Edible Films and Coatings: Tomorrow’s Packagings: A Review

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I. INTRODUCTION

The quality of food product depends on organoleptic, nutritional, and hygienic characteristics, but these evolve during storage and commercialization. Such changes are mainly due to exchanges between foods and surrounding media, or migrations between the different components in a composite food.

Many physical and chemical processes, such as sterilization, high pressure, radiations or actives agents, were developed to steady foods and thus to preserve food quality. However, the use of a performing package is necessary in the ultimate step of the preservation process. Therefore, packaging is preponderent for the durability of food quality.

The performance of synthetic packaging materials is appraised by their efficiency to reduce mass transfers between food and storage medium, that is, by the determination of their permeabilities. The constant progress in synthetic packagings, such as resins, cellulosic and plastic films, permitted the use of composite (copolymer) and/or multilayered film packagings, which are able to significantly reduce gas and solute transfers selectively.

However, the suitability of plastic films is not universal. The combination of synthetic and edible packagings was proposed to increase the efficiency of food quality preservation by the packaging. In other respects, edible packagings are nonpollutant products because they consist of natural and biodegradable substances from agriculture. Thus, they contribute to the protection of the environment.

Over 90 patents and scientific papers concerning the manufacture of edible packaging have been published since 1990. Most of this work deals with water vapor transfers, but some other potential applications exist. Indeed, edible packagings can be used to encapsulate aroma compounds, antioxidants, antimicrobial agents, pigments, ions that stop browning reactions or nutritional substances such as vitamins.

The characteristics required for edible films and coatings depend mainly on the adulteration of the food product, which may be coated. Therefore, low oxygen permeability is required for oxidation-sensitive products like polyunsaturated fats. The properties of mass transfer selectivity wished for are, for example, to allow fruit and vegetable respiration (O₂, CO₂, ethylene exchanges) even while limiting their dehydration during storage, or avoiding the solute penetration during the osmotic dehydration of fruits.

Besides the barrier efficiency, edible films and coatings have to be organoleptically and
functionally compatible with foods. Although edible packagings offer numerous potentialities to improve the quality and the shelf life of foodstuffs, little industrial applications were developed. Indeed, the formulation of these packagings remains empirical and uneasy, which makes their use and application to foods relatively tricky. More fundamental research is then necessary to better understand the transfer mechanisms of solutes and volatiles through polymeric polymers from agricultural origins, such as edible films and coatings.

II. HISTORY OF EDIBLE COATINGS

The use of edible films in food products seems new, but food products were first covered by edible films and coatings many years ago. Wax has been used to delay dehydration of citrus fruits in China since the twelfth and thirteenth centuries. While not the earliest use of edible coatings, application of coating to meats to prevent shrinkage has been the usual practice since at least the sixteenth century, where meat cuts were coated with fats. Later in the last century, the preservation of meat and other foodstuffs by coating them with gelatin films was suggested. Yuba, a proteic edible film obtained from the skin of boiled soy milk, was traditionally used in Asia to improve the appearance and preservation of some foods since the fifteenth century. In the 19th century, sucrose was initially applied as an edible protective coating on nuts, almonds, and hazelnuts to prevent oxidation and rancidness during storage. The more important application of edible films and coatings until now, and particularly since the 1930s, concerns the use of an emulsion made of waxes and oil in water that was spread on fruits to improve their appearance, such as their shininess, color, softening, onset of mealiness, carriage of fungicides, and to better control their ripening and to retard the water loss. A number of edible polysaccharide coatings, including alginites, carrageenans, cellulose ethers, pectin, and starch derivatives, have been used to improve stored meat quality. Over the last 40 years, a great number of works on the formulation, application, and characterization of edible films and coatings have been done in both scientific and patent literature.

III. REQUIREMENTS FOR THE USE OF EDIBLE PACKAGINGS

When a packaging like a film, a sheet, a thin layer or a coating is an integral part of a food and is eated with, then it is qualified as “edible packaging”.

