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(Review Article)

Hydrocolloids is a new trend as meat preservative

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Abstract

Meat eating aids in the absorption of proteins and vital amino acids, as well as vitamins and minerals such as vitamin B, vitamin A, zinc, and iron, all of which are required for a balanced diet. This evaluation looked into the many types of hydrocolloids and whether they may be used as a new, safe natural meat preservative. Natural, semi-synthetic, and synthetic hydrocolloids are classified according to their origin. Hydrophilic polymers generated from natural sources such as plants, animals, microbes, and seaweeds are known as natural hydrocolloids. Semi-synthetic hydrocolloids, on the other hand, are modifications of naturally formed hydrocolloids, whereas synthetic hydrocolloids are chemically manufactured from petroleum-derived base materials to produce a product with a structure comparable to natural polysaccharides. In recent years, natural hydrocolloids have been widely preferred in the food industry for improving the stability, functionality, quality, safety, nutritional and health benefits of various food products over semi-synthetic and synthetic hydrocolloids due to: Extracted from renewable sources, readily available and easy to handle, Biocompatible, Non-toxic, Capable of physical and chemical modification, Eco-friendly and cost-effective, More acceptance by the general public. According to the study, the growth is a direct outcome of the increased use of hydrocolloids. In the food industry, functional qualities are still the most common application of hydrocolloids.

Keywords: Seed endosperm gum; Microbial hydrocolloids; Animal hydrocolloids; Natural hydrocolloids; Semi-synthetic hydrocolloids; Synthetic hydrocolloids

1. Introduction

Red meat has long been an important part of the human diet, and its consumption has risen in recent years in both high- and low-income countries. Meat eating aids in the absorption of proteins and vital amino acids, as well as vitamins and minerals such as vitamin B, vitamin A, zinc, and iron, all of which are required for a balanced diet [1, 2].

Processed meat exacerbates the problem because it typically contains a high number of preservatives and salts and undergoes extensive processing, resulting in nutritional loss. Processed meat consumption can also raise the chances of having detectable amounts of dioxin-like polychlorobiphenyl, a well-known carcinogenic agent. However, the main challenges in the production of such products are to obtain acceptable sensory attributes and nutritional value similar to the original products [3, 4].

This review concerned with study Hydrocolloids categories and if it can be used as a novel safe natural meat preservative.

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2. Hydrocolloids Categories

As indicated in Figure 1, hydrocolloids are classified as natural, semi-synthetic, or synthetic depending on their origin. Hydrophilic polymers generated from natural sources such as plants, animals, microbes, and seaweeds are known as natural hydrocolloids. Semi-synthetic hydrocolloids, on the other hand, are modifications of naturally formed hydrocolloids, Synthetic hydrocolloids, on the other hand, are made chemically from petroleum-derived basic materials to produce a product that resembles natural polysaccharides in structure [5].

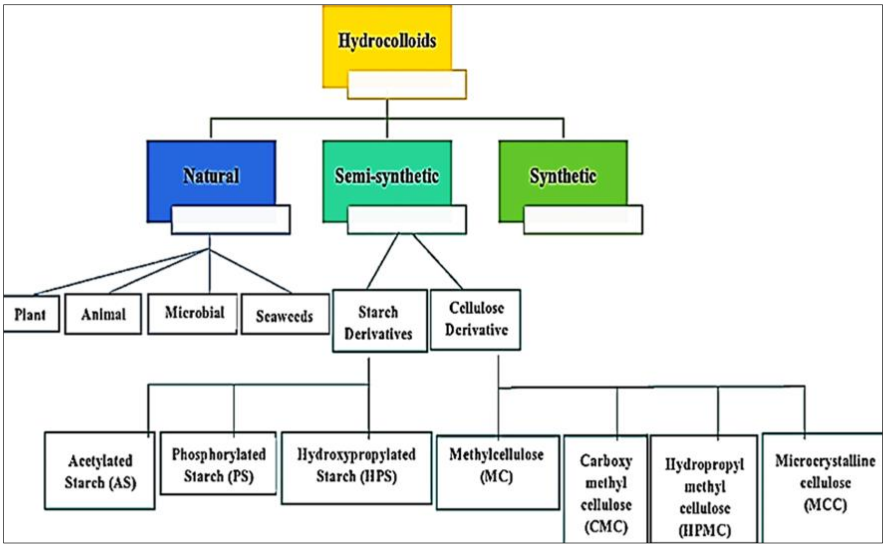

Figure 1 Classification of hydrocolloids [5]

