A REVIEW | International Journal of Agricultural Engineering | Volume 6 | Issue 2 | October, 2013 | 564–568

Edible coating an innovative technology for food preservation

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Received : 09.04.2013; **Accepted :** 18.11.2013

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ABSTRACT : This review presents current knowledge on types, preparation techniques and industrial application of edible coating. Use of biodegradable packaging materials in foods due to increased environmental awareness has resulted in a new era for edible films and coatings. Edible films/coatings have become the focus of such study not only due to their potential for solid disposal problem, but also for maintaining quality and shelf-life of the product. Application of edible films on the food products could also be utilized as a protective coating to extend the shelf life. As research in this area is somewhat limited and involves the most important functionalities of an edible film or coating such as control of mass transfer, mechanical protection, sensory appeal, maintaining purity of fruits, providing functionality, controlling adhesion, cohesion, barrier properties and extending shelf life. In view of the extensive applications of edible coating the review was attained.

KEY WORDS : Edible coating, Mechanical protection, Edible film, Applications

HOW TO CITE THIS PAPER : Lamdande, A.G., Garud, S.R. and Kadam, V.D. (2013). Edible coating an innovative technology for food preservation. *Internat. J. Agric. Engg.*, **6**(2) : 564-568.

Edible film and coating enhances the quality of food products, protecting them from physical, chemical and microbiological deterioration (Kester and Fennema, 1986). Generally, edible films and coatings function as a barrier against gases or vapor and as carriers of active ingredients such as antioxidants, flavours, fortified nutrients, colorants, antimicrobial agents or spices (Gennadios and Weller, 1990; Guilbert *et al.*, 1995). The most important function of edible film or coating includes control of mass transfer, mechanical protection and sensory appeal. The purpose of edible films is to provide mechanical integrity or handling characteristics of the food, and a selective barrier to various gases, moisture, aroma and lipids. Besides their barrier properties, edible films and coatings may control adhesion, cohesion and durability, and improve the appearance of coated foods.

Coating containing some antimicrobials can inhibit microbial growth and extend product shelf life as compared with uncoated samples. In the preservation of paneer edible coating with antimicrobial agents could be best alternative since such techniques have been successfully applied in some dairy products (e.g. Cheese) and other food products like fruits, confectionary products, chocolate, etc.

An edible coating film can simply be defined as a thin continuous layer of edible material formed on or placed between food and food components (Torres, 1994). The film varies from transparent to translucent depending on formulation, purity of protein, sources and composition. The plasticizers are low molecular weight high boiling point molecules that impart flexibility and extensibility to the edible polymeric film (whey proteins in this case). They facilitate the processing of edible films by reduction of the intermolecular forces between adjacent polymer chains, resulting in a reduction of the polymer glass transition temperature.

Edible films and coatings for food preservation:

Edible films and coatings are produced from edible biopolymers and food grade additives. Film forming biopolymers can be protein, polysaccharides (carbohydrate and gum) or lipids (Gennadios *et al.*, 1991). Edible film and coating enhances the quality of food products, protecting them from physical, chemical and microbiological deterioration. Edible films or coatings are generally defined as stand-alone thin layer of materials. They usually consist of polymers able to provide mechanical strength to the stand-alone thin structure. It can protect food products from moisture migration, microbial growth on the surface, light induced chemical changes, oxidation of nutrients, etc. (Kester and Fennema, 1986). Most commonly edible films and coatings function as a barrier against gases or vapour and as carriers of active substances, such as antioxidants, antimicrobials, colour and flavours (Gennadios and Weller, 1990; Guilbert and Gontard, 1995). The purpose of edible films is to provide mechanical integrity or handling characteristics of the food, and a selective barrier to oxygen, carbon dioxide, moisture, aroma and lipids. Besides their barrier properties, edible films and coatings may control adhesion, cohesion and durability, and improve the appearance of coated foods. These materials can also act as carriers of active ingredients, such as antioxidants, flavors, fortified nutrients, colorants, antimicrobial agents, or spices.

Composite film coating is more effective than pure protein or polysaccharide films as reported by Kester and Fenema (1986). Nisin is one of the most heavily investigated bacteriocins in antimicrobial edible film studies. It can be incorporated into the film solution or applied directly to the film surface after casting. Various nisin containing protein based films (e.g. whey protein, sodium caseinate, corn zein, wheat protein, and soy protein) have been assessed for antimicrobial activity against pathogens (Hoffman *et al.*, 2001; Janes *et al.*, 2002; Teerakarn *et al.*, 2002).