Coatings are either applied to or made directly on foods when films are independent structures that can wrap food after their making. They are located on the food surface or as thin layers between several parts within the product, for example, between the fruits and the dough in a pie.

Are edible packagings considered food ingredients or should we be more cautious and qualify them as food additives? Nowadays, there is no regulation in the European Community to specify how edible packagings have to be classified.

Foods are described in the Codex Alimentarius as: all raw, partially treated or treated substances used for human nutrition and feeding. This concerns drinks, chewing gum and all components used in the formulation, preparation, making or treatment of foods, but turns down substances used as drugs, cosmetics and tobacco. If we consider the latter definition, edible films and coatings could be classified as foods. However, in most cases, edible packagings do not provide a significative nutritional value to the coated food, and, thus, they should be considered more like an additive than an ingredient. It all depends on the application of the edible packaging. It can also be used to improve the nutritional quali-
ty of the food, and thus be qualified as a food ingredient.

As food components, edible films and coatings usually have to be as tasteless as possible in order not to be detected during the consumption of the edible-packaged food product. When edible films and coatings have a significant or particular taste and flavor, their sensorial characteristics have to be compatible with those of the food.

Although many functions of edible packagings are identical to those of plastic films, particularly their barrier properties to gas, vapors, and solutes, their use strictly requires an overpackaging, notably for handling and hygienic reasons. Edible films appear to be a complementary parameter, interesting, and sometimes essential for the quality and stability of some fresh, treated, or frozen food products.

Because they are both a packaging and a food component, edible films and coatings have to fulfill some requirements:

- Good sensory qualities
- High barrier and mechanical efficiencies
- Enough biochemical, physico-chemical and microbial stability
- Free of toxics and safe for health
- Simple technology
- Nonpolluting
- Low cost of raw materials and process

IV. FUNCTIONALITY AND COMPOSITION OF EDIBLE FILMS AND COATINGS

Edible packagings must have some functional and specific properties. Indeed, first of all they have to be selective toward mass transfers, but in some cases they have active properties, or they can be both selective and active.

Selective properties of edible films and coatings are summarized in Figure 1. In most cases, the water barrier efficiency of films is desirable to retard the surface dehydration of fresh (meat, fruits, and vegetables) or frozen products. The water absorption inducing the caking in food powder or the loss of crispness in dried cakes, for example, could be delayed by coatings. The control of gas exchanges, particularly of oxygen, allows better control of the ripening of fruits or to significantly reduce the oxidation of oxygen-sensitive foods and the rancidity of polyunsaturated fats, for example. Organic vapor transfers have to be diminished in the aim to retain aroma compounds in the product during storage or to prevent solvent penetration in foods, which can involve toxicity or off-flavors. The penetration of oil during frying and of sucrose or sodium chloride during osmotic dehydration can be limited by an edible film. One of the more interesting applications of edible films and coatings is their use inside a composite food to control mass transfers between the different compartments of the product, for example in order to reduce water migration in a pie. The effect of light and the effect of UV light that involves radical air reactions in foods could be reduced.

In the latter case, the efficiency of the film to prevent light effect can be improved by the addition of pigments or light absorbers. Thus, when films are carriers or used for encapsulation of food additives or ingredients, they are active (Table 1). Edible packagings can improve mechanical properties of food to facilitate handling and carriage. Sensorial characteristics such as colour, shininess, transparency, roughness or sticking can be improved. Edible films and coatings enable to protect or separate small pieces or food portion for individual consumption, or to isolate predosed quantities of food additives or ingredients in the aim of facilitating the formulation and the preparation of food in industrial plants.

