

AN OVERVIEW OF FOOD HYDROCOLLOIDS AND THEIR APPLICATIONS

Abstract

Hydrocolloids are polysaccharides that are now widely used as additives in different types of food products to improve their textural properties. The main function of hydrocolloids is that they act as thickening, gelling, as well as stabilizing agents. In most cases, they are derived from plants and are easily soluble in both warm and cold water. Plants are typically the source of these compounds. Hydrocolloids are commonly used in the development of low-calorie food products. These are commonly used in dairy products, confectionery products, bakery products, and salad dressings. Nowadays, interest is growing in the use of hydrocolloids in the development of edible film and coatings for packaging. This chapter focused mostly on the role as well as the application of hydrocolloids in food products. In this chapter, we will talk about certain hydrocolloids that are utilized rather frequently in food goods.

Keywords: Food Hydrocolloids.

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I. HYDROCOLLOIDS

Hydrocolloids can be characterized as complex chains of polymers (namely polysaccharides and proteins) that are non-digestible. The word "hydrocolloid" is obtained from the Greek words "hydro" and "kolla," which respectively translate to "water" and "glue." Hydrophilic in nature, these substances are widely utilized in the food business due to their ability to disperse freely and exhibit partial or complete solubility in both cold and hot water (Jafari et al., 2013; Williams & Phillips, 2021). The hydrophilic property of the substance enables it to form a colloidal solution when placed in an aqueous phase. According to Anderson and Andon (1988), Bergenstahl et al. (1988), and Juan and Shao (2015), the substance has a thickening or viscosity-enhancing action upon dissolution or dispersion in water. These substances possess a substantial molecular weight and serve various functions such as thickening, gelling, emulsifying, stabilizing, replacing fats, clarifying, flocculating, clouding, and whipping. Functional additives are commonly employed in food formulation to enhance the consistency and gelling properties of food products while also exerting control over their microstructure, texture, flavor, and shelf life. Hydrocolloids possess the capability to mitigate or impede the development of sugar or ice crystals in ice cream. Consequently, hydrocolloids are extensively employed as agents for thickening and gelling, as supported by various studies (Lu et al., 2020; Li & Nie, 2016; Nishinari et al., 2018; Jafari et al., 2012). The extensive usage of hydrocolloids is attributed to their hydrophilic character, which allows them to disperse in water, causing the liquid to thicken. This function is commonly observed among all hydrocolloids. The thickening property is contingent upon the nature and kind of hydrocolloid. Certain hydrocolloids can achieve thickening at low concentrations, while others necessitate higher concentrations to yield the desired thickening effect. In addition to their ability to make things thicker, several hydrocolloids have the ability to create gels. Gels can be thought of as a structural framework that exists between the liquid and solid states. This framework is made up of cross-links between polymer molecules. This process leads to the formation of a 3D network inside an aqueous solution, effectively entrapping water and thus enhancing the viscosity. Hydrocolloid gels are commonly described as physical gels due to their formation by several mechanisms, such as hydrophobic interaction, hydrogen bonding, and cation-induced cross-links (Abaee et al., 2017; Munarin et al., 2012; Saha & Bhattacharya, 2010; Glicksman, 1982). Furthermore, hydrocolloids have the capability to enhance the longevity of dairy products through the augmentation of water holding capacity (WHC) and the mitigation of whey syneresis. Additionally, hydrocolloids may effectively suspend dispersed particles and hinder the flocculation of protein micelles. Adding hydrocolloids to dairy products has been shown to reduce whey separation in yogurt (Sahan et al., 2008; Temesgen and Yetneberk, 2015; Emine and Ihsan, 2017), cheese (Rubel et al., 2019), and ice cream (Sharma and Hissaria, 2016; Maity et al., 2018). In addition, the consumption of hydrocolloids has been associated with specific nutritional advantages, including its probiotic effect. Consequently, hydrocolloids are often referred to as a beneficial food additive due to their potential to safeguard against a range of ailments, including cardiovascular disease, colon cancer, and diabetes mellitus (Liu et al., 2014; Mayakrishnan et al., 2013; Xu et al., 2013). Hydrocolloids are often employed as components within the food sector. Polysaccharides have several functions in food applications, including thickening, gelling, emulsifying, stabilizing, replacing fats, clarifying, flocculating, clouding, and whipping. Moreover, they find utility in edible films, flavor encapsulation, and inhibiting crystallization.

