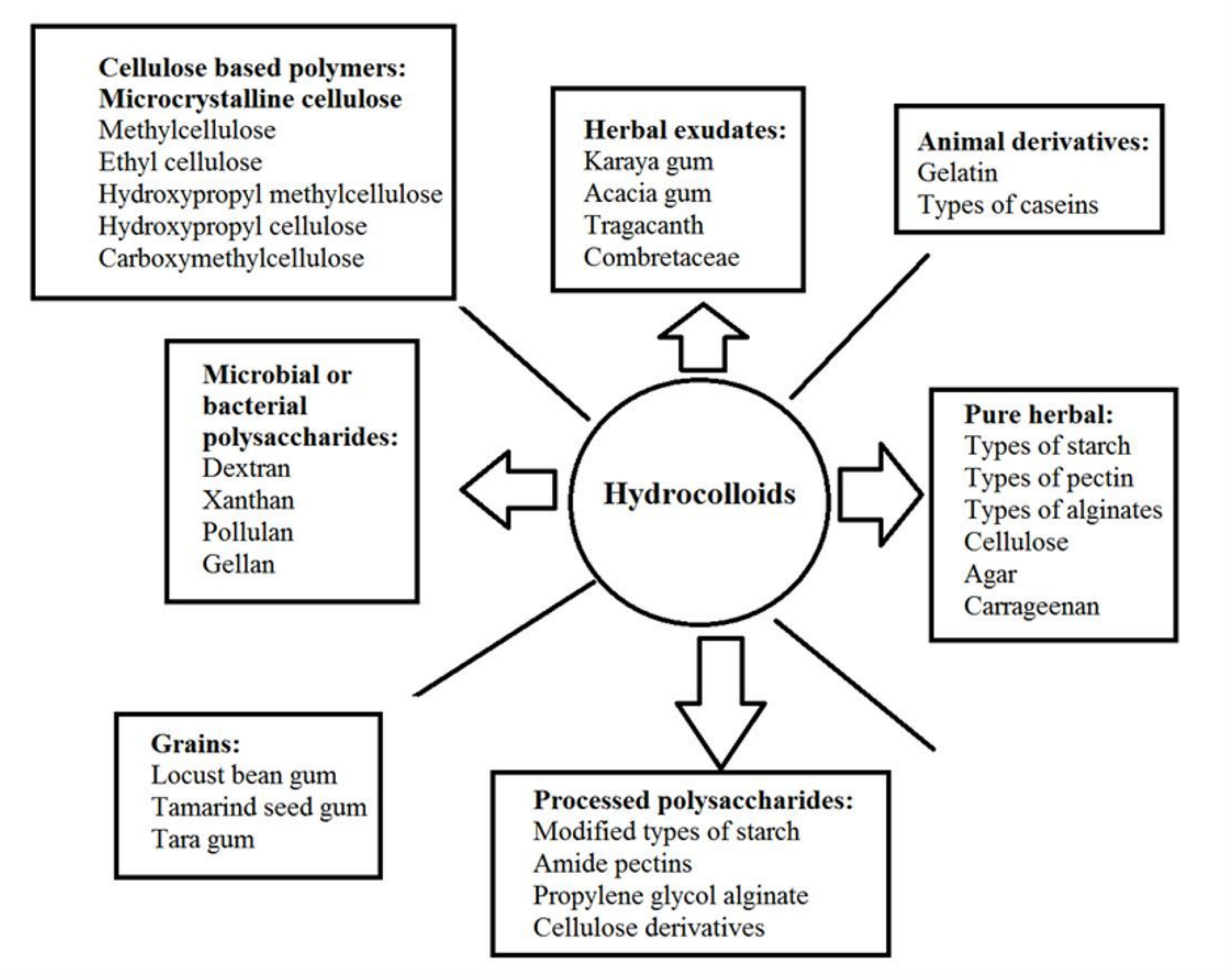


Figure 1

List of used hydrocolloids in food industry