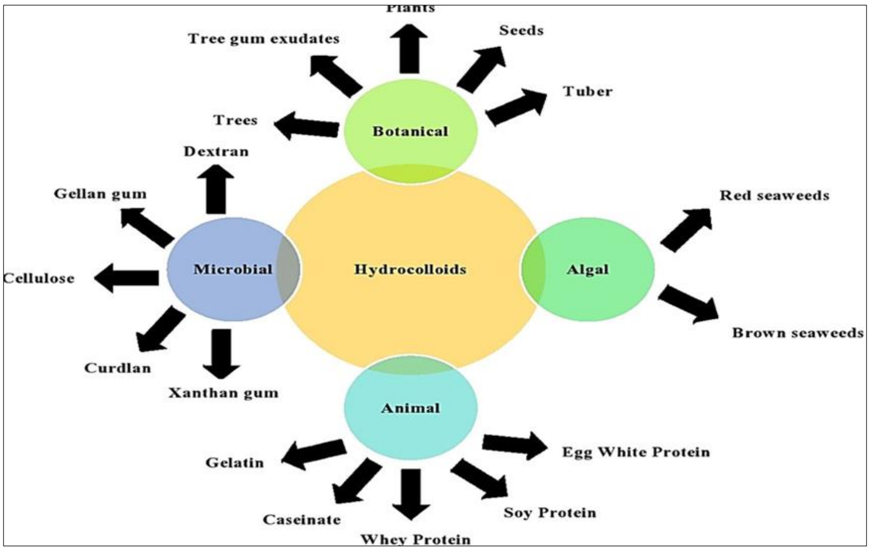

Figure 2 Classification of natural hydrocolloids on basis of origin [5]

Natural hydrocolloids, as opposed to semi-synthetic and synthetic hydrocolloids, have been the most generally desired in the food business in recent years for increasing the stability, functioning, quality, safety, nutritional, and health benefits of various food products:

- More acceptance by the public due to numerous health benefits
- Capable of physical and chemical modification

- Readily available and easy to handle
- Extracted from renewable sources
- Eco-friendly and cost-effective
- Biocompatible
- Non-toxic [6].

3. Edible hydrocolloids generated from nature

Natural hydrocolloids can be made from two primary macromolecules consumed by humans on a daily basis: proteins and carbohydrates. As illustrated in Figure 2, natural hydrocolloids are classified according to their origin.

3.1. Natural algal seaweed derived edible hydrocolloids

Seaweeds are a rich source of marine renewable resources that have long been employed in Asian countries and traditional remedies around the world, as well as playing a significant role in ancient meals (Khalil *et al*. 2018). Seaweeds are divided into four categories based on their pigments: red, brown, blue, and blue-green. Red (*Rhodophyceae*) and brown (*Rhodophyceae*) hydrocolloids are key sources (*Phaeophyceae*). The former, which includes agar and carrageenan, and the latter, which includes alginate, are the most extensively used stabilizers, thickeners, emulsifiers, and fillers in the food business [7 – 9].

3.1.1. Red seaweed

Red algae (agarophytes) from the genera Gelidium and Gracilaria make up the majority of agar (McHugh 2003). Agarose and agaropectin are two key polysaccharide groups found in it. Agarose, which comprises up 70% of the mixture and has a strong gelling property, is neutral or low sulfated/methoxy substituted, whereas the thickening agent, agaropectin, is charged, heterogeneous, and considerably sulfated. The agarose-agaropectin balance varies depending on the seaweed species and isolation condition [10].