II. MARKET TRENDS OF HYDROCOLLOIDS

There are several functions attributed to hydrocolloids that contribute to their high demand in the market. The rise in customer demand for convenience foods and low-calorie options has led to an indirect increase in the demand for hydrocolloids. These hydrocolloids serve as fat replacers, stabilizers, thickeners, and binders in food products (Anon, 2022a).

The market size of hydrocolloids on a global scale was recorded at \$9.07 billion in the year 2019. The market is anticipated to have a growing trend, with the total value of the industry anticipated to increase from \$9.37 billion in 2020 to \$13.30 billion in 2027. The anticipated expansion is projected to transpire at a compound annual growth rate (CAGR) of 5.13% during the timeframe encompassing 2020 to 2027. The global impact of the COVID-19 pandemic has been unparalleled, leading to a substantial fall in the demand for hydrocolloids across several sectors. According to reports, the global market for hydrocolloids during COVID-19 showed a small growth of 3.31% in 2020 compared to the preceding year. According to the global market share report, it is evident that hydrocolloids such as xanthan gum, carrageenan, guar gum and gelatin hold a major market share. Gelatin is the hydrocolloid that dominates the market due to its wide application in the pharmaceutical industry, which includes dressings and tablet development. Following gelatin, xanthan gum holds 18.96% of the global market. It finds broad use in many food items to enhance attributes such as texture, flavor, consistency, and shelf life. Additionally, it was estimated that a majority of hydrocolloids in China, approx. 59.0 % were employed within the food and beverage sectors. The remaining hydrocolloids were employed in the pharmaceutical, cosmetic, and personal care industries (Anon, 2021).

During the period between 2023 and 2027, the size of the hydrocolloids market is expected to expand at a compound annual growth rate (CAGR) of 7.2%. The increase in the market size of hydrocolloids in India is due to the increase in demand for food products with reduced fat content. Hydrocolloids such as starches, gelatin gum, xanthan gum and others are the most popular in the Indian market and are widely used in products like bakery, dairy, meat, beverages and confectionaries. The major players in the market for hydrocolloids are CP Kelco, Rousselot, Cargill Inc., Hawkins Watts, DuPont, and Royal DSM. There is a wide increase in the demand for hydrocolloids in bakery industries to produce gluten-free processed food because a large population of Indians suffers from celiac disease (Anon, 2022b).

III. HISTORY OF HYDROCOLLOIDS

Hydrocolloids have been recognized in the scientific community for a considerable period of time, with the earliest patent for hydrocolloids being granted in 1967 specifically for their application in stoma care. The utilization of hydrocolloids has been initiated several years ago. Hydrocolloids such as gelatin, pectin, agar, and starches have been utilized for an extensive period of time and are readily available for direct consumer purchase at the retail level (Imeson, 2011). The aforementioned healthcare products are widely recognized in the market, with gelatin being the most favored among them.