Whey protein isolate/plasticizer formulation of edible coating was found to be effective as a source of glaze in the confectionery industry (Lee *et al.*, 2002). Whey protein films and coatings have been shown to be excellent aroma and oxygen barrier, moisture barrier as well as gloss enhancers (McHugh and Krochta, 1994; Lee *et al.*, 2002). This film can be applied over or between foods by immersion, spraying, or panning. When food-grade proteins and other food-grade additives (e.g. plasticizers, surfactants, acid or base, salts, enzymes etc.) are used and only protein changes due to heating, pH modification, salt addition, enzymatic modification, and water removal, the resulting film or coating is edible. This type of materials unlike synthetic polymers, come from natural sources and are biodegradable *i.e.* they can be degraded completely by microorganisms in a composting process to only natural compounds such as carbon dioxide, water, methane, and biomass.

There are several advantages associated with edible coating like (1) they may be eaten by the consumer along with food (2) their use could reduce the waste and solve the solid disposal problem (3) they could enhance the organoleptic, mechanical or nutritional properties of food, (4) they can reduce the cost by utilizing by products e.g., whey (Guilbert, 1986). Baldwin *et al.* (1995) reported that the use of edible coating to preserve the quality of minimally processed fruits, vegetables and nuts are desirable. Edible coating generally stabilizes the products thereby increasing the shelf life. Specifically the coatings have the potential to reduce moisture loss, restrict oxygen entrance, lower respiration, retard ethylene production, seal in flavour volatiles and carry additives that retard discoloration and microbial growth in various food products.

Types of edible films :

Polysaccharide films :

Polysaccharide films have poor moisture barriers, but have good mechanical properties. Polysaccharides that have been used for film forming are cellulose and cellulose derivatives, starch, some hydrocolloids like carrageenam, pectin, etc. (Rico-Pena and Torres, 1990). Lazarus *et al.* (1976) observed that polysaccharide coating increase moisture, and reduce perception of warmth over flavour induced by lipid oxidation.

Protein films :

Different proteinaceous substances that have been used for film forming are milk proteins, *i.e.* casein and whey protein, wheat gluten, corn protein, soy protein, etc. The use of casein and whey protein for film forming is very recent. Although protein film is poor moisture barrier due to their hydrophilic nature but they have considerable mechanical and gas barrier properties. Gennadios and Weller (1990) noticed that zein protein have also been used effectively as coatings for confectionery products. Avena-Bustillo *et al.* (1994) studied on one of the oldest known edible coatings used for packing meat products (made from the collagen) casein proteins, derived from milk, have been used in emulsion based coatings to reduce water loss in zucchini.

Lipid film :

Lipid is very hydrophobic and, therefore, acts as a good moisture barrier. However, their mechanical properties are inferior to protein and polysaccharide based films. Lipids like bees wax, carnauba wax acetylated mono glyceride, etc. has been used for film making (Banarjee and Chen, 1995).

Composite films and bilayer coatings:

Composite film consists of two or more components so that characteristics of the film are enhanced by individual contribution from each component. Therefore, protein, lipid or polysaccharide–lipid composite films are more effective than pure protein or polysaccharide films (Kester and Fennema, 1986). Baldwin (1994) noticed that composite and bilayer coatings are the edible coatings of the future. These two types of coatings work to combine the beneficial properties of coating ingredients to create a superior film. Wong *et al.* (1994) studied that bilayer coatings, which already have been used to a limited extent, combine the water barrier properties of lipid coatings with the greaseless feel and good gas permeability characteristics of polysaccharide coatings. Such a bilayer coating has been shown to reduce gas exchange, and result in higher internal carbon dioxide and lower oxygen concentrations in cut apple pieces. Unfortunately, little or no data exists showing the effects of bilayer coatings on whole fruits or vegetables and other food materials.

Coating technologies :

Coating application consists of applying a liquid or a powder ingredient on to a base product. Application of coating generally requires a four step process:

– Deposition of coating material (solution, suspension, emulsion or powder) on the surface of the product to be coated through spraying, brushing, spreading or casting.

– Adhesion of coating material (solution, suspension, emulsion or powder) to the food surface.

– Coalescence (film forming step) of the coating on the food surface.

– Stabilization of the continuous coating layer on its support or food product through co-acervation by drying, cooling, heating or coagulation.

Choice of coating system or apparatus depends mainly on size, shape and characteristics of the product to be coated.

Mode of application of coatings on food products :

Enrobing :

Enrobing involves application of a thick coating layer by dipping the product to be coated in solution batter or in molten lipid (e.g., a chocolate-based coating). Coating of fresh or frozen products with a batter and/or breading can enhance palatability, add flavour to an otherwise bland product and reduce moisture loss and oil absorption during frying.

Pan coating :

Pan coating is used to apply either thin or thick layers onto hard, almost spherical particles in a batch process. For example, coating confectionery centres (peanuts and almonds) with gum arabic provides a uniform base layer for further coating and a hydrophilic/ lipophilic surface, prevents moisture and fat migration and allows incorporation of additional flavour.