The backbone of two alternating disaccharides, agarobiose and neoagarobiose, is made up of alternating units of -D-galactopyranose and 3,6-anhydro—L-galactopyranose joined by -(1-3) and (1-4) glycosidic connections [11]. Agar is a stronger cold-set gelling agent, and when cooled, its aqueous solution goes through a sol-gel transition [12, 13]. Approximately 80% of global agar is used in culinary applications, with the remaining 10%–20% used in medicinal and biotechnology uses [14].

3.1.2. Carrageenans

Carrageenans are a type of negatively charged, linear, sulfated A marine hydrocolloid polysaccharide derived from red seaweed (Rhodophyceae) that largely consists of alternating units of 3-linked and 4-linked D-galactopyranose that create repetitive disaccharide units [13].

3.1.3. Brown seaweed (Alginate)

It is made from the outer layer of the brown algal cell wall, which is obtained from brown seaweed (Phaeophyceae). Alginate is commercially accessible from species like Laminaria digitata and Ascophyllum nodosum, Laminaria hyperborean, and Macrocystis pyrifera. Alginate is a straight, unbranched polymer made up of a variety of monomeric uronic acids linked by (1-4) glycosidic linkages and arrayed in an asymmetrical pattern with changing proportions depending on the seaweed source, harvest method, and harvest season. The M/G ratio and block structure have a big influence on alginate's physiochemical properties. Increasing the alginate concentration produces gels that are stronger, clearer, and more brittle. Alginates can be found in the market as sodium, potassium, or ammonium salts. Burey and colleagues [15]. Due to an ionotropic process in the polymer chain involving inter-chain ionic binding between guluronic acids blocks (G-blocks) with divalent cations such as calcium, barium, and strontium, alginates with high G-block content elicit stronger gels, resulting in a three-dimensional network with restricting zones between the G-blocks. Alginate gels are affected by gelation temperature, alginate concentration, and ion concentration. Alginate has a wide range of applications in the food and pharmaceutical industries due to its versatility [8, 16].

3.2. Hydrocolloids generated from plants that are edible

The increased benefits and consumer friendliness of botanical sources such as plant cell walls, tree exudates, and seed endosperm, the demand for hydrocolloids from botanical sources is higher than from animal sources [17]. Some of these are discussed below:

3.2.1. Plants starch

It acts as the primary food reserve polysaccharide. It is mostly made up of two different types of molecules: amylopectin (70–80 percent) and amylose (20–30 percent). Amylopectin is a branching polysaccharide with 95 percent -(1-4) and 5% -(1-6) connections, whereas amylose is a linear carbohydrate (1-4)-D-glucan is a type of glucan that is connected to another glucan [18, 19].

Edible starch has a wide range of applications in biomedicine, food packaging, medicines, agriculture, personal care, and food processing, among others. It is tasteless, odorless, biologically absorbable, nontoxic, semipermeable to carbon dioxide, colorless, and oxygen resistant [20 -22].

3.2.2. Plants pectin

It is an intercellular glue that works as a structural polymer in terrestrial plant tissue, supporting the underlying cellulose structure of plant cell walls and middle lamellae. It's created with 1 percent fruits and vegetables, 15% apple pomace, 30% citrus peels, and 1% sunflower heads or sugar beet remnants, all boiled at 60–100°C in acidic circumstances (pH 1.5–3) [23, 24].

3.2.3. Tree gum exudates

Plants create plant-based polysaccharide gums in response to stress. According to their origin, they are divided into four groups. Many gums are available currently, but only a handful are important, such as gum arabic, gum tragacanth, gum karaya, and gum ghatti, which have been employed in a variety of food and pharmaceutical applications [25].

Tree gum exudates gum Arabic (acacia gum exudate)

It is a naturally edible branching multifunctional heteropolysaccharide hydrocolloid that is neutral or slightly acidic. This hybrid polyelectrolyte is made up of calcium, magnesium, and potassium salts with a little quantity of protein (for emulsifying properties) and polysaccharides sub-units (6 carbohydrate moieties). The main chain of this hydrocolloid polysaccharide is made up of 1,3-linked -D-galactopyranosyl units (main chain) joined to the side chain by 1,6-linkages. It is commonly utilized for taste stabilization, inhibiting flocculation and coalescence of carbonated beverages, and flavor oil emulsions due to its stability in acidic conditions due to its structure and conformation at the molecular level [26 – 28].