The utilization of reversible hydrocolloids in the creation of impressions for fixed prostheses dates back to 1937, while irreversible hydrocolloids have been employed for the

same purpose since 1947. The impression procedures employed during this period were comparable to those utilized in contemporary practices. The veracity of dimensional correctness in reproducing irreversible hydrocolloids has been established since 1947. This study aimed to evaluate the dimensional accuracy of three recently developed alginates, namely Algi-X (Algiflex Super, Howmedica Alginate), Ardent Alginate, and Ultrafine, as well as a combination material called Colloid 80/ Algiace (Dentloid/Algiace). The comparison was made with two agar hydrocolloids and an addition silicone under varying conditions of stock trays commonly used in dental clinics. In the majority of clinical scenarios, the recently developed alginates utilized in metal stock trays exhibit comparable levels of accuracy to conventional imprint materials. The accuracy of the combination material diminishes when there is a need to replicate numerous abutment preparations. The choice between perforated or non-perforated metal stock trays has no impact on the precision of the alginates. The utilization of alginates in disposable plastic trays has the potential to result in significant inaccuracies. In the context of limited areas characterized by pronounced unobstructed undercuts, certain alginates examined in this work may exhibit worse performance compared to other impression materials.

IV. CLASSIFICATION OF HYDROCOLLOIDS

It is traditionally categorized as polysaccharides and sorted by its origin. Further, the classification of hydrocolloids is based on their chemical structure and can also be grouped as non-ionic and anionic gums. Table 1, 2 and 3 represents a classification of hydrocolloids based on different types of sources, their chemical structure and their ionic group (Li and Nie, 2016).

Table 1: Classification of Hydrocolloids based on Different Type of Sources

Group	Hydrocolloids
Plant	Pectin, inulin, gum arabic, gum ghatti, gum tragacanth, gum karaya, cassia seed gum, basil seed gum, mesquite seed gum, fenugreek gum, chicle gum, oat gum, rye gum, konjac, psyllium, guar gum, locust bean gum, flaxseed gum, wattle gum, starches
Animal	Chitin, chitosan, gelatin
Seaweed	Agar, carrageenan, alginic acid, alginate, furcellaran, ulvan, fucoidan, red alga xylan
Microbial	Xanthan, gellan gum, tara gum, dextran, pullulan, welan gum, curdlan, levan
Synthetic	Methylcellulose, methyl ethyl cellulose, carboxy methyl cellulose, hydroxyethyl cellulose, hydroxyl propyl cellulose, hydroxypropyl methylcellulose, microcrystalline cellulose

Table 2: Classification of Hydrocolloids based on their Chemical Structure

Group	Hydrocolloids
Glucan	Starch, oat gum, barley gum, curdlan, welan gum, pullulan, dextran
Fructan	Inulin, levan
Xylan	Red alga xylan

Rhamnan	Ulvan
Galactomannan	Guar gum, locust bean gum, tara gum, cassia seed gum, basil seed gum, mesquite seed gum, fenugreek gum
Glucomannan	Konjac, alginate
Arabinoxylan	Psyllium, flaxseed gum (containing another galacturonan fraction), rye gum, wheat gum
Galactan	Agar, carrageenan, fucoidan, furcellaran
Arabinogalactan	Gum Arabic
Galacturonan	Pectin
Glycano-rhamnogalacturonan	Gum karaya, gum tragacanth (containing another arabinogalactan fraction)
Glycano-glucuronomannoglycan	Gum ghatti
Glucosamine polymer	Chitin, chitosan
Protein	Gelatin

Table 3: Classification of Hydrocolloids based on their Ionic Group

Non-Ionic Gums	Anionic Gums
Non-ionic hydrocolloids include - xanthan gum, guar gum, and locust bean gum	Anionic hydrocolloids includes - gellan gum carrageenan, gum arabic, gum karaya,