Drum coating :

Drum coating is often the best technique for applying either a thin or a thick layer onto hard or solid foods in a continuous process (e.g., nuts). Oiling and salting of nuts enhances palatability, adds flavour, and delays lipid oxidation in peanuts. Adding a chocolate coating to cornflake cereals enhances palatability, adds flavour and delays moisture absorption.

Screw coating:

A screw coater allows application of a thin layer of coating onto a solid and firm food material in a continuous process. For example, it is often used to deposit thin coatings on sticky particles, such as cheese shreds and pieces, to improve anti caking properties and prevent agglomeration of particles when product is stored in flexible packaging.

Spray coating:

The spray-coating technique can be used alone or in combination with pan, drum, screw and fluidized-bed coaters. Spraying makes it possible to deposit either thin or thick layers of aqueous solution or suspensions and molten lipids or chocolate. It is the most commonly used technique for applying food coatings. The spraying nozzle plays a critical role in the coating process. Spraying efficiency depends on the pressure, fluid viscosity, temperature and surface tension of the coating liquid, as well as nozzle shape or design. This in turn affects the flow rate, the size of the droplets, spraying distance and angle, and overlap rate.

Application of edible coating in food industry:

Since most of the work on the application of edible films and coating was done fruits and vegetables and not much work is done in dairy products so related review is presented here. According to Martins and Buraoda-costa (2003), alginate and gelatin coating at different concentrations with plasticizers such as glycerol and carboxymethyl-cellulose (CMC) and sucroesters coating plasticized with mono/ diglycerides were tested. The effects of those coating on the storage stability were followed by measurements of peel and pulp firmness. The 2 per cent alginate and 5 per cent gelatin coating significantly reduced weight loss, thus maintaining fruit firmness and thereby preserving fruit freshness. The effect of these coatings includes the improving appearance and imparting an attractive natural looking sheen to the fruit.

Dangaran *et al.* (2006) worked on whey protein-sucrose coating and reported that whey protein coating protects foods from deterioration and can extend product shelf life. Whey protein coatings may also undergo change over a period of time if not properly formulated. WPI coating containing raffinose had significantly higher gloss values. Edible coating of WPI can be used to improve the effectiveness of water based high gloss edible coatings.

Han and Krochta (2007) studied physical properties of whey protein coating solution and films containing antioxidants. Antioxidants (ascorbyl palmitate and alfa-tocopherol) were incorporated into 10 per cent of whey protein isolate (WPI) (w/w) and coating solution containing 6.67 per cent (w/w) glycerol (WPI: glycerol = 6:4) were studied. The antioxidants mixture was incorporated into heat denatured whey protein solution and viscosity and turbidity to determine transparency and oxygen barrier properties (permeability, diffusivity, and solubility).

According to Bravin (2006) edible coating of polysaccharide-lipid film composed of corn starch, methylcellulose (MC) and soybean oil had effective moisture transfer control in moisture sensitive products. It was evaluated by coating crackers, a low water activity type cereal food. Spread film gave better water vapour barrier and mechanical properties than sprayed film. Coated crackers had longer shelf life and higher concentration at all storage conditions. Coating containing hydrocolloids and sweeteners were tested for lipid barrier and sensory properties in addition to chocolate viscosity and water activity. A coating containing high methoxy pectin, acacia gum, high fructose corn syrup, dextrose, fructose and sucrose was most effective.

Kimura (2006) found that an edible coating with excellent adhesion, pleasant mouth feel and good moisture transfer resistance, is based on a macromolecular polysaccharide derived from seaweed and edible vegetable fibre which could be effective for meat products. The coating containing a mixture of the macromolecular polysaccharide and vegetable fibre with the food and an agent containing an appropriate metal ion to cause gelation was applied to meat products.

Lee *et al.* (2002) studied consumer acceptance of whey protein coated chocolate as compared with shellac coated chocolate. The WPI formulations without lipid varied in native as compared with the heat denatured WPI amount. The WPI formulations with lipid varied in the lipid amount. The shellac formulation consisted of 30 per cent solids of which 90 per cent was shellac and 10 per cent was propylene glycol. The results strongly indicate that water based WPI lipid coating can be used as an alternative glaze with higher consumer acceptance than alcohol based shellac.

Lee *et al.* (2002) also studied the effect of an edible coating combined with modified atmosphere (MA) (60%, O_2, 30% CO_2 and 10% N_2) packaging and gamma irradiation on the microbial stability and physicochemical quality of minimally processed carrots. A coating based on calcium caseinate and whey protein isolate was used. Samples were evaluated periodically for aerobic plate counts (APCS) and physicochemical properties (firmness, white discoloration and whiteness index). The coating was able to protect carrots against dehydration during storage under ambient condition. Coating and irradiation at 1 KGy were also able to protect carrots firmness during storage under ambient condition. MA packaging retarded whitening of uncoated carrot but had a detrimental effect on firmness. The edible coating used in this study did not significantly inhibit microbial growth on carrots.

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