Application of edible coating for improving meat quality: A review

Muhammad Issa Khan, Muhammad Nawaz Adrees, Muhammad Rizwan Tariq and Muhammad Sohaib

National Institute Of Food Science & Technology, University of Agriculture Faisalabad-Pakistan

*Corresponding Author: drkhan@uaf.edu.pk

ABSTRACT

Edible coatings can improve the quality of fresh, frozen, and processed meat, poultry, and seafood products by retarding moisture loss, reducing lipid oxidation and discoloration, enhancing product appearance in retail packages by eliminating dripping, sealing in volatile flavors, functioning as carriers of food additives such as antimicrobial and antioxidant agents, and reducing oil uptake by battered and breaded products during frying. This paper reviews the application of various types of lipid, polysaccharide and protein-based edible coatings, as well as multicomponent edible coating systems, on meats, poultry, and sea foods.

Key words: Edible coating, Meat Quality, oxidative stability, cooking loss

INTRODUCTION

Edible coatings from polysaccharides, proteins, and lipids can extend the shelf-life of foods by functioning as solute, gas, and vapor barriers. Although use of edible coatings and films to preserve food quality is not a novel concept, research in this field at academic, government, and private industry laboratories has intensified recently. Factors contributing to renewed interest in development of edible coatings include consumer demand for high quality foods; food processors’ needs for new storage techniques; environmental concerns over disposal of nonrenewable food packaging materials; and opportunities for creating new market outlets for film-forming ingredients derived from under-utilized agricultural commodities.

Film formation and properties for several polysaccharide, protein, and lipid substances have been reviewed (Kester et al., 1999). Commercial applications of edible films and coatings include fresh produce coatings from waxes, oils, resins, and sucrose fatty acid polyesters (Baldwin, 1994); collagen casings for sausages (Hood, 1987); chocolate coatings for confections (Alikonis, 2000); confectioner’s glaze made from shellac (Biquet, 1998); corn zein-based coatings for nutmeats, candy, and pharmaceutical tablets (Andres, 1984); gelatin-based pharmaceutical coatings (Rose, 1987); and cellulose ether-based water soluble pouches for food ingredients (Anon, 1992). This overview discusses the rationale of using edible coatings on meats, poultry, and sea foods and summarizes research findings on the effectiveness of and the problems associated with various types of coatings.

Rationale of Using Edible Coatings on Meats, Poultry, and Sea foods

Almost any sector of the food industry could utilize appropriately formulated edible coatings to meet challenges associated with marketing safe, nutritious, stable, economical, and high quality foods. Particularly with regard to the meat, poultry, and fisheries industries, the following are potential benefits of using edible coatings:

(i) Moisture loss during storage of fresh or frozen meats leads to texture, flavor, and color changes, while also reducing saleable weight. Edible coatings with good moisture barrier properties could help alleviate the problem of moisture loss. For example, when meat is removed from vacuum packages, a 3–5% reduction in weight occurs due to moisture evaporation.

Application of coatings prior to vacuum packaging could prevent this moisture loss, thereby having an important economic impact by increasing saleable weight of products.

(ii) When fresh meat, poultry, or fish cuts are packaged in retail plastic trays, dripping of product juices occurs making such packages unattractive to consumers. Edible coatings could hold in juices, prevent dripping, enhance product presentation, and eliminate the need for placing absorbent pads at the bottom of trays.

(iii) The rate of rancidity causing lipid oxidation and brown coloration-causing myoglobin oxidation in meats could be reduced by using edible coatings of low oxygen permeability, although not so low as to create anaerobic conditions.
(iv) Edible coating solutions, which have been heated just prior to application, could reduce the load of spoilage and pathogenic microorganisms and partially inactivate deteriorative proteolytic enzymes at the surface of coated meat, poultry, and fish cuts.

(v) Volatile flavor loss from, and foreign odor pick-up by meat, poultry, and seafoods could be restricted with edible coatings.

(vi) As an application of active packaging, edible coatings carrying antioxidants (e.g. toco-pherols) and/or antimicrobials (e.g. organic acids) can be used for direct treatment of meat surfaces, thereby delaying meat rancidity and discolouration, and reducing microbial loads.

(vii) Coatings applied on the surface of fish, poultry, and meat pieces prior to battering, breading, and frying, could improve the products’ nutritional value by reducing oil uptake during frying. It is evident from the above that edible coatings could substantially improve the quality of meats, poultry, and seafoods.

