The Pharma Innovation Journal 2018; 7(7): 331-333

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2018; 7(7): 331-333

www.thepharmajournal.com
Received: 02-05-2018
Accepted: 04-06-2018

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Edible films and coatings: a brief overview

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Abstract
Edible films and coatings may be defined as protective layers created around food surface by applying solutions made from edible polymers like polysaccharides, proteins, lipids or their combinations. This protective layer acts as a barrier between the food and external environment and thus delay the ripening and spoilage process. Different types of commercial edible coatings are widely used to prevent moisture loss and to add shine to fruits and vegetables. Other commercial applications of edible coating include coating of nuts, processed foods, seafood, minimally processed fruits and vegetables etc. This review is an attempt to provide a brief overview of edible films and coatings and also recent developments related to them.

Keywords: Edible films, edible coatings

1. Introduction
Harmful effects of synthetic packaging on human and environmental health have paved way for development of biodegradable and edible packaging. Edible packaging broadly denotes edible films and coatings. Edible films and coatings may be defined as protective layers created around food surface by applying solutions made from edible polymers like polysaccharides, proteins, lipids or their combinations. The protective layer thus created, acts as a barrier between the food surface and spoilage causing factors thereby enhancing the shelf life of coated food. This protective layer results in improvement of gas and moisture barrier properties, mechanical properties, sensory quality and even the nutritional characteristics of coated/ wrapped food [1]. Edible films and coatings can be differentiated from biodegradable packaging on the basis of ediblity and non- toxicity which is the basic and foremost requirement of any edible film/coating. An edible coating or film shall be formulated with substances that are legal as per the prevailing food laws and must not interfere with the sensory profile or other quality attributes of the coated food [2]. Other than these basic requirements, an edible coating or film may also be used as a carrier for bioactive compounds like flavors, nutraceuticals, antimicrobials etc. thereby enhancing the functional or nutritional qualities of the coated food [3].
Use of edible coatings for extending shelf life of foods dates back to centuries. However, the first recorded use was in China where wax coatings were used for prolonging the shelf life of citrus fruits. Later, larding (use of lards or fats) was practiced in England to enhance the shelf life of meat products. Today different types of commercial edible coatings are widely used to prevent moisture loss and add shine to fruits and vegetables. Other commercial applications of edible coating include coating of nuts, processed foods, seafood, minimally processed fruits and vegetables etc.
There is a lack of consensus regarding the differences between a *film* and a *coating*. However, an edible film can be differentiated from an edible coating by the notion that an edible film is a standalone material that can be wrapped around the food whereas the edible coating is an exterior layer which remains attached to the coated food. Recent advances related to edible films and coatings have resulted in significant improvement of their physical and barrier properties thus paving the way for their consideration as an alternative to synthetic packaging materials. The major advantage of edible films and coatings over synthetic packaging is their biodegradability since film forming substances i.e. proteins, polysaccharides and lipids are inherently biodegradable.
Recent advances in edible films and coatings can broadly be classified into three categories: i) composite (combinational) films, ii) exploration of their ability as carriers of bioactive compounds and iii) use of nanotechnology for enhancing their physical, mechanical and functional properties. Composite edible films or coatings are created with more than one film

forming substance and thus derive benefits of additive or synergistic effect between different substances. For example, edible films or coatings made from polysaccharide blends fare better than those made from single polysaccharide which can be attributed to the synergistic relationship between different polymers [4]. Transparency, water vapour barrier and mechanical properties improved for tragacanth- locust bean gum blend films in comparison with single polymer films [5]. Addition of sunflower oil has been reported to improve the water vapor permeability of Quinoa protein- Chitosan-Sunflower oil edible films which may be due to hydrophobic interactions and presence of clusters of hydrophobic masses on the surface of such films [6].

Edible films and coatings are a promising carrier of bioactive compounds since they are ingested along with food thus ensuring the intended delivery of bioactive compounds like antioxidants, vitamins, probiotics etc. Other than adding nutritional value to coated food, these bioactive compounds also help in enhancing the functional attributes of film/coating e.g. antioxidants help in prolonging the shelf life of food. Edible Kefiran films have been succesffully used as carriers of lactobacillus with only one log cycle reduction of viable organisms during film forming process [7]. Incorporation of cinnamic acid (1g/L) as antioxidant agent in xanthan gum based edible coating has shown to enhance its anti-browning effect and shelf life extending capacity in case of pears [8]. Nanotechnology is a promising tool for improving physical, mechanical and functional properties of edible films. Incorporation of nanoparticles like solid lipid nanoparticles and silver nanoparticles have shown to improve barrier and antimicrobial properties. Candeuba wax® solid lipid naoparticles at concentrations of 60-65 g/L have shown to enhance moisture barrier properties of xanthan gum based edible coatings [9]. Incorporation of silver nanoparticles in agar-banana powder blend films resulted in distinctive antimicrobial activity against food-borne pathogenic bacteria, *Escherichia coli* and *Listeria monocytogenes* [10]. This review is an attempts to provide a comprehensive outlook on different aspects of edible films and coatings along with elaboration of recent trends and developments.