Functional efficiency strongly depends on the nature of components and film composition and structure. The choice of film-forming substance and/or active additive is a function of the objective, of the nature of the food
FIGURE 1. Selective functions of edible films and coatings.
product and of the application method. So, lipids or hydrophobic substances such as resins, waxes or some non soluble proteins are the most efficient for the moisture transfer retardation. On the contrary, water soluble hydrocolloids, like polysaccharides and proteins, are low efficient barrier against water transfer; however, their permeability to permanent gases is often lower than those of plastic films. Moreover, hydrocolloids usually provide higher mechanical properties to edible packagings than lipids and hydrophobic substances. Therefore, the advantages of all substances can be used in composite films made from both hydrocolloids and lipids. Natural film-forming substances, particularly proteins, need the use of film additives such as plasticizers to improve film resistance and elasticity or such as emulsifiers to increase the hydrophobic globule distribution in composite emulsion-based edible films.

Different types of edible packagings can be obtained as a function of the composition and the manufacturing technique. Indeed, homogeneous films with a smooth surface are obtained from homogeneous solutions of polysaccharides or proteins, or from molten lipids. Their appearance depends on the nature of the main component; for example, water-soluble cellulose derivatives give transparent and shiny films when gluten or casein-based films are colored and unpolished. Some mixtures of proteins and polysaccharides make homogeneous edible packagings if all components are completely soluble in water or in a hydroalcoholic solution. Composite packagings are defined as films or coatings that structure is heterogeneous, that is, composed with a continuous matrix with some inclusions, such as lipidic globules in the case of an emulsion, or solid particules in the case of nonsoluble substances (fibers, hydrophobic proteins), or composed of several layers. Usually, multilayered films have better mechanical and barrier efficiencies than emulsion-based films and coatings, but their manufacturing requires one step of spreading or lamination and drying for each layer. Therefore, their use in an industrial plan does not seem very interesting because of too many steps in their making; on the contrary, emulsion-based edible films providing nearly the same properties, only requires one operation in their preparation.

V. FILM MANUFACTURING PROCESSES

The formulation of films and coatings need the use of at least one component capable to form a structural matrix with a sufficient cohesiveness. Edible films made with several substances have been perfected in order to account for the complementary functional properties of each component and to minimize their disadvantages. Most of the composite films studied associate a hydrophobic compound, often lipids, and usually a hydrocolloid structural matrix.
The film-forming substances are able to form a continuous structure by settling the interactions between molecules under the action of a chemical or a physical treatment. The film and coating formation involves one of the following processes:\textsuperscript{12, 15, 19}

- Melting and solidification of solid fats, waxes and resins,
- Simple coacervation where a hydrocolloid dispersed in aqueous solution is precipitated or gelified by the removal of the solvent, by the addition of a non-electrolyte solute in which the polymer is not soluble, by the addition of an electrolyte substance inducing a “salting out” effect, or by the modification of the pH of the solution,
- Complex coacervation, where two hydrocolloid solutions with opposite charges are combined, inducing interactions and the precipitation of the polymer mixture,
- Thermal gelation or coagulation by the heating of the macromolecule solution which involves denaturation, gelification, precipitation, or by a rapid cooling of the hydrocolloid solution that induces a sol-gel transition, for example.

Films, that is, independent structures, have been obtained in laboratories after laying or spreading a film-forming solution on support, drying it, and then detaching it. For industrial processes, techniques used for the making of flexible plastic films are transposable to edible and biodegradable films.\textsuperscript{21,22} These techniques can be extrusion or coextrusion for multilayer films, lamination, and mainly roll-drying for the solvent removal of the polymer solution. Non-water-soluble film-forming substances such as oils, fats and waxes are applied on supports, on foods as emulsions or microemulsions in water, or as solutions in organic solvents.\textsuperscript{10}

Edible packagings are mainly used as coatings in industrial process, and the techniques used are traditional coating methods, such as spraying, dipping, or brushing. These processes are usually followed by drying steps for aqueous products, or by cooling for lipid-based coatings.\textsuperscript{19}