Types of coating

There are mainly three types of coating.

1. Lipid-based Coatings

2. Polysaccharide based coating

3. Protein based coating

1.1 Waxes, fats, and oils

Coating foods with fat, a practice known as ‘larding’, was used in 16th century England (Labuza and Conrrt, 1993). Waxes (e.g. carnauba wax, beeswax, paraffin wax) and oils (mineral oil, vegetable oil) have been commercially used since the 1930s as protective coatings for fresh fruits and vegetables (Baldwin, 2002). In the 1950s, several meat processors in the U.S. were applying strippable coatings of petroleum derived microcrystalline wax on frozen meats, such as beef, veal, lamb, hamburger patties, and luncheon meats (Megrath, 2004).

Generally, wax coatings have been shown to be substantially more resistant to moisture transport than most other lipid or non lipid edible coatings (Watters and Brekke, 1998). However, wax-based, as well as fat- and oil-based, coatings present application (i.e. thickness and homogeneity control, greasy surface, cracking) and organoleptic (i.e. waxy taste, rancidity) problems (Guilbert, 2000). Few references can be found in the literature regarding the effectiveness of waxes, fats, and oils as protective coatings for meats. (Mcnally, 1992) dipped dressed whole chickens into molten wax, mineral oil, corn oil, or lard prior to freezing. Mineral oil and wax reduced moisture loss from the frozen birds more than corn oil or lard but not as much as cellophane bags.

Freshly cut meats, on which protective coatings of molten fat (e.g. beef tallow, lard) droplets had been deposited, were superior to uncoated control samples in terms of color and moisture retention during storage at 2 to 4°C (Lieberman and Gilbert, 2002). Frozen meats, poultry, and fish did not undergo substantial dehydration when coated in oil-in-water emulsions prepared at 60 to 80°C by blending an animal fat or vegetable oil with emulsifiers, water, and, optionally, seasoning and preservative agents. Substantial reduction in moisture uptake during stor-age of freeze-dried meats was reported when liquefied fat-based coatings, at a temperature in the range of 52 to 79°C, were sprayed on dehydrated meat pieces (Aydt et al., 1999). These coatings were composed of beef tallow, lard, a lactic acid–fatty acid triglyceride (e.g. glycerol lactopalmitate), and a vegetable oil. The use of long chain (16 to 20 carbon atoms) saturated fatty alcohols or fatty acids as protective coatings to control moisture loss and freezer burn in refrigerated or frozen meats was suggested by Anderson (Brandenburg et al., 2003). These coatings were applied on meats prior to refrigerating or freezing in the form of aqueous, elevated temperature (50 to 90°C) emulsions of fatty alcohols or fatty acids and, optionally, an emulsifier. Reportedly, better results were obtained in frozen meats when the meat was first coated with ice prior to applying the fatty film and with refrigerated meats when the fatty film-forming material was applied as an emulsion in glycerin or water–glycerin (Mchugh and Krochta, 2000). It was claimed that the inter- mediate hydrophilic layer of ice, glycerin, or water–glycerin formed between the film and the meat surface attracted polar groups of the fatty film-forming material while repelling its hydrophobic carbon chains. As a result, fatty molecules were properly aligned and compressed together and the moisture-retarding ability of the fatty film increased (Brandenburg et al., 2003).

1.2 Glycerides and acetylated glycerides

Monoglycerides (monoacylglycerols), diglycerides (diacylglycerols), and triglycerides (triacylglycerols) are the mono-, di-, and triesters, respectively, of glycerin with fatty acids (Navar, 2000). Acetylated glycerides (acetoglycerides) can be prepared either through the reaction of glycer-ides with acetic anhydride or through the catalysed interesterification of a fat or oil with triacetin (Feuge, 1991). Both glycerides and acetylated glycerides have been utilized as coatings.