V. ROLE/ FUNCTIONS OF HYDROCOLLOIDS

Hydrocolloids finds extensive utilization in the dairy and food sectors owing to its broad range of applications. The utilization of this substance is employed to execute various functions based on the specific requirements within food goods. They possess the ability to fulfill diverse functions within food matrices, including serving as thickeners in soups, gravies, salad dressings, sauces, and toppings (Krystyjan et al., 2012). Additionally, they can act as gelling agents in puddings, jellies, and aspics, as well as emulsifiers in yoghurt, ice cream, and butter (Kiani et al., 2010). Moreover, they have the ability to be used as substitutes for fat in meat and dairy products (Pinero et al., 2008). Additionally, they possess the capability to act as coatings in confectionery and fried foods, adhesives in bakery glazes, clarifying agents in wine and beer, clouding agents in juices, flocculating agents in wine, encapsulating agents in powdered fixed flavors or certain oils, crystallization inhibitors in ice cream and sugar syrups, whipped toppings and foam stabilizers in beer, suspending agents in chocolate milk, starch retrogradation inhibitors in batters and breads, water-binding agents in gluten-free foods (Mohammadi et al., 2015; Ziobro et al., 2013), syneresis inhibitors in frozen foods and cheeses, and bioplastics for food, among other applications (Jafari et al., 2012; Nishinari et al., 2018).

There are currently several different hydrocolloids available on the market. The careful selection of hydrocolloids for certain goods is of utmost importance. The choice of hydrocolloids is determined by the specific properties desired in the product, as well as the stability of hydrocolloids in said product. Table 4 shows an assortment of hydrocolloids that are frequently used in food products. (Goff and Guo, 2019).

Table 4: Utilization of Hydrocolloids in Different Types of Food Products

Type of Food	Utilization of Specific Hydrocolloids
Bakery fillings	Carrageenan, pectin, locust bean gum, guar gum, pectin, alginate, konjac gum, xanthan gum, agar, gellan gum
Muscle foods	Alginate, konjac, carrageenan, glucomannan, modified starch
Restructured foods	Alginate
Culture dairy products	Locust bean gum, modified starch, gelatin, xanthan gum, carrageenan, guar gum
Salad	Propylene glycol alginate (PGA), xanthan gum, guar gum, microcrystalline cellulose (MCC), modified starch
Bakery products	Guar gum, xanthan gum, carboxymethyl cellulose (CMC), konjac gum, fenugreek gum

- 1. Thickening/ Viscosity Property:** Hydrocolloids are extensively employed in the enhancement of the thickening characteristics of food products. This improvement in thickening is mostly attributed to the increase in viscosity. Upon the introduction of hydrocolloids into an aqueous solution, the viscosity of the solution will increase as a result of intermolecular entanglement. This entanglement hinders the flow of the solution and consequently causes the products to thicken. The phenomenon of thickening takes place when the concentration of a substance above a threshold value known as the overlap concentration (C^*).

According to Phillips and Williams (2000), the dispersion exhibits Newtonian behavior below the critical value C^* , while it displays non-Newtonian behavior beyond C^* . Hydrocolloids are mostly employed in fat-free or reduced-fat formulations, wherein water is incorporated as a replacement for fat or oil. The water is thickened by the addition of hydrocolloids, resulting in a product that exhibits comparable characteristics to full-fat meals. The inclusion of hydrocolloids in reduced fat or fat-free food does not have a significant impact on the mouthfeel, body, and texture that may be compromised when fat is removed from these food products. This is due to the important contributions fat contributes to the body, mouthfeel, and texture of such foods.

- 2. Gelation:** Furthermore, a wide range of hydrocolloids not only possess thickening capabilities but also have the capacity to produce gels. The gel phase is an intermediate stage of the hydration process that takes place between the solid and liquid states. Also, a wide range of hydrocolloids not only possess thickening capabilities but also have the capacity to produce gels. The gel phase is an intermediate stage of the hydration process that takes place between the solid and liquid states. Hydrocolloids, including gelatin, gellan, carrageenan, pectin, agar, hydroxylpropyl methylcellulose, and methylcellulose, are extensively employed as gelling agents in many applications. The aforementioned gelling agent has been extensively utilized in various food products, including dairy desserts (Verbeken et al., 2006), bakery products, and jellies (Uzuhashi and Nishinari, 2003; Stanley, 2006). Additionally, it has been employed in puddings, milkshakes, and tofu (Puvanenthiran et al., 2003; Michel et al., 1997), as well as in glazes, jellies, milk-based desserts and jams (Wilats et al., 2006; Capel et al., 2006). Moreover, this particular ingredient has demonstrated its versatility in the realm of restructured food products and

cold bakery creams (Roopa and Bhattacharya, 2008, 2009). Additionally, it has been successfully incorporated into a wide range of culinary creations, including beverages, salad dressings, whipped toppings, and cake batters (Williams, 2006).

