Review Article

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Journal of Food Biotechnology Research

2018
Vol.2 No.1:3

General Characteristics of Edible Films

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Citation: Erkmen O, Barazi AO (2018) General Characteristics of Edible Films. Vol.2 No.1:3

Abstract

Edible films and coatings have an increasing trend among preservation of food materials. This review covers definition, history, general information about edible films, their components and quality parameters required for food preservation. History of edible films dates back to 12th and 13th centuries but its evolution continues with big applicational progress up to now. Today there are more than 12 types of commercially used edible films and coatings with sub brands used for preserving food materials. Components of edible films and coatings may vary in order to qualify requirements of food materials that will be protected. So, some ideal criteria should be chosen for selection of suitable components. According to their compositions edible films should meet some quality parameters in order to be used for food preservation. Components and quality parameters should be met with characteristic profile of an edible film or coating.

Keywords: Edible film; Coating; History; Quality parameters

Received: January 22, 2018; **Accepted:** January 29, 2018; **Published:** February 05, 2018

Introduction

Edible films and coatings are defined as any thin material used for wrapping or coating food materials and drugs to extend shelf life of the product which may be consumed together or removed before consumption. The term “edible film” has two main considerations. First part “edible” means, films may be consumed together with foods in contact so they need to cover all properties of safe-food ingredients according to Food and Drug Administration (FDA) having Generally Recognized As Safe (GRAS) status [1]. Latter part “films” means, covering material should have packaging properties which protect the inner part from outer environment and limit gas and water vapor transportation between food material and outside. Generally, this material should not alter the appearance, smell, and taste of the product. Because of these quality concerns, film material should be as thin as possible acquiring adequate mechanical properties to protect food material. Formerly, edible films and coatings were used to protect food materials by functioning as a barrier to gas, and moisture migration. Recently, edible films can be used with more functional features such as; encapsulation of aroma volatiles, vitamins, flavouring agents, antimicrobials and antioxidants [1,2]. Also, they can improve quality of food products by protecting them from physical, chemical and microbiological deteriorations such as moisture loss, enzymatic browning reactions, microbial spoilage and lipid oxidation [3].

History of using edible films and coatings may be seem new like last 50 years, but using edible films as coatings dates back to 12th and 13th centuries. Waxes applied to oranges and lemons in China to delay water loss during transportation and storage in 12th century. In the early 15th century, first edible film formation in Japan was made by utilizing soy milk proteins after boiling in pans and further air drying, which is called “Yuba” films [4]. Similar to waxing, larding of fruits, vegetables, meats and fish in order to prevent moisture loss was common in England during 16th century [5]. During 19th century, first US patent was achieved for gelatin films in order to protect several meat products [4]. Sucrose and sugar derivatives were used as protective coating on nuts to prevent oxidative rancidity by limiting gas transport through edible coatings. Commercial waxing and lipid applications of coating were applied on fruits and vegetables in 1930s while allowing natural respiration, limiting dehydration during transport [6]. In the early 20th century, during World War I and World War II, high demand of textile products from protein-based agricultural materials to produce textile products for soldiers such as, uniforms, blankets etc., increased the rate of production of commercialized protein-based wool substitutes. Casein, peanut protein, soy and corn zein were used to form commercialized textile, buttons, boxes and umbrella handles. The increased demand leads to search cheaper materials such as petroleum-based products for production of food package. During 2005-2006 dramatic increase of cost of the petroleum

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increased cost of packaging materials [6]. Currently, from 1990 up to now, more than 90 patents and 220 scientific research papers have been published which sharing the same concerns for food packaging; limiting water vapor transfers and carrying functional properties within the films, such as antioxidants, antimicrobial agents, vitamins and aroma compounds [1,7].

Today increasing quality demands of consumers to fresh and safe food materials and healthy packaging alternatives lead the production of commercial edible films prepared for several food packaging systems. Some examples to commercial brands that produce edible films are given in **Table 1** [4,8].