The adhesiveness of the coating on the food product surface mainly depends on its respective nature, that is, on its affinity, but little on the application or coating technique used. Adhesiveness depends on the nature and on the number of interactions or bondings between film and support. So, the use of tensioactive substances such as emulsifiers makes possible the sticking of a hydrophobic coating on very hydrophilic food products.\textsuperscript{19} On the contrary, the film thickness depends essentially on the application technique and on the solution viscosity. Indeed, highly viscous solution cannot be or very uneasy sprayed, and thus only falling coating or dipping techniques apply, giving high thickness to the coating.\textsuperscript{22}

\textbf{VI. EVALUATION OF EDIBLE PACKAGING PERFORMANCES}

The suitable use of edible packagings strongly depends on their mechanical and barrier properties. Therefore, the importance of accurate methodologies for determining film performances have been developed, particularly for the measurement of permeability values that can be used in product shelf-life predictions. The apparatus used for permeability measurements are only standardized and available for water vapor and permanent gas transfers. They were introduced for plastic and synthetic packagings films.

Water vapor permeability (WVP) is defined as the rate of water vapor transmission per unit area of flat material of unit thickness induced and per unit vapor pressure difference between two specific surfaces, under specified temperature and humidity conditions. WVP must not be mixed up with transport through pores because it consists of a process of solution and diffusion where the solute vapor dissolves on one side of the membrane, diffuses through to the other side, and then de-
sorbed by evaporation. Several techniques have been perfected, based on infrared sensors such as the Permatran-W series available from Mocon (Modern Controls Inc., Minneapolis, MN, U.S.A.) or the WVP tester L80-4000 series of Dr. Lissy (Lissy, Zurich, Switzerland), based on a coulometric method or a spectrophotometric methods as developed by Holland and Santangelo. These techniques are well fitted for high barrier efficiency polymers such as plastics or wax-based edible films, but not for hydrophilic polymers. The Permatran-W apparatus was only used by Gennadios and Weller to determine the WVP of wheat protein-based edible films. The most common method used by people working on edible packagings is the “cup method” based on the gravimetric technique. This is the standardized method for the determination of WVP through films and thin sheets of packagings. Modified “cup methods” were suggested by several authors to prevent some disadvantages such as the effects of stagnant layers, or to control more accurately the vapor pressure and temperature gradients. Gennadios et al. suggested a corrective calculation taking into account the effect of stagnant layers. A continuous weighing system with an electric fan to maintain a large flow rate within the chamber was optimized by Debeaufort et al.; it enables to follow the permeability kinetics and to minimize unstirred layers. A further advantage of the continuous measurement system was its significantly lower experimental variability.

The permanent gas permeability of edible films was often studied for fruits and vegetables applications, particularly oxygen and carbon dioxide. Manometric and volumetric methods described by the ASTM D1434 and ISO 2556 standards were not used for edible films. The apparatus generally used for the determination of the oxygen permeability of films is based on coulometric sensor as the Oxtran (Mocon, Modern Controls Inc., Minneapolis, MN, U.S.A.), or on manometric methods, such as the Lyssy L100 series (Lyssy, Zurich, Switzerland) for dry and noncorrosive permanent gases, certified by the ASTM D3935 standard. However, these apparatus and techniques do not allow the measurement of gas permeability for different relative humidities as required when simulating the food products. Even so, Oxtran was the more suitable apparatus available for gas permeability determination through edible films. Therefore, some works on gas permeability of edible packagings were carried out a gas chromatographic method as developed by Karel et al. for plastic packagings, by Liebermann et al. for collagen films, by Hagenmaier and Shaw for lipids, waxes, and resins-based edible films. Recently, Debeaufort and Voilley have optimized a gas chromatographic method to measure permanent gases, water, and organic vapors transfers automatically, continuously, and simultaneously.