- 3. Stability:** When a formulation undergoes partial removal of oil or fat and is substituted with thicker water, it typically causes the development of an emulsion as a result. The primary role of hydrocolloids is frequently to stabilize emulsions, mitigate phase separation and regulate the formation of ice crystal frozen food products. In order to mitigate the issue of the formation of ice crystals in frozen foods, novel technologies and ingredients have been devised. However, it is important to note that hydrocolloids will persist in their involvement in this domain. Most ice cream products found in retail establishments are often fortified with stabilizing agents, including carrageenan, locust bean gum, and/or guar gum. The aforementioned discussion highlights the advantageous emulsion-stabilizing effects of low-fat salad dressings.
- 4. Fat Replacer:** Nowadays, individuals are increasingly concerned about caloric intake. They aim to minimize their consumption of high-calorie food to the greatest extent possible. The market has seen an increasing interest in reduced fat or fat-free food products, mostly driven by the considerable caloric contribution of fat. Dairy goods, such as cheese and ice cream, are currently being extensively manufactured with reduced fat content. The sensory and textural qualities of foods will be impacted by the removal of fat. The incorporation of hydrocolloids into the food matrix facilitates water binding, resulting in improved mouthfeel and textural characteristics that closely resemble those of conventional food products. As a result, there has been a subsequent rise in the demand for hydrocolloids. For instance, the Italian dressing incorporates xanthan gum as a substance that increases its thickness, while the 'Light' mayonnaise ingeniously integrates guar gum and xanthan gum as additives to deftly substitute fat and enhance its viscosity (Milani and Maleki, 2012).
- 5. Reduces Whey Syneresis:** The phenomenon of gel shrinkage is commonly referred to as whey syneresis, as described by Lucey (2004). The occurrence of defects in gels, particularly in cheese and yogurt, is a prevalent phenomenon observed during storage. According to Bhatti et al. (2021), the prevalent issue observed in ricotta cheese during storage is spontaneous whey syneresis, resulting in a significantly reduced shelf life. Spontaneous syneresis (SS) is the observable liquid that is obtained on the surface of cheeses, whereas internal serum (IS) is generated with the application of external force, such as centrifugal force. Consequently, the incorporation of hydrocolloids results in a reduction of whey syneresis in gels. Numerous authors have documented that the inclusion of hydrocolloids leads to a reduction in whey syneresis in yogurt (Emine & Ihsan, 2017; Temesgen & Yetneberk, 2015); cheese (Rubel et al., 2019; Joyner and Damiano, 2015) and other food products.
- 6. Used as Edible Films:** An edible film can be defined as a thin membrane that possesses the ability to be consumed, employed as a covering for a food item, or utilized as a safeguarding interface between the food and its external environment. One prominent illustration of consumable packaging is observed in the context of sausage meat, wherein the casing is retained during the cooking and consumption process. Hydrocolloids are employed in the creation of edible films that are applied onto food surfaces and utilized as

a barrier between various food constituents. These coatings function as barriers against the migration of lipids, scent, gas and moisture. Numerous gums and their derivatives have been employed for the purpose of coating. It includes cellulose, alginate, carrageenan and its derivatives, starch, pectin and its derivatives, among others. Due to their hydrophilic character, the hydrocolloids generate coatings that possess inherent limitations in terms of moisture barrier capabilities.