According to Lovegren and Feuge, 1998 acetylated glycerol monostearate coatings were slightly more permeable to water vapor than poly-amide, ethylcellulose, and polystyrene films and sig-nificantly more permeable to water vapor than cello-phane and
polyethylene films. In terms of oxygen barrier ability, acetylated glycerol monostearate coat-ings were less permeable to oxygen than ethylcellulose and polystyrene films (Lovgren and Feuge, 2001). (Woodmansee and Abbott, 2004) dipped broiler legs scalded at 53 to 60°C into Myvacet acetylated monoglyceride types 5-00 and 9-40 (2:1 mixture). In the Myvacet products the first number indicates degree of acetylation (e.g. 5 stands for 50% acetylation) while the second number is the iodine number. After storage at 4°C for 10 d, Myvacet-coated broiler legs had a weight loss due to dehydration of 4.2 to 6.3% as opposed to a weight loss of 15.1 to 30.2% for uncoated control broiler legs.

The coated broiler legs exhibited less skin darkening during storage than uncoated control samples (MCHUGH and KROCHTA, 2000). Saturated acetylated glyceride coatings in which the antibiotic chlortetracy-cline had been incorporated increased the time elapsing before microbial populations caused off-odors in fresh beef steaks stored at 5°C. Excellent moisture retention by coated steaks was also reported although the coating’s high impermeability to oxygen resulted in meat discoloration during storage (HOUTS, 2001). According to (SKERRITT et al., 2002) found that Myvacet 7-00 and, to a lesser extend, Myvacet 7-15 acetylated monoglyceride coatings retarded moisture loss from fryer parts stored at 0.5°C for 28 d or at −18°C for 6 months. The greater effectiveness of the Myvacet 7·00 coating as a moisture barrier can be explained by the unsaturation (iodine number 15) of the Myvacet 7-15 product. In general, as unsaturation of the hydrocarbon chain increases, the water vapor permeability of lipid coatings increases as well.

The effect of acetylated monoglyceride coat-ings on organoleptic properties of broiler parts was investigated by (FAROUK, et al., 2005) .They coated samples for fresh storage (2°C for 1 or 2 weeks) with Myvacet 7-00, and samples for frozen storage (−18°C for 1 or 8 months) with Myvacet 7-15. Reportedly, after oven-roasting or deep-fat frying, coated broiler parts were equally acceptable in terms of flavor and juiciness scores, moisture content, and fat content, to the uncoated control samples which had been stored in polyvinylidene wraps (ZABIK, M.E. and L.E. DAWSON, 1999).

2. Polysaccharide-based Coatings

Film formation and properties of several polysaccha-ride materials such as starch and starch derivatives, alginates, cellulose derivatives, carrageenan, various plant and microbial gums, chitosan and pectinates have recently been reviewed by Nisperos Carriedo, 1994). In general, due to their hydrophilic nature, polysaccharide films generally exhibit limited water vapor barrier ability. However, certain polysaccharides, applied in the form of high moisture gelatinous coatings, can retard moisture loss from coated foods by functioning as sacrificing agents rather than moisture barriers (KESTER, 1999). Application of various types of polysaccharide-based protective coatings on meat products is discussed below

2.1 starch and starch derivatives

Amylose, the linear fraction of starch, is known to form coherent, relatively strong, free-standing films in contrast to amylopectin films which are brittle and non-continuous (Zobel, 1998). Transparent, oil-impermeable films cast from water–butanol solutions of gelatinized amylose had very low oxygen permeabilities in dry condi-tions (Wolff et al., 1995). Presumably, films cast from ethanol– water dispersions of dimethyl sulfoxide-pretreated high amylose (71%) starch retained low oxygen permeability even at high RH (Mark et al.,1990).

Hydroxypropylated derivatives of high amylose starch made films with very poor moisture barrier abilities but with substantial oxygen barrier abilities of RH up to 78% (Jokay et al., 1999). Presumably, such films could protect meat products during frozen storage and subsequently be dissolved during thawing and cooking. However, no references can be found in the literature assessing the effectiveness of hydroxypropylated high amylose starch films as protective coatings for frozen meat, poultry, and sea foods. In terms of food packaging applications, these films were primarily intended for use on frozen foods including frozen meat, poultry, and fish. Reportedly, Ediflex wraps were flexible, transparent, impermeable to oxygen, resistant to oil and grease, heat sealable, soluble in hot or cold water, and printable (HOUTS, 2001). Presumably, such films could protect meat products during frozen storage and subsequently be dissolved during thawing and cooking. However, no references can be found in the literature assessing the effectiveness of hydroxypropylated high amylose starch films as protective coatings for frozen meat, poultry, and seafoods (TAYLOR, 2005).