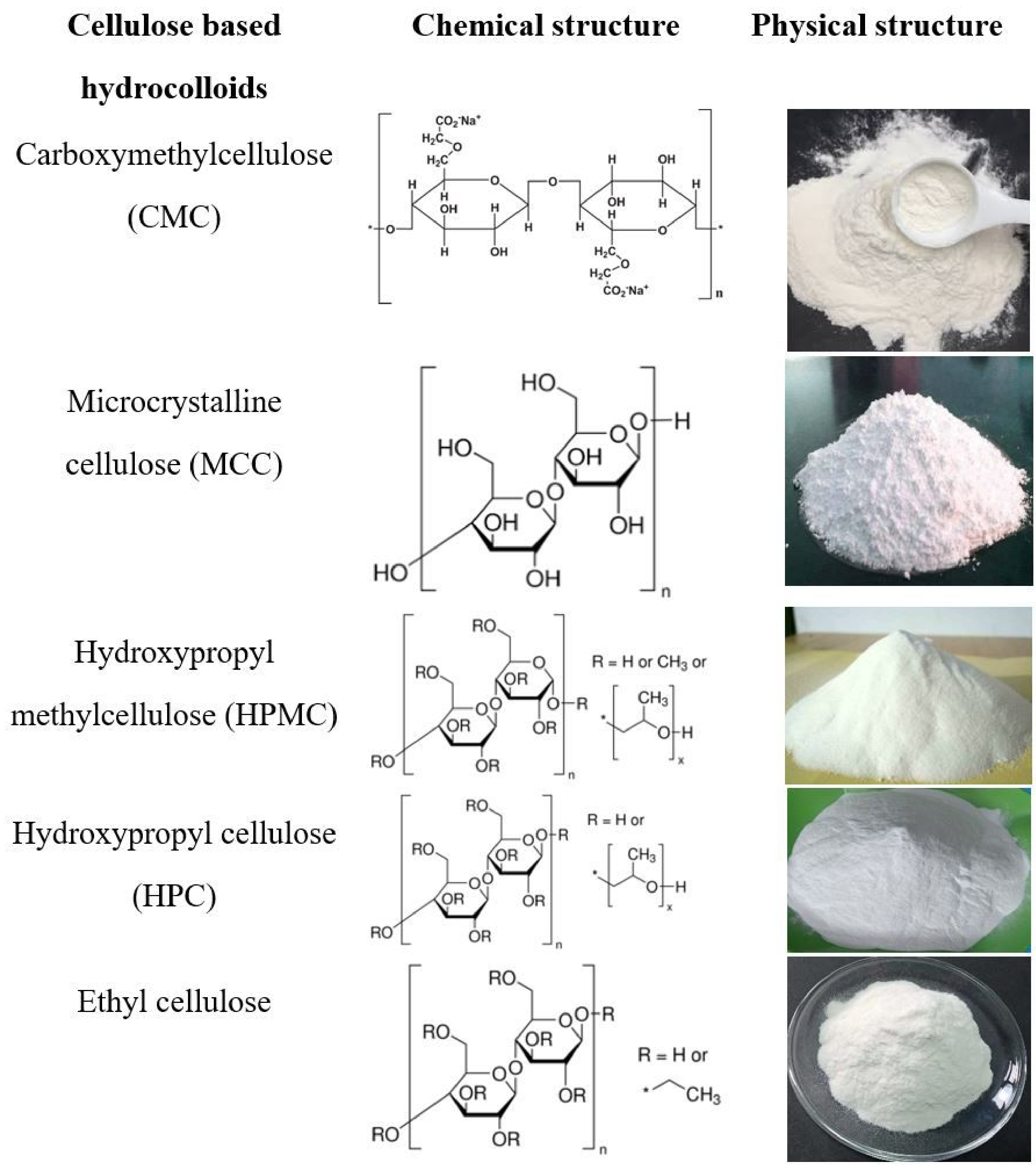


Figure 2

Chemical and physical structure of Cellulose based hydrocolloids (French, 2017)