Nevertheless, when employed in a gel state, they possess the capability to impede the loss of moisture during brief periods of storage, wherein the gel functions as a sacrificial agent rather than a barrier to the transmission of moisture. Moreover, it has been observed that certain instances exhibit an inverse correlation between the permeability of oxygen and water vapor. Consequently, these films possess the capability to offer efficient safeguarding against the oxidation process of lipids and other vulnerable constituents found in food. The hydrocolloid edible films can be classified into two distinct classes depending on the composition of their constituents, which encompass proteins, polysaccharides, or alginates.

VI. COMMONLY USED HYDROCOLLOIDS IN FOOD PRODUCTS

- 1. Guar Gum:** Guar gum is a polysaccharide that originates from the Indian term "Gua-ahar," wherein "gau" denotes cow and "ahar" signifies sustenance. The substance under study is derived from the endosperm of the drought-resistant guar plant, scientifically known as *Cyamopsis tetragonoloba* and belongs to the legume family. The galactomannan constituent found in guar gum is accountable for its water solubility and physical attributes. Guar gum is acquired in the form of a granular powder, including a ratio of around 2:1 (mannose: galactose), with one galactose unit present on every other mannose unit. The hue of guar gum varies from off-white to a pale yellow or green shade, and it possesses a mild flavor (Kay 1979; Prem et al., 2005; Whistler and Hymowitz, 1979; Yu, 1996).

Oliveira et al. (2011) studied the effect of guar gum varying in concentration in the range between 0.0025–0.01 percent by weight in Edam cheese prepared by using low-fat milk. They also prepared Edam cheese with full-fat milk and low-fat milk without guar gum as a control sample. The Edam cheese made with guar gum was found to have a higher amount of protein and moisture while having a lower percentage of fat, according to the results of the compositional analysis. Rheological investigations, on the other hand, found that samples with 0.0025% weight-per-volume of guar gum were comparable to those of full-fat cheese.

Ghodke (2009) conducted research to determine how the presence of guar gum affected the stickiness of whole wheat chapatti dough as well as the staleness of chapatti while it was being stored. Guar gum was added at varying concentrations, ranging from 0.25% to 1.0% of the weight of the whole wheat flour. The stickiness of dough was investigated with the help of a stickiness measurement probe known as the Chen-Hoseney probe. According to the findings, the inclusion of guar gum demonstrated the ability to mitigate the staling phenomenon in chapattis. Results also showed that chapatti with guar gum had a higher amount of moisture, in-vitro enzyme digestibility (IVED) and water soluble starch (WSS) as compared with the control chapatti. Chapattis with added

hydrocolloids require a lower force to tear it. Nevertheless, the incorporation of guar gum at a concentration of 0.75% w/w relative to whole wheat flour resulted in the production of chapattis with the most desirable softness. However, the extensibility of the chilled chapatti that included guar gum remained relatively unchanged for up to three days after being stored in the refrigerator. Finally, it was shown that chapatti preserved in a refrigerated environment and containing guar gum exhibited a reduced decline in extensibility, maintaining this characteristic for a duration of three days.

Gautam et al., 2023 prepared ricotta cheese spread by blending the ricotta cheese curd and guar gum (0.4%) along with required amount of water for moisture adjustment and salt of 1.5% for taste. Sensory evaluation reported that the product obtained by convectional as well as mechanized method were equally acceptable.

- 2. Xanthan Gum:** Xanthan gum is an extracellular polysaccharide produced by the synthesis of bacteria. The compound under consideration has a substantial molecular weight and is composed of d-glucose units that are connected by β -(1, 4) bonds. Additionally, xanthan gum has a trisaccharide side chain. The substance in question is produced through the secretion of *Xanthomonas campestris*, a bacterium. Its commercial manufacturing involves a batch-submerged fermentation method that incorporates vigorous agitation. The substance exhibits solubility in cold water and finds extensive utilization within the food sector, specifically in the production of baked goods, yogurt, cheeses, drinks, ice creams, desserts, sauces and dressings. Xanthan gum demonstrates a pronounced non-Newtonian pseudoplastic flow behavior, characterized by a decrease in viscosity with increasing shear rate. Moreover, it exhibits remarkable viscosity stability throughout a broad spectrum of pH levels and temperatures. The substance exhibits solubility in cold water and demonstrates resistance to enzymatic destruction. Additionally, there is evidence of a synergistic interaction between the substance in question and galacto-mannans, specifically guar gum, locust bean gum (LBG), and konjac mannan (Sworn, 2021; Katzbauer, 1998).