2.2 Alginites

Alginites, which are extracted from brown seaweeds of the Phaeophyceae class, are the salts of alginic acid, a linear co polymer of D-mannuronic and L-guluronic acid monomers (Sanderson, 2001). Films produced by evaporation of water from a thin layer of alginate solution are impervious to oils and greases but, as with other hydrophilic polysaccharides, have high water vapor permeabilities (King, 1996). The ability of alginites to react with di- and trivalent cations is utilized in alginate film formation. Calcium ions, which are more effective than magnesium, manganese, aluminium, ferrous, and ferric ions as gelling agents (Allen, et al., 2004), ‘bridge’
alginate chains together via ionic interactions, a phenomenon followed by inter chain hydrogen bonding.

Alginates have often been combined with regular and modified starches, oligosaccharides, or simple sugars in meat containing formulations. According to (Hartal, 1994), tearing strength of alginate coatings increased by adding maltose, lactose, and corn syrup of intermediate (Jokey et al., 1999) dextrose equivalent (DE). Nevertheless, when reducing sugars are included in coatings, non-enzymatic browning may occur during cooking (Earle, 1990). According to (Taylor, 2005) coated fresh beef steaks, pork chops, and skinned chicken drumsticks by immersion (1 s) in an aqueous solution of sodium alginate, or sodium alginate and regular corn starch, or sodium alginate and oxidized starch, followed by immersion in a 5 mol/L CaCl2 solution (1–2 s). After storing at 1°C and 85–95% RH for 1, 2, 4, and 7 d, product shrink was generally reduced by the coatings. Furthermore, all three coatings were equally effective in improving product texture, juiciness, and, in some cases, color, general appearance, surface texture, and odor of uncooked and cooked products. Similarly, (Hartal, 1994) reported significant improvements in moisture reten-tion, texture, and juiciness for chicken drumsticks coated with an alginate-intermediate DE corn syrup film or an alginate-intermediate DE corn syrup monoglyceride film prior to storing (1°C, 85–95% RH, 12 d). Despite the aforementioned improvements, an experi-enced sensory panel found the flavor of cooked beef steaks and pork chops which had been coated with alginate or alginate–starch films to be inferior to the flavor of uncoated samples (WILLIAMS et al., 2004). Also, free calcium and other metal cations used for fixing alginate coatings may increase proteolytic enzyme activity on meat surfaces by acting as enzyme activators. Sensory evaluation data showed that alginate coatings fixed in calcium propionate solutions had better flavor than coatings fixed in CaCl2 solutions (Mark et al.,1990). However, because calcium propionate has weaker ionizing properties than CaCl2, immersion time in calcium propionate solution had to be longer to obtain coatings of similar strength to those fixed in a CaCl2 solution. A method for protecting seafood from dehydration and oxidation during frozen storage was described by Earle and Snyder (1998). Microorganisms and enzymes in the seafood were first inactivated by heating in water (e.g. at 70°C for 30 min); soaking in an aqueous solution containing chlorine; or soaking in a weak solution of acetic acid. Subsequently, the products were immersed in an aqueous dispersion of sodium alginate (0.02 to 0.15) and native starch, oxidized starch, or dextrins (0.98 to 0.85). For better results, a vegetable oil also was incorporated into the mixture. Gelling of the coating was accomplished by dipping in a 0.2 mol/L CaCl2 solution (1–2 min). It was claimed that shrimp, mack-erel, and kingfish treated in this manner retained their original flavor, texture, and color after frozen storage for 3 months (WANSTEDT et al., 2003). Earle and Snyder (1998) were awarded patents for a fresh meat coating process in which a sodium alginate–oligosaccharide solution and a CaCl2 -thickening gum gelling solution were successively applied on fresh meat by spraying or dipping. Based on these two inventions, an edible alginate-based coating, Flavor-Tex, for use on meats, poultry, seafood, and other foods was developed by Food Research, Inc. (Tampa, FL) and marketed by D. H. McKee, Inc. (Tampa, FL) in the 1970s (MCCORMICK, 2005). Flavor-Tex’s formulation included maltodextrin along with sodium alginate in the first solution and carboxymethyl cellulose along with CaCl2 in the second solution (STOLOFF, 2001). Alginate Flavor-Tex coatings applied on lamb carcasses stored at 4°C and on beef cuts stored at 5°C reduced moisture loss without significantly affecting total aerobic microbial counts on coated meat surfaces. Hydrochlorous acid incorporated into the alginate coating did not inhibit microbial growth on beef cuts. Sensory evaluation of cooked lamb and beef cuts that had been coated with Flavor-Tex did not reveal any significant differences in comparison with uncoated control samples (NATRAJAN and Sheldon, 2004). During frozen storage at ~18°C, red snapper and silver salmon treated with Flavor-Tex alginate coatings and sealed in polyethylene bags had slightly greater mois-ture contents and developed less lipid oxidation (based on thiobarbituric acid assays) than uncoated controls in polyethylene bags (Mark et al.,1990). Trimethylamine (indicator of bacterial growth) concentration, hypoxanthine (indica-tor of nucleotide degradation) concentration, and aerobic plate counts were not significantly affected by Flavor-Tex coatings. In terms of frozen fish moisture content, there were no significant differences between Flavor-Tex coatings and ice glazes. However, Flavor-Tex coatings remained intact after thawing so that drip loss was reduced.WILLIAMS et al., 2004) studied the effects of alginate Flavor-Tex coatings on sensory attributes of raw and precooked (before or after coating) pork patties stored at ~20°C while wrapped in polyethylene-coated freezer paper. Alginate-coated patties had improved texture, flavor, juiciness, and overall palatability over uncoated control samples. Moreover, warmed-over flavor (lipid oxidation) was eliminated in coated patties with no precooking and patties coated after precooking as judged by sensory scores and thiobarbituric acid values. In a recent study, (Hargens-Madsen, 2006) coated pre-cooked pork chops with CaCl2-gelled alginate–starch coatings. During storage at 4°C for 3, 6, or 9 d, the coatings did not retard moisture loss. However, sensory evaluation of microwave-heated pork chops showed that coated samples were juicier than uncoated control samples. Thiobarbituric acid values and sensory scores showed