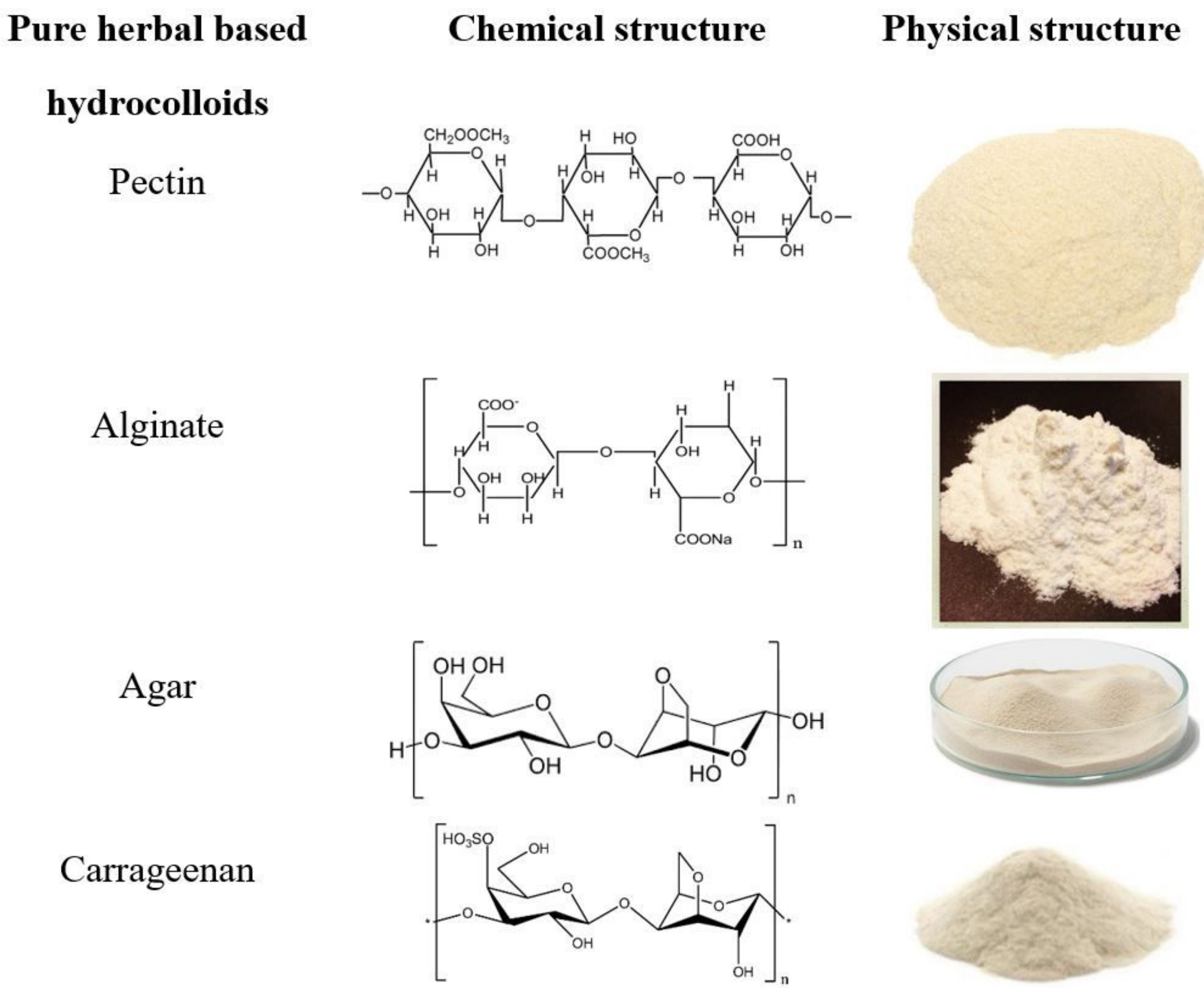


Figure 3

Chemical and physical structure of pure herbal based hydrocolloids

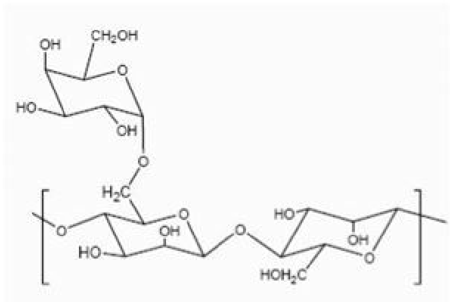
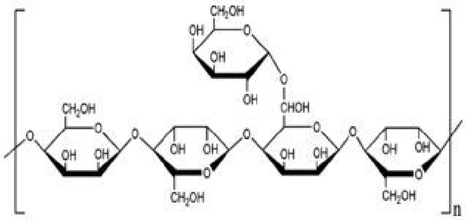
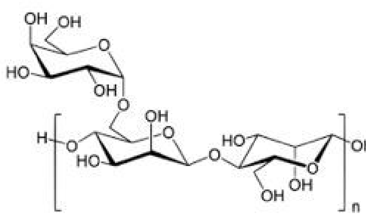
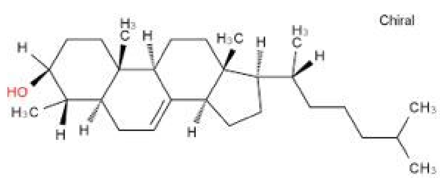
Hydrocolloids based on plant gums	Chemical structure	Physical structure
Guar gum		
Locust bean gum		
Zedo Gum		
Gum Arabic		
Tragacanth gum		