Murtaza et al. (2017) examined the impact of xanthan gum on the production of low-fat cheddar cheese derived from buffalo milk. The researchers reached the conclusion that there was a steady decline in the hardness of reduced-fat cheddar cheese as the concentration of gums increased, namely at levels of 1.5%, 3.0%, and 4.5%. The use of gums in cheese formulations resulted in enhanced sensory acceptance. Ultimately, it has been noted that there exists an enhancement in both the functioning and acceptability of low-fat Cheddar cheese derived from buffalo milk.

In a study conducted by Ghods Rohani et al. (2019), the researchers examined the impact of Konjac and Xanthan gums on the spreadability of processed cheese. The findings indicate that the incorporation of Konjac and Xanthan gums into the cheese resulted in a reduction in pH. The researchers noted that augmenting the quantity of xanthan and konjac gums resulted in an elevation of both flavor and firmness scores while concurrently leading to a decline in spreadability scores. The augmentation of xanthan and konjac gums' concentration resulted in an elevation in cheese stiffness, cohesiveness, gumminess, and chewiness while concurrently diminishing its adhesiveness.

Also, Nateghi et al. (2012) examined the impact of xanthan gum in combination with sodium caseinate as substitutes for fat in reduced-fat Cheddar cheese. The findings indicate a large increase in moisture and protein content with a reduction in fat level. The researchers reached the conclusion that the use of xanthan gum in low-fat cheeses yields improvements in key textural attributes, including hardness and gumminess. Furthermore, an electronic olfactory system was employed to assess the presence of volatile taste compounds in a low-fat cheese product enriched with a substantial quantity of xanthan gum. The findings of the study indicate that an increased concentration of xanthan gum has a beneficial impact on the release of taste compounds in low-fat cheeses.

- 3. Locust Bean Gum:** The substance known as locust bean gum is a powder that appears white to creamy white in color. It is classified as a neutral polysaccharide and has a stated molecular weight ranging from 300,000 to 360,000. This substance is commonly referred to as carob gum due to its extraction from the seeds of the carob tree, a member of the legume family. The trees discussed in this context are mostly distributed in Mediterranean countries, with a notable concentration in Spain. From a botanical perspective, they are scientifically classified as *Ceratonia siliqua* L. The carob seed comprises three primary components, namely the husk, endosperm, and germ. Following the mechanical removal of the husk, the endosperm of the carob seed was subjected to milling in order to get the LBC (Ensminger and Ensminger, 1993; Batlle, 1997; Custódio et al., 2005; Maier, 2012; Maier, 1993).

Mandala et al. (2007) examined the impact of hydrocolloids on the physical characteristics of bread when kept under low-temperature conditions. They reported that the incorporation of hydrocolloids (Locust bean gum and guar gum) increases the overall yield of baked products. The texture of the finished product was improved and produced a more viscous dough. Additionally, it was shown that hydrocolloids had significant efficacy in reducing blood cholesterol levels and showed potential in the treatment of diabetes.

- 4. Pectin:** Pectin is a complex polysaccharide with partial methyl esterification of the carboxyl groups, formed by the condensation of α (1→4) linked anhydrogalacturonic acid. While, galactose, xylose and arabinose rhamnase are the four neutral sugars most commonly associated with pectin (Brejnholt, 2009). Pectin, a kind of structural carbohydrate, is ubiquitously present in higher plants. Typically, commercial pectin preparations are sourced from citrus peel or apple pomace, which are residual materials generated during the production of juice. The majority of global pectin production is allocated towards the manufacturing of jams and jellies, while there is a growing utilization of this substance in confectionery items, beverages, and acidified milk beverages. Pectin demonstrates favorable suitability for use in acidic food items due to its notable durability at low pH conditions (Milani and Maleki, 2012; Goff and Guo, 2019; BeMiller, 2008).