2. Classification of edible films and coatings

Edible films and coatings are classified on the basis of their principal ingredients. Four broad categories of edible films and coatings include:

2.1 Polysaccharide based edible films and coatings

Polysaccharides like starch, pectin, cellulose, exudate gums, seaweed extracts etc. are used for making edible films and coatings. These ingredients are selected after checking their suitability in terms of the physical, mechanical and functional properties of edible films and coatings. Polysaccharide based films and coatings are characterized by poor moisture barrier properties but are moderately less permeable to O2 and selectively permeable to O2 and CO2. This makes them suitable for preservation of fruits and vegetables where they can reduce the respiration rate by modifying the environment inside the product. Pea starch based edible films by incorporated with guar gum and glycerol resulted in improvement of food and non-food applications of pea starch films [11].

2.2 Protein based edible films and coatings

The modification of proteins results in films and coatings with enhanced functional and technological properties. This aspect of protein related films and coatings is receiving increasing interest from scientists and manufacturers. Animal proteins like gelatin and plant based proteins like soy protein, gluten etc. can be utilized for development of edible films and coatings. For example, sesame seed protein was effectively utilized for development of edible films [12].

2.3 Lipid based edible films and coatings

Lipids have a long history of use as edible coating for preservation of food articles. Wax coatings were used in ancient China for preservation of citrus fruits. Later, larding (use of lards or fats) was practiced in England to enhance the shelf life of meat products. Some of the lipids, waxes and resins used for development of edible films and coatings are mentioned below:

i) Lipids: Sunflower oil, palm oil, coconut oil, cocoa butter etc.
ii) Waxes: Bees wax, Carnauba wax, Jojoba oil, Candelilla wax etc.
iii) Resins: Gum arabic, Mesquite gum, Tragacanth gum etc.

2.4 Composite edible films and coatings

Composite edible films and coatings are developed by the use of more than one ingredients mentioned above. The logic behind using more than one ingredient is to take advantage from synergistic reactions between them. Tragacanth-locust gum bean blend films were reported to have better physical and barrier properties than their individual counterparts.

3. Applications of edible films and coatings

Some of the common applications of edible films and coatings are in preservation of fruits and vegetables, meat and poultry, bakery and confectionery products, breakfast cereals, dry fruits like raisins and nuts etc. Some of these applications have been discussed below in detail.

3.1 Preservation of fruits and vegetables

Fruits and vegetables are considered as perishable commodities due to lot of free moisture and high respiration rate. Edible films and coatings tend to act as protective layer around the surface of fruits and vegetables and delay the spoilage by reducing respiration. Some of the common applications include:

a) Edible coating applications for controlling mass transfer in fruits and vegetables.
b) Edible coatings applied for reducing oxidative reactions in fresh and processed fruits and vegetables.
c) Edible coatings for improving gloss and shine on fruits and vegetables surface.
d) Edible Coatings for improving textural properties.

3.2 Meat, fish and poultry

Following table summarizes the use of edible films and coatings in the preservation of meat, poultry and fish products:

Table 1: Application of edible films and coatings in meat preservation

Type	Applications
Starch	Beef, pork
Carageenan	Beef, fish, pork
Chitosan	Beef, fish, pork and poultry
Collagen	Beef, pork
Gelatin	Beef, pork, fish

4. Limitations and gaps related to edible films and coatings

There are many advantages of edible films and coatings like affordability, ease of application, natural ingredients etc. But there are several weak areas which require attention from scientists and developers. However many of these drawbacks can be overcome by development of composite edible films where synergistic reactions between constituents improve the limiting properties. Some of the drawbacks related to different types of edible films and coatings are mentioned below:

Table 2: Limitations of edible films and coatings

Type of edible film/ coating	Limitations
Protein based	Poor physical properties like tensile strength, elongation at break, puncture strength etc.
Polysaccharide based	Poor moisture barrier properties due to hydrophilic nature of constituents.
Lipid based	a) Poor oxygen barrier property which make the food prone to oxidative spoilage. b) Negatively affect the sensory properties of food.

5. Conclusion

Edible films and coatings are fast emerging as alternatives to the synthetic packaging materials. Research and development efforts have resulted in many new types of edible films and coatings which are at par with their synthetic counterparts in terms of functionality. Their biodegradability and edibility make them obvious choice for packaging of food commodities. However, there are still many grey areas which need to be worked upon to improve the commercial properties of edible films and coatings.

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