Tree gum exudates: gum karaya

It is a dry exudate derived from Sterculia urens or Cochlospermum gossypium, often known as Sterculia gum or Indian gum. This complex, branching, and partially acetylated polysaccharide is made up of D-galactose, L-rhamnose, L-glucuronic acid, and D-galacturonic acid. Rhamnogalacturonans have a mixture of (1,4)-linked D-galacturonic acid and (1,2)-linked L-rhamnosyl residues in their backbone chains. The side chain consists of (1-3) linked -D-glucuronic acid or (1-2) linked -D-galactose on the portion of galacturonic acid unit in which one half of rhamnose is substituted by (1-4) linked D-galactose [29]. There are 60 percent neutral saccharide residues (galactose and rhamnose) in commercially available gum, 40 percent acidic residues (galacturonic and glucuronic acid), and 8% acetyl groups karaya [30, 31].

Tree gum exudates: gum ghatti

It is a Combretaceae tree, exudes an indistinct transparent gum exudate. Gum ghatti is made up of monosaccharide variables such L-arabinose, D-galactose, D-mannose, D-xylose, and D-glucuronic acid in a 10:6:2:1:2 ratios with traces of 6-deoxyhexose [32].

Tree gum exudates: tragacanth gum

It is an air-hardened gum exudate generated naturally from the branches and stem of Astragalus gummifer or its species. Tragacanth gum is a highly branched, acidic heteropolysaccharide composed of repeated units of (1-6)-linked D-galactosyl backbone connected to highly branched L-arabinose side chains by (1-2), (1-3), and/or (1-5) connections. The water-soluble component (Tragacanthin) accounts for 30–40% of the gum, whilst the water-insoluble component

(Tragacanthic acid) accounts for 60–70%. The gum's popularity stems from its unique functional properties as well as its high level of safety [33].

3.2.4. Seed endosperm gum: guar gum

It is made from the endosperm of the seeds of the drought-resistant guar plant (Cyamopsis tetragonolobus) or the cluster bean. It's a galactomannan polysaccharide that's nonionic (Achayuthakan and Suphantharika 2008). The ratio of D-mannose to D-galactose is 1.6:1. A linear backbone is formed by mannose units bound to (1-4). Single terminal D-galactose units are connected to the main backbone via (1-6)-glycosidic connections to the 4, 6-mannose units. A galactose unit is related to almost every second mannose unit. Guar branching accounts for its higher water activity and stability in pH 4–10 solutions, as well as its simpler hydration properties. Guar gum is widely used as a binder and thickener in the food industry [34].

Seed endosperm gum

From locust beans Carob gum, commonly known as the endosperm of carob tree seeds is milled to make locust bean gum (Ceratonia silique). It's a neutral galactomannan polysaccharide composed of D-mannose and D-galactose, with an average molecular ratio of 3.5:1 (Achayuthakan and Suphantharika, 2008). The molecule is made up of a linear backbone of -mannose units joined by (1-4) glycosidic linkages connects every fourth unit of mannose to the galactose unit (1-4). Because guar gum and locust bean gum have similar properties, they can be used interchangeably in the same applications where synergistic connections bring further benefits, such as sorbets, ice creams, and dairy desserts [35].

Seed endosperm gum: tara gum

Carob bean gum (Peruvian carob bean gum) is made by milling the endosperm of the Caesalpinia spinosa tara tree's seeds. It's a neutral galactomannan polysaccharide having a linear main chain of (1-4) linked mannose units and -1- 6-linked side chains from a single galactose unit. Mannose to galactose (M/G) is a 3:1 ratio. Guar gum and locust bean gum have a lot in common. It does not generate gels on its own, but when mixed with xanthan gum, it possesses gelation capabilities, but it is slightly weaker than xanthan when paired with locust bean gum. It is used as a thickener and stabilizer in a range of foods in both food and industrial applications [36].

3.2.5. Seed endosperm gum: tamarind gum

It is a galacto xyloglucan derivative obtained from the seed kernel of *Tamarindus indica*. It's a highly branched polysaccharide made up of 3:2:1 glucose, galactose, and xylose molecular ratios. The linear main chain is connected by (1-4) glucose units. It is primarily used as a stabilizer, thickener, binder, and gelling agent in the food and pharmaceutical industries [37].