Apart from the system developed by Debeaufort and Voilley, only one apparatus is available to measure organic vapors transfers through edible or plastic packagings developed by Mocon. It is the same for solute permeability such as salts, pigments, or lipids, although standardized methods exist for lipid migrations in packagings, but there is no available systems. Therefore, Nelson and Fennema were the first researchers who developed a lipid permeability cell to study the fat transfers through water-soluble cellulose derivative films. The method for the salt and acid permeability determinations was improved for potassium sorbate and sorbic acid by Vojdani and Torres and by Rico-Peña and Torres. An edible film or coating with very good barrier properties could be inefficient if its mechanical properties do not permit to maintain the film integrity during handling, packaging and carrying processes. Thus, the mechanical resistance and deformability of edible coatings have to be determined. Traditional methods used for plastic packagings are perfectly suitable and used for edible films. An apparatus such as a texturometer, a univer-
Sal tensile testing machine (Instron Engin. Corp., Canton, MA, U.S.A) or a dynamical-mechanical thermal analyzer, was often used for the tensile strength, elongation, deformability, elastic modulus, etc., characterizations of edible films.\textsuperscript{13,35,54,55,56,57,58} The tensile testing machine lets you study the effect of factors as temperature or relative humidity on mechanical properties.\textsuperscript{42,59,60,61}

Several other film characteristics are often studied, especially for the understanding of mechanical and barrier properties of films. These are the thickness, water sorption isotherms, solubility in aqueous solutions or in solvents, diffusivity of solutes within the films, color and opacity, etc.

VII. APPLICATIONS OF “EDIBLE PACKAGINGS”

The choice of an edible packaging mainly depends on the specific characteristics of the food product that requires protection and on storage conditions. Many materials have been used for film and coating formulations such as carbohydrates, proteins, lipids, or mixtures of these. Edible films and coatings have been applied on meat, poultry, seafood, fruits, vegetables, grains, candies, heterogeneous and complex foods, or fresh, cured, freezed, and processed foods. The applications cited in the following part only give examples of all potentialities of edible films and coatings in the function of the nature of the food product and of the polymer-film-forming agents.

A. Poultry, Meat, Fish, and Seafood

Carbohydrates, edible films, and coatings have been often used to improve the quality and the stability of meat during storage and commercialization. Although carrageenan coatings have poor water barrier properties such as most polysaccharides, they were applied on fresh and frozen meat, poultry and fish to prevent superficial dehydration.\textsuperscript{62} Indeed, the loss of product water is delayed until the water contained within the gel has been evaporated. The lamb carcasses coated with alginates gelled with calcium chloride are not preserved from water loss, but this method permits the reduction of microbial growth.\textsuperscript{63} Moreover, the cooking loss, flavor, odor, and overall organoleptic characteristics were not modified. The color of beef loin pieces, off-odors, and appearance are significantly improved after 96 h in alginate coatings.\textsuperscript{64} Stuchell and Krochta\textsuperscript{65} displayed an efficient protection of salmon against lipid oxidation and water loss by a coating composed of a mixture of whey proteins and acetylated monoglycerides. Dinitrosyl ferrohaemochrome encapsulated in $\beta$-cyclodextrins and further trapped in an edible coating lay out on a nitrite-free meat cured product confers the color characteristics of a nitrite cured meat after processing.\textsuperscript{66} The texture and juiciness of beef steaks, pork chops, and skinned chicken drumsticks were better when coated with a mixture of alginates, pork chops, and skinned chicken drumsticks were better when coated with a mixture of alginates and starch.\textsuperscript{67} Collagen, caseins, and cellulose derivatives such as carboxymethylcellulose, methylcellulose, hydroxypropylmethyl-cellulose can be used as a precoating to improve the adhesion of the batter mix onto meat and fish and significantly reduce oil absorption during frying.\textsuperscript{68,69} Water-soluble cellulose derivatives can also be used to make glazed sauces in order to minimize runoff and water loss during cooking. The mixture of hydrocolloids (alginites, gums, cellulose derivatives, etc.) and acids (lactic or acetic acids) or antimicrobial agents laid out on meat pieces reduces the growth of microorganisms such as \textit{Listeria monocytogenes}.\textsuperscript{70,71} Guts traditionaly used to provide shape and preservation of sausages during fermentation, drying, or smoking are already mainly substituted by collegenic and/or cellulotic edible films. The latter are more easily industrialized and allow a better control of the manufacturing process and storage.
B. Fruits, Nuts, Grains, and Vegetables