4

Pakistan Journal of Food Sciences (2013), Volume 23, Issue 2, Page(s): 71-79
that pork chops developed less lipid oxidation after refrigerated storage for 6 and 9 d when the natural antioxidant tocopherol was incorporated into the alginate–starch coatings. However, the trained sensory panel detected an off-flavor in pork chops treated with tocopherol-containing alginate–starch coatings. In this study by Hargens-Madsen pork chops gained almost 20% of their original weight from alginate–starch coatings (with or without tocopherol). From a practical standpoint, application of such thick coatings may be unrealistic.

2.3 Carrageenan

The polysaccharide gum carrageenan, a galactose polymer, is extracted from Irish moss (Chondrus crispus) and from other species of red seaweeds (Whistler and Daniel, 1991). Carrageenan is a complex mixture of at least five distinct polymers designated as é, ë, î, i- and i-carrageenan (Whistler, 1991). Of these, mixtures of é-, ë- and i-carrageenan are used in food applications. Gelation of é- and ë-carrageenan occurs with both monovalent and diva-lent cations, whereas i-carrageenan is nongelling (Sanderson, 2002). Use of carrageenan coatings for prolonging frozen storage life of fatty fish has been proposed (Stoloff, 1989).

Coating mackerel fillets by dipping into aqueous carrageenan solutions (10 g/kg) prior to freezing and storing at −18°C prevented any major sensory changes for up to 5 months, whereas uncoated controls were found unacceptable after 3 months (Stoloff, 1989). Further delay of spoilage, until the seventh or eighth month of storage at −18°C, was noticed when antioxidants, gallic acid or ascorbic acid were added to carrageenan coating solutions (PEARCE and LAVERS, 2003). Lecithin was also claimed to reduce oxidation in meat when incorporated into carrageenan meat coatings. Pearce and Lavers studied the effect of applying a carrageenan coating prior to freezing on the shelf-life of defrosted whole chicken carcasses. Birds were coated by dipping into aqueous boiling (100°C) solutions containing carrageenan and potassium chloride in a 4:1 mixture (40 g/L). Reportedly, the refrigerated (4°C) shelf-life of defrosted coated birds, as judged by off-odor development, increased from 120 h for uncoated controls to 168 h. Shelf-life was further increased to 192 h when salt was incorporated into carrageenan coatings (Whistler, 1991). Carrageenan coatings were also applied on poultry meat by (Jokey et al., 1999). Fresh chicken parts were dipped into a 40 g/L aqueous solution of carrageenan at 64°C. During storage at 2°C, shelf-life of coated poultry slightly increased. Spoilage was further retarded by incorporation of water soluble antibiotics (i.e. chlortetracycline, oxytetracycline) into carrageen-nan coatings. In fact, inclusion of antibiotics into coatings was a more effective spoilage retardation method than dipping poultry into antibiotic–saline solutions (MEYER, et al., 2003). However, antibiotics are no longer approved for use on poultry meat as a preservative.