3.2.6. Tuber: Konjac Mannan

It is a water-soluble vegan polysaccharide derived from konjac tubers that acts as a gelatin substitute. It's mostly made up of sugars with (1-4)-linked D-glucopyranose and -D-mannopyranose links. The molecular ratio of mannose to glucose is 1.6:1 on average. Because of its safe, biocompatible, and organically degradable nature, it is widely used in the food and pharmaceutical industries. Konjac is utilized in baking, pasta, sweets, and restructured meat and vegetable products for shelf life extension, coating adhesion, and binding [37].

3.3. Hydrocolloids generated from microbes that are edible

Extracellular polysaccharides are produced by microorganisms, with xanthan gum accounting for over 90% of the global food market for microbial hydrocolloids. Curdlan, dextran, phullan, and gellan gums are examples of microbial hydrocolloids [17].

3.3.1. Xanthan gum

From glucose or sucrose fermentation, Xanthomonas campestris creates an extracellular anionic polysaccharide. In the primary structure, a cellulose backbone containing D-glucose units are linked by (1-4) glycosidic linkage. It is replaced with a trisaccharide side chain made up of two mannose units separated by glucuronic acid on alternate glucose residues. The pyruvate group is connected to around half of the terminal mannose units, whereas the non-terminal residues (usually an acetyl group) are mostly dependent on the Xanthan campestris strain, resulting in different xanthan solution viscosities [29, 38].

3.3.2. Curdlan

Nonpathogenic bacteria *Agrobacterium biobar* and mutants of *Alcaligenes faecalis* var. create an extracellular polysaccharide called *Agrobacterium biobar* and mutants of *Alcaligenes faecalis* var. Myxogenes are produced by traditional fermentation methods. It's a high-molecular-weight linear (1-3)-glucan glucose polymer with no branching. It becomes an irreversible gel when heated. It has a strength that falls between between cellulose and amylose, is insoluble in water, edible, biodegradable, and impermeable to oxygen films. In the food and pharmaceutical industries, it can be used to substitute agar and gelatin in the preparation of jams, jellies, and other foods etc [39].

3.3.3. Dextran

It is made by bacterial enzymes of the species Leuconostoc or Streptococcus fermenting the disaccharide sucrose. It is a neutral, highly branched polysaccharide made up of glucose units with glycosidic linkages that appear as -(1-4) or (1-3) Dextran can be used to make protective coatings [40].

3.3.4. Gellan gum

Polysaccharide is produced by Sphingomonas elodea. Gellan has a linear chemical structure made composed of glucose, rhamnose, and glucuronic acid repeating units. Acetate and glycerate, two acyl substituents, are accessible in both native and high-acyl forms. Both substituents are found on the same glucose residue, with one glycerate and one acetate per two repeating units on average. Low acyl groups don't have any acyl groups. The presence of acyl groups in native gellan disrupts aggregation, resulting in a weaker gel, while side chains disrupt cation-induced aggregation of branching gellan variations, resulting in only "weak gel" synthesis [41].

3.4. Natural animal derived edible hydrocolloids

Animal hydrocolloids come from swine, cattle, and other animal bones and skins. Gelatin is the most frequently used hydrocolloid, accounting for 99 percent of all animal hydrocolloids on the market. Other hydrocolloids derived from animals include whey protein and chitosan [42, 43].

3.4.1. Gelatin

It is a partial controlling acid or alkaline hydrolysis of animal connective tissue (collagen) found in the skins or bones of many animal species, a protein-based biodegradable and non-immunogenic hydrocolloid polymer is created (beef, pork, fish and poultry). The triple helical shape formed by repeating sequences of glycine-proline-hydroxyproline amino acids across the polymer chain in gelatin molecules gives gelatin-based gels exceptional flexibility, reversibility, and transparency. However, it has poor mechanical and thermal stability, which can be addressed by changing the chemical makeup. Over 400 degrees Celsius, gelatin solution acts like a standard synthetic polymer. Agar, alginate, carrageenan, and pectin are commonly employed in food items at higher quantities (1–5% w/w) than gelatin gels. The characteristics of gelatin gelation are determined by the gelatin content, pH, and cooling rate utilized during gelation and gelling. It's frequently utilized in the food business for its gelling, flexibility, reversibility, transparency, and forming properties, as well as in non-food areas for its low immunogenicity and cytotoxicity [44 – 47].