Figure 4

Chemical and physical structure of hydrocolloids based on plant gums

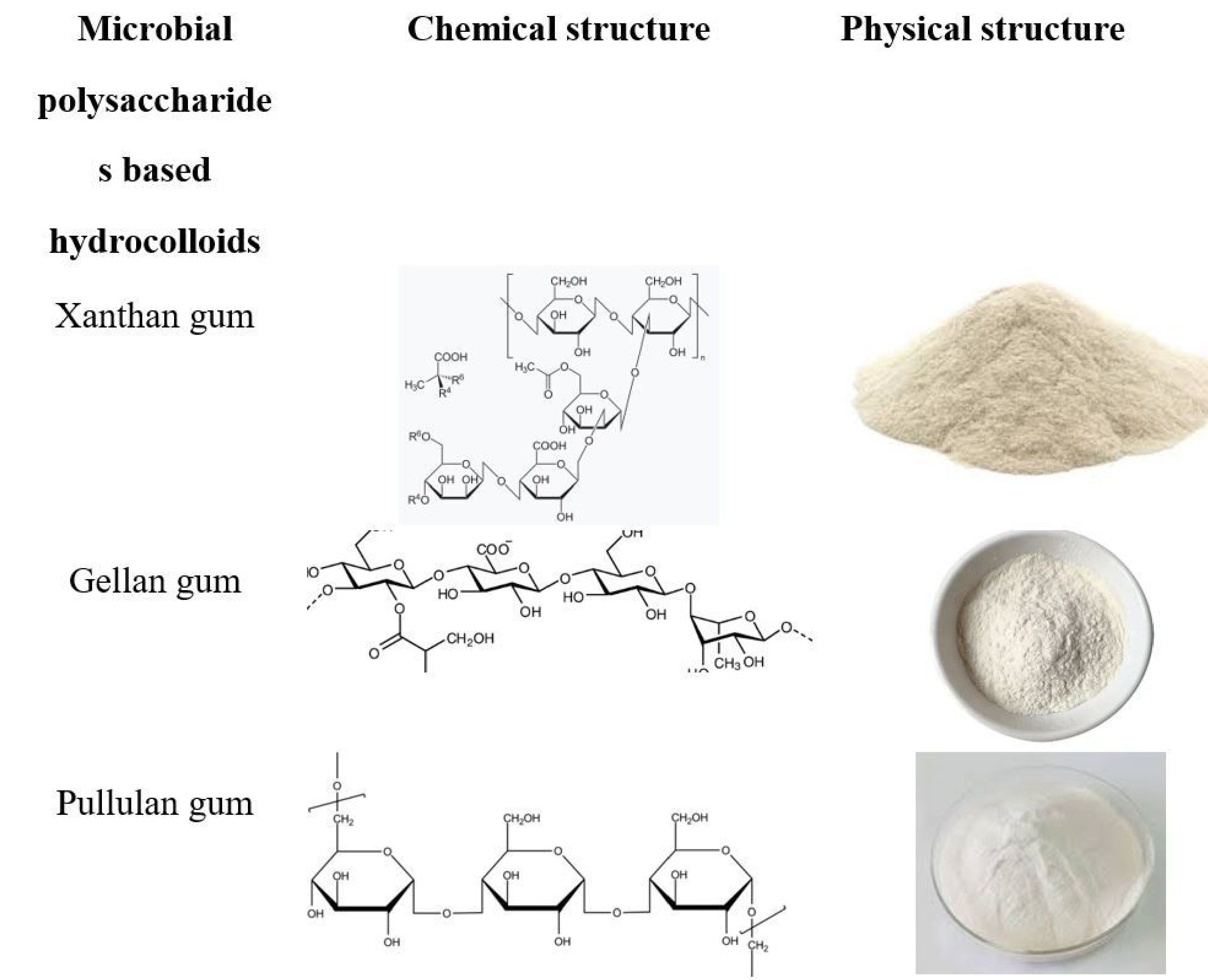


Figure 5

Chemical and physical structure of microbial polysaccharides based hydrocolloids