The principal methods of fruit and vegetable spoilage are gas exchanges (respiration and transpiration) during ripening and storage, and/or microbial growth, particularly molds and rots. Waxes (mineral oils, paraffin, carnauba, candelilla, beeswax, polyethylene, shellac) are used largely as coatings on fruits such as orange, lemon, grapefruit, apple, pear, cherry, banana, guava, mango, lychee, date, coconut, peach, grape, melon, and on some vegetables such as carrot, cucumber, root crop, pumpkin, sweet corn, eggplant, pepper, tomato, asparagus, celery, radish, potato, and turnip. Waxes and oils, alone or in emulsion with hydrocolloid or protein solutions, are really efficient barriers to water and can prevent from weight loss. However, a thicker layer of waxes strongly modify oxygen and carbon dioxide exchanges; this involves anaerobic storage conditions inducing nonhomogeneous ripening up to adulteration of fruits and vegetables. Consequently, some edible films were developed to better control the ripening by reducing oxygen penetration in the fruit and increasing CO₂ and ethylene evaporation. In addition, proteins and polysaccharides, whether mixed with lipids or not, present the best ratio between CO₂ and O₂ permeabilities, from 10 to 25 when those of plastic wrappings are lower than 5. Indeed, corn zein coatings applied on tomatoes or sucrose polyester “semperfresh” applied on apples delayed color, weight, and firmness changes. Spoilage can be retarded or prevented by incorporating antimicrobial agents within the film or by the natural antifongic property of the hydrocolloid used. In such a manner, chitosan coatings induce the production of the chitinase enzyme by the fruit itself, which is a natural antifongic agent. Chitosan coatings also have very selective barrier properties to gases and water vapor, thus allowing a good respiration and low water loss via transpiration when they are layed out on the strawberries or raspberries. Nuts, almonds, hazelnuts, and peanuts are well protected against oil migration and oxidation by low methoxy pectin or cellulose derivative coatings. Processed fruits and vegetables can also be preserved by coating during and after the manufacturing processes. Mazza and Qi have shown that the nonenzymatic browning of peeled and blanched potatoes can be inhibited by a coating composed of gums, starch, gelatin, and calcium chloride. A large number of fruits (grapes, apricots, bananas, guavas, mangoes, pineapples, etc.) are preserved during storage by air drying or osmotic dehydration. Because of their high sugar content, they tend to be sticky and agglomerate. The loss of moisture causes the product to become hard and tough when water uptake involves spoilage and sometimes rancidness. Thus, some coatings made from wax, cellulose derivatives, starch, pectins, and/or proteins were suggested to hinder these defects. To reduce solute absorption, and particularly sucrose during osmotic dehydration, several authors have shown that alginates, pectins, starch, or milk proteins are suitable barriers against solutes when they are applied on apples or papaya slices, for example.

C. Confectioneries

Many candies require an edible coating to prevent stickiness, agglomeration, moisture absorption, and oil migrations in the case of chocolate or fat containing confectioneries. Indeed, milk and whey proteins, cellulose derivatives and edible varnishes like shellac or wax, are well known to reduce water and oil migrations, like the oily or greasy feeling on fingers. These are used to make the M&M’s products commercialized by the Mars Company. Similarly, dragees are the oldest edible coated confectioneries where the sugar coating reduces the lipid oxidation of almond or nut contained in the candy. Nelson and Fennema showed that methylcellulose films and coat-
ings have a very low lipid permeability (lower than plastics) able to reduce fat migrations and thus to inhibit the whitening or the blooming of chocolate in confectioneries containing other lipids than cocoa butter. Mixtures of zein-ethanol used as film-forming solutions obtain a better effect than the traditional confectioner’s glaze, with reduced drying time. Dyhr and Sorensen suggested the use of sorbitol-based hard coatings to replace traditional sugar coatings on chewable dragees. Bilayer films composed of a hydrocolloid film-forming agent and a wax layer that improved adhesiveness was applied on chewing gum sheets to extend shelf life and reduce moisture loss. This formulation was developed and patented by the JR Wrigley Company. A new active function of edible films and coatings on sugar-based confectioneries and cereals was launched. It dealt with a coating that changes color when immersed in aqueous media like milk or the mooth.