Components of Edible Films

A typical edible film has three major components; film forming material, plasticizer, and additives. Additionally, edible films need a suitable solvent in order to prepare a film forming dispersion (FFD). Mostly water, alcohol or aqueous alcohols are used as solvents according to natural solubility characteristics of film forming materials. Proteins, polysaccharides, lipids and combination or mixture of these are major film forming materials [2]. Additionally, functional additives such as plasticizers, antioxidants, vitamins, antimicrobial agents, essential oils, pigments and chemical preservatives are used to improve protective properties of edible films and coatings [2,9]. Examples of film forming materials and their components are given in **Table 2** [1,2,10-14]. Most of the edible films are used to minimize moisture loss, and respiration of food materials. Moisture and gas barrier properties are found to be the most important requirements of edible films and coatings for food materials after being food grade [1].

General Characteristics of Edible Films

Edible films and coatings are used to protect foods from unfavourable conditions while keeping them safe and fresh during shelf life. Usage purposes of edible films and coating vary according to requirements of foods during their storage. Also, natural characteristics of film forming materials may limit protective features due to their migration mechanisms of moisture and gases. An edible film or coating must meet with some characteristics for use for foods. An ideal edible film or coating [1,4,15,16];

- Should be safe to consume, recognized as safe for human consumption (GRAS) and FDA approved.
- Should be non-toxic, non-allergic, fully digestible and biodegradable.
- Should be stable in both production and storage.
- Must be mechanically stable against damage during transportation, handling, and storage of food materials.
- Should have film forming materials which are readily dispersed and dissolved in a solvent (such as water, alcohol or their mixture) and other solvents (such as acetone) during manufacturing.
- Should have good, uniform and homogenous adhesion to surface of food.
- Should have good mechanical and rheological properties due to manufacture and application conditions.
- Should control water migration both in and out of the protected food to maintain desired moisture content.
- Should have control both cohesion between film forming polymer molecules and adhesion between film and the foods.
- Should provide control over maintaining internal equilibrium of gases involved in aerobic and anaerobic respiration of foods.
- Should not adversely affect the characteristics necessary

Table 1 Commercial edible films produced for coating and packaging of food materials.

Name	Film-forming component	Usage area
BioEnvelop ®	cellulose derivative-based and starch-based films	Mechanical protection of several foods
Chris-Kraft Polymer Inc.	hydroxypropyl-methylcellulose (HPMC)	Protecting several foods
COGIN ®	carrageenan-based films	-
ENAK ®	HPMC, alginate and carrageenan-based films	-
Freshseel™	Sucrose esters	Extending shelf life of melon
Fry Shield™	Calcium pectinate	Frying fish, potatoes, and other vegetables
GREENSOL ®	HPMC-based films	-
Nature Seal™	Calcium ascorbate	Coating apples, avocado, carrot, and other vegetables
Nutrasave™	N,O-Carboxymethyl chitosan	Coating avocado
Opta Glaze™	Wheat gluten	Prevent microbial growth
Seal gum, Spray gum™	Calcium acetate	Prevents darkening of potato during frying
Semperfresh™	Sucrose esters	Protect pome fruits from moisture loss
SHELLAC (E904)	Resin from lac insect	Confectioneries glaze
Z-Coat™	Corn protein (zein)	Extends shelf-life of nut meats, pecan and chocolate covered peanut

Table 2 Food components used in film coat formation.