Arioui et al. (2017) studied the effect of pectin extracted from the peel of *citrus sinensis* on the physico-chemical as well as sensory properties of yogurt. They incorporated pectin in milk at four different levels, 0%, 0.1%, 0.3% and 0.6%, before the inoculation of a specific culture in milk. Results showed that there was a direct correlation between the pectin concentration and viscosity of yogurt, and acidity as well.

Yogurt with 0.6% pectin was reported to be more viscous as compared with the other samples containing a lower amount of pectin. Also, pectin content had a positive correlation with the reduction in whey syneresis seen in yogurt. Finally, it was concluded that yogurt containing 0.6% pectin exhibited superior rheological behavior, specifically in terms of cohesiveness, viscosity and adhesiveness as well.

Macků et al. (2008) prepared processed cheese with 40% and 50% fat by weight on dry matter and studied the effect of pectin on the viscoelastic and sensory behavior of the final product. Pectin was added at four different levels: 0.2%, 0.4%, 0.6% and 0.8%. Results depicted that the addition of pectin made a more rigid product, whereas the spreadability was comparably low with the control sample (without pectin). Increasing the concentration of pectin will increase the storage as well as loss moduli. The sensory study reported that there was a direct correlation between rigidity and pectin concentration.

- 5. Carrageenan:** Carrageenans are classified as structural polysaccharides obtained from marine red algae. It is classified within the taxonomic group Rhodophyceae, and is commonly obtained from species such as *Chondrus crispus*, *Euchema cottoni*, *Euchema spinosum*, *Gigartina skottsbergi*, and *Iradaea laminarioides*. These are derived from seaweed, are not metabolized by the human body and lack nutritional value. Its functional properties, which make it widely applicable, are its gelling, thickening, and stabilizing properties in food items. There are generally three types of carrageenan, which include kappa, iota and lambda. The main difference between the above three carrageenan is the sulphate content and 3, 6-anhydrogalactose content as well. It is widely used as thickeners to achieve a creamy texture (Milani and Maleki, 2012; Pegg, 2012).

In a study conducted by Černíková et al. (2008), the researchers examined the impact of k-carrageenan and i-carrageenan on the viscoelastic properties of processed cheese containing lipids at concentrations of 45% and 50% by weight, based on dry matter. Both the hydrocolloids added at three different levels of 0.05%, 0.15% and 0.25% w/w. They reported that with the increase in the concentration of hydrocolloids, both losses as well as storage moduli increased, which might be due to the stronger gel formation. The study's findings indicated that the addition of i-carrageenan at doses of 0.15% and 0.25% exhibited more efficacy in addressing stiffness when compared to k-carrageenan.

VII. CONCLUSION

Hydrocolloids represent a class of polysaccharides that have excellent solubility in both warm and cold aqueous environments. This chapter mainly focuses on the function of hydrocolloids in various food products. Nowadays, hydrocolloids have emerged as critically significant ingredients in today's food industry due to their wide applications. The gelling effect, as well as the thickening effect, are the most important properties of hydrocolloids. These are able to improve the textural properties of food products. Modern consumers have become more health conscious and want to consume low-calorie foods. The best way to produce low-calorie food is to remove excess fat from the food products. However, removing fat from food will deteriorate the textural as well as the organoleptic properties of food, as fat is the major contributor to the above-listed properties. Therefore, hydrocolloids present a

favorable choice for incorporating into low-fat or reduced-fat food formulations, owing to their capacity to bind water. This attribute enables them to emulate the desired textural characteristics typically associated with full-fat food products.

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