D. Elaborated and Heterogeneous Foods

The most interesting application of edible films and coatings comes with elaborates and heterogeneous foods. Indeed, plastic films or wrappings cannot be inserted within the food product, for example, between the tomato paste and the pastry or between the fruit mixture or the puree and the cake. A mixture of stearic-palmitic acids and hydroxypropylmethyl cellulose laid on the pastry is really suitable to reduce moisture transfers without modifying the organoleptic properties of the food product. The coating by dipping lightly dehydrated apricots into acetylated monoglycerides retains their water during cooking and storage when they are incorporated in cakes. Several formulations were patented to reduce moisture transfers between low water activity components (cereals, biscuits, dry nuts, or fruits) that have to be incorporated in high moisture content compartments such as soup, yoghurt, cream, puree, etc. A bilayer methylcellulose and palmitic acid coating was tested as a moisture-impermeable barrier in sundaes ice cream cones. This kept crispness in the cone over 3 months. Nowadays, many applications of edible films and coatings to heterogeneous foods are applied, developed, or tested by industrial firms, but little data are available in the scientific and patent literature.

E. Noncoating Applications

Noncoating applications correspond to the use of edible film-forming properties of food substances such as protein or polysaccharide hydrocolloids in the making of films, casings, bags, and wrappings. Actually, only one industrial edible bag is approved by the French food regulatory administrations (DGCCRF–AFNOR) and commercially available from Gemef Industrie S.A. This edible bag contains breadmaking additives; it is named SOLUPAN, and consists of hydroxypropyl-methyl cellulose, starch, and potassium sorbate. Although few edible bags, wrappings, and packagings are available for purchase, many patents were registered; they describe the composition, making, and potential uses of edible films and packagings. Major components of edible films are hydrocolloids such as hydroxypropylmethyl cellulose and glycerol (Monosol LPX 1832, Chris Craft Industrial Products, South Holland, Illinois, U.S.A.), starch and proteins starch and softenings, firming, anticaking and color agents, high amylose acetate starch, starch and gelatin, gelatin and collagen, collagen, chitosans, carrageenans and polyhydric alcohol, curdlan, pectins, gums, and proteins soybean proteins, caseins and caseinates, fish proteins. Edible films usually have lower mechanical properties than plastics, and, for hygienic reasons, they need to be overpackaged with traditional paper or plastic packagings. All the hydrocolloids used in the edible film making are fully or partially soluble in water. Thus, in most cases, their
use is restricted to dry, low water activity, low moisture content, or powdered ingredients, additives, or food products. However, they have relatively good processability and they are heat sealable and perfectly biodegradable.

VIII. BIOPACKAGING: THE FUTURE?

Edible coatings are very promising systems for the future improvement of food quality and preservation during processes and storage. Indeed, they could be used where plastic packaging cannot be applied, that is, they can separate several compartments within a food. Edible packagings are intelligent packagings because they are both active and selective and have infinite potential use. Edible films and coatings are natural polymers obtained from agricultural productions such as animal and vegetable proteins, gums, and lipids and are perfectly biodegradable, and therefore perfectly safe for the environment. Their cost is 10- to 50-fold higher than those of polyethylene or polypropylene films, but is the same order than complex, multilayered, or active plastic films. However, their cost is not a handicap to their development because quantities used are very low, and they are especially applied for very specific goals in value-added food products. Thus, the knowledge of edible polymers and that of plastic materials should be used synergistically for the development of new applications, new biodegradable materials, and new environmental approaches. Consequently, both plastic and edible packagings potentiality appear to be a successful key for tomorrow’s food packagings.

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