3.4.2. Whey protein (serum protein)

The major by-product of cheese production has a high nutritional value and biocompatibility due to its wide range of applicability in the production of gels, emulsions, and gelled emulsions, and is thus extensively used in food items. Whey protein is made up of three primary components: -lactalbumin, -lactoglobulin, and bovine serum albumin. Whey proteins gels have a good pH-sensitive swelling capability above their isoelectric point. Its usage in industrial applications is limited, however, due to its fragile nature. For example, glycerol has been used as a plasticizer to make materials more flexible, making it an appealing candidate for food and novel pharmaceutical applications [48 -51].

3.4.3. Chitosan

Which is After cellulose derived from chitin, another most abundant and extremely significant polysaccharide Crustacean exoskeletons, such as lobster, shrimp, and crab, have this structural component. It's a polymer composed of -(1-4)-D-glucosamine and N-acetyl-D-glucosamine units formed by partial chitin deacetylation. Chitin has a similar molecular structure to cellulose, except that in fungi, yeast, green, brown, and red algae, the hydroxyl groups at O-2 of the glucose unit are replaced by N-acetylamino groups, and it therefore substitutes cellulose. Chitin has a crystalline structure that is well ordered and stabilized by multiple intermolecular hydrogen bonds. Chitosan is a hydrocolloid that dissolves when it comes into contact with water. It's also the only polysaccharide that has a positively charged or cationic amino group that may interact with other negatively charged or cationic amino groups effectively. Anionic molecules are responsible for the formation of gels. It's a commonly used hydrocolloid. Nowadays, it is not digested by humans due to its antimicrobial properties, nontoxicity, and biodegradability, but it can be used as a source of dietary fiber [52, 53].

4. Functionality of hydrocolloids

The physiological understanding of "natural" materials, as well as their capacity to alter the widespread usage of hydrocolloids in many applications such as food, pharmaceutical, biotechnology, agricultural, and chemical industries is due to the rheology of the food system, as well as countless other potentially advantageous qualities [54]. Hydrocolloids have a wide range of applications. They're in foods for two reasons: they're good for you and they're good for the environment.

- Physical properties such as viscosity or gelation, as well as mechanical solid properties (texture). The sensory properties of food change as the parameters of the food system change, and hydrocolloids are now used as significant food additives for specific objectives [29, 55 - 57].
- Benefits to your health a significant number of hydroxyl groups, resulting in greater H-bonding interactions and hydrocolloid rheological behavior in aqueous solution. These behaviors are markers of the chemical structure and conformation of the polymer in solution, and they're used to provide functionalities including structure development, changing the textural aspects of the food system, and extending the shelf life [17, 55].
- Hydrocolloids from various sources have been explored for several years in food, biomedical, and pharmaceutical uses [58]. According to numerous estimations and forecasts in the industry, the international food hydrocolloid market will grow by at least 50% in the next ten years [59].

5. Conclusion

According to the study, the growth is a direct outcome of the increased use of hydrocolloids. In the food industry, functional qualities are still the most common application of hydrocolloids. The use of hydrocolloids in encapsulating prebiotics and probiotics, bioactive chemicals, food additives, and nutrients has evolved into a vibrant subject. They're also commonly employed as edible films or coatings on a variety of food items to increase their functionality. Hydrocolloids now provide exceptional, one-of-a-kind technical properties that are impossible to achieve using conventional nanotechnology methods. Pectin, inulin, bglucan, and resistant starch, for example, promote health and nutritional benefits such as metabolic and chronic disease effects, as well as prebiotic activity. utilization of food hydrocolloids.

Compliance with ethical standards

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Disclosure of conflict of interest

Authors have declared that no competing interests exist.

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