2.4 Agar

Agar is a gum derived from a variety of red seaweeds of the Rhodophyceae class and, like carrageenan; it is a galactose polymer (Sanderson, 2004). It forms strong gels characterized by melting points far above the initial gelation temperature (Whistler and Daniel, 1991). Similar to carrageenan coatings, agar coatings in which water soluble antibiotics (i.e. chlortetracycline, oxytetracycline) had been incorporated were effective in extending shelf life or poultry parts stored at 2°C (Meyer, et al., 1998). Also, the storage life of beef steaks at 5°C was extended by 2 d by applying chlortetracycline-contain-ing, glycerin-plasticized agar coatings (AYRES, et al., 2004). However, despite their substantial thickness (0.8–0.9 mm), these agar coatings did not reduce moisture loss from meat as acetylated glyceride or ethylcellulose-based coatings did (36). Recently, Natrajan and Sheldon studied agar coatings as vehicles for addition of the bacteriocin nisin to fresh poultry. EDTA, citric acid, polyoxyethylene sorbitan monolaureate, and 500 ìg/mL nisin were incorporated into agar coatings and applied on broiler skin samples contaminated with Salmonella typhimu-rium a 1:2 weight ratio (coating:skin). Reductions in S. typhimurium populations of 1.8 to 4.6 log cycles were recorded after storage at 4°C for 96 h (Natrajan and Sheldon, 2004).

2.5 Dextran

Dextrans are microbial gums composed solely of α-D-glucopyranosyl units but with varying types and amounts of glycosidic linkages. Leuconostoc mesenteroides and L. dextranicum are the micro-organisms usually employed in dextran biosynthesis from sucrose fermentation (Whistler and Daniel, 1991). Dextran coatings applied in the form of aqueous solutions or dispersions have been proposed for use on unpeeled shrimp, peeled shrimp, fish (Toulmin, 1996), and meat products such as ham, sausage, and bacon (Novak, 2000) to preserve their flavor, color, and freshness during refrigerated or frozen storage.

2.6 Cellulose ethers

Cellulose, the structural polysaccharide of plants, is composed of D-glucose units linked through α-1,4 glycosidic linkages. Native cellulose is a crystalline cold water-insoluble high molecular weight polymer (Ganz, 1998). The reactivities of the three hydroxyl groups at positions 2, 3, and 6 on the glucosyl units of cellulose are utilized for making useful derivatives.

Cellulose ethers are polymer substances obtained by partial substitution of hydroxyl groups in cellulose by
ether functions. Methylcellulose (MC), hydroxypropyl cellulose (HPC), hydroxypropyl methylcellulose (HPMC), and carboxymethylcellulose (CMC) are water soluble ethers possessing good film-forming properties (Felch, 1999). Their relative hydrophilicities increase in the order of HPC<MC<HPMC<CMC. Ethylcellulose (EC) is another film-forming cellu-lose ether which, in contrast to the aforementioned ethers, is water insoluble (Krumel, and Lindsay, 2001).