	Food Materials	Examples
Film forming materials	Animal proteins	Whey protein, collagen, gelatin, casein, egg-white protein, fish myofibrillar protein, feather keratin
	Plant Proteins	Soy protein, corn zein, wheat gluten, pea protein, rice bran protein, cottonseed protein, peanut protein
	Linear, neutral polysaccharides	Agar, curdlan, cereal b-glucan, methylcellulose, hydroxypropyl methylcellulose, Microcrystalline Cellulose, pullulan, konjac glucomannan, inulin.
	Linear, anionic polysaccharides	Sodium alginate, propylene glycol alginate, carrageenan, pectin, gellan gum, carboxymethylcellulose or cellulose gum
	Linear, cationic polysaccharides	Chitosan
	Linear, substituted, neutral polysaccharides	Fenugreek (*Trigonella foenum-graecum*), guar gum, tara gum, locust bean gum
	Linear, substituted, anionic polysaccharides	Xanthan gum
	Branched polysaccharides	Gum arabic, gum ghatti, karaya, larch arabinogalactan
	Lipids	Waxes (beeswax, paraffin, carnauba wax, candelilla wax, rice bran wax), acetoglycerides
	Resins	Shellac, terpene, asafoetida, benjoin, chicle, guarana, myrrhe, opoponax, sandaraque, styrax
Plasticizers	Polyols	Glycerol, propylene glycol, polypropylene glycol, sorbitol, polyethylene glycol, corn syrup
	Others	Sucrose and water
Additives	Flavors	Oil based flavors, Citrus, Mints, Volatile oils
	Colors	Pigments
	Antimicrobials	Organic acids (acetic, benzoic, lactic, propionic, sorbic); Fatty acid esters (glyceryl monolaurate); Polypeptides (lysozyme, peroxidase, lactoferrin); nitrites and sulfites, chitosan, bacteriocins (nisin, pediocin), parabens, liquid smoke, sodium chloride.
	Antioxidants	Ascorbic acid, 4-hexylresorcinol, amino acids (cysteine and glutathione), citric acid.
	Nutrients	Vitamin E, calcium, zinc, aluminum
	Emulsifiers	Lecithins, mono- and diglycerides, mono- and diglyceride esters, Fatty sucrose esters, fatty alcohols, fatty acids
	Lipid emulsions	Edible waxes, fatty acids
	Probiotic organisms	*Bifidobacterium* (*Bifidobacterium lactis* Bb-12)
	Plant essential oils	Cinnamon, oregano, lemongrass, savory, sweet inula, vanilin, clove, citronella, thyme

for consumer acceptance such as odor, flavor, taste and appearance. But it may enhance these characteristics.

- Should provide biochemical and microbial surface stability while protecting against contamination, pest injuries, microbial growth, and other types of spoilage.
- Should serve as carrier for desirable additives such as flavor, odor, coloring, nutrients, antioxidants, antimicrobial agents wand vitamins.
- Should be easily manufactured and economically feasible due to cost and application conditions of foods.

Quality Parameters of Edible Films

In order to achieve ideal properties, edible films and coatings should be tested by some measurable quality parameters. The most important properties to be evaluated in edible films and coatings are their moisture and gas barrier properties, microbiological stability, moisture adsorption capacity, adhesion, cohesion, solubility, transparency, mechanical properties, sensory and organoleptic properties [17]. Some of the parameters used to measure quality of an edible film or coating are followings [1];

- Water vapor permeability or water vapor transmission rate.
- Oxygen permeability or oxygen transmission rate.
- Moisture adsorption during storage.
- Mechanical properties; tensile strength, percent elongation, elongation at break, elastic modulus and glass transition temperature.
- Chemical properties; solubility in water, alcohol and mixtures and hydrophilic-hydrophobic interactions.
- Organoleptic properties; color, taste, appearance and odor.
- Physical properties; opacity and light transparency.
- Antimicrobial properties; minimum inhibitory concentrations, minimum bactericidal concentrations, maximum tolerated concentrations and antimicrobial activity against target organisms for edible films containing natural antimicrobials.

Characteristics of edible films and coatings are affected by several parameters such as the kind of film forming material composition, the conditions under which films are prepared like; type of solvent, pH of medium, temperature and the type and concentration of additives (plasticizers, antimicrobials,

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antioxidants, cross-linking agents or emulsifiers) [2,15-17,18]. Hydrocolloid films (protein and polysaccharide based) possess good gas barrier properties (oxygen, carbon dioxide) even lower than plastic films and adequate barrier properties to lipids but not to water vapor [15]. Lipid based edible films and coatings (such as waxes and resins) are most efficient film forming materials to prevent moisture loss and gain due to their low water vapor permeability and hydrophobic nature but their appearance is mostly opaque and unattractive as a packaging material [19].

Conclusion

As a general rule, edible films should provide a safe protection for food materials during storage time. Determining shelf life of perishable foods needs extra consideration when food materials are coated with edible films due to altered gas and moisture exchange between inner and outer layers of food surfaces. General accepted quality parameters and nature of edible film components are effective factors prolonging the shelf life of food materials coated. In order to determine suitable coating material and its constituents, every food material needs a preliminary research and development of their unique characteristics of edible film materials. So, edible films and their general characteristic profiles should be examined in detail during manufacturing of food materials having a prolonged shelf life when coated with edible films.

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