3. Protein-based Coatings

Formation and properties of films from animal and plant proteins, such as collagen, gelatin, milk proteins, wheat gluten, soy protein, corn zein, and peanut protein, have recently been reviewed (Gennadios, 2003). Over-all, in a similar manner to polysaccharide films, protein films exhibit relatively high water vapor permeability values, i.e. approximately two to four orders of magnitude greater than those of conventional polymeric packaging materials such as polyethylene, polypropylene, polyester, and polyvinylidene chloride (Lieberman and Gilbert, 1994). The limited resistance of protein films to water vapor transmission is attributed to the substantial inherent hydrophilicity of proteins and to the significant amounts of hydrophilic plasticizers, such as glycerin and sorbitol, incorporated into films to impart adequate flexibility. On the other hand, the good oxygen barrier properties in low relative humidity environments of films from collagen, wheat gluten, corn zein, soy protein, and whey protein have been documented by (MOREAU and ROSENBERG, 2002). A problem that may be encountered with protein-based coatings on raw meat, poultry, and seafood is the expected susceptibility of proteins to proteolytic enzymes present in these foods. Moreover, in terms of consumer acceptance and food labeling requirements, researchers investigating the application of protein-based coatings on meat and other food products need to consider the potential occurrence of individualistic adverse reactions to proteins. For example, food aller-gens have been identified among the protein fractions of milk, egg white, peanuts, soybeans, and rice. Certain individuals develop an adverse reaction to wheat gluten, and its gliadin fraction in particular, known as celiac disease or gluten-sensitive enteropathy or non-tropical sprue (Gennadios, 2003). Lactose intolerance exhibited by lactase deficient individuals is another, fairly common, dietary intolerance. Elevated levels of lactose, the carbohydrate contained in considerable amounts in bovine milk, are present in total milk proteins and in whey protein concentrates which may be employed in formation of edible coatings (Krumel, and Lindsay, 2001).

3.1 Collagen

Production of collagen sausage casings from the regenerated corium layer of food-grade beef hides is a well established technology and has been discussed else-where (Gennadios et al., 2003). As an alternative to preformed collagen casings, Unilever has developed a technology where the collagen casing is co-extruded around the sausage meat batter (Smits, 1991). The co-extrusion process is continuous and better controlled than the conventional batch process where meat batter is stuffed into pre-formed casings. Large processing plants with high volume lines use the co-extrusion technology for collagen casing production. Furthermore, use of proteins other than collagen, such as wheat gluten, corn zein, soy protein, peanut protein, and feather keratin, in manufacturing of sausage casings has been suggested (Jones and Whitmore, 2002).

Collagen-based edible coatings also have been pro-posed for use on meat products other than sausages. Jones and Whitmore described a method where ground collagen was mixed with an aqueous mixture of lactic acid and glyceraldehyde, heated to about 75°C, and neutralized to pH 7 to make a coating for hamburgers capable of withstanding cooking temperatures without melting. An edible collagen film (Coffi, Brechtteen Co., Mt. Clemens, MI), intended for use on netted roasts, boneless hams, fish fillets, roast beef, and meat pastes, was commercialized in the U.S. in the late 1980s. According to the manufacturer, Coffi can reduce cook shrink, increase product juiciness, and allow for easy removal of elastic stretch netting after heat processing YOUNG et al., 2004. (SHEU and ROSENBERG, 2002) reported that both refrigerated and frozen/thawed round beef steaks wrapped in Coffi collagen film prior to standard retail packaging (perme-able film overwrap) or vacuum packaging exhibited significantly less fluid exudate than unwrapped controls. Moreover, based on thiobarbituric acid analysis and on instrumental (Hunter color meter) and sensory color evaluation, the collagen films had no significant effect on meat oxidation and color.

3.2 Gelatin

Film-forming applications of gelatin, which is derived by partial hydrolysis of collagen, in the pharmaceutical and food industries include microencapsulation of ingredients and manufacture of tablet and capsule coatings (Gennadios, 2003). Similar to other types of edible films, gelatin coatings have shown potential as carriers of antioxidants. Turkey steaks sprayed with an aqueous gelatin suspension of various antioxidants developed less lipid oxidation (lower peroxide values by 60–90%) in skin and meat fat than uncoated controls during frozen storage at –12°C for 6 months (Klose et al., 1990).
3.3 Milk proteins

Edible films and coatings from casein, whey protein, and total milk proteins have been discussed in detail (Torres, 1994). Recent studies have combined caseinates with stearic acid for coating peeled carrots and with acetylated monoglycerides for coating zuc-chini. Whey protein-based coatings have been tested on breakfast cereals, raisins, frozen peas, and cheese pieces and as oxygen barriers on peanuts. Also, food additives have been microencapsulated in whey protein or in whey protein/carbohydrate wall systems (Klose et al., 1990).

Applications of coatings that combine acetylated monoglycerides with caseinates or with whey protein isolate on frozen salmon pieces were discussed earlier. Whey protein isolate coatings alone, followed by an antioxidant (ascorbic acid and citric acid) spray did not affect moisture loss rate but delayed onset of lipid oxidation and reduced peroxide values in frozen King salmon samples (Earle, 1990).

3.4 Cereal proteins

Film formation from corn zein, the prolamin fraction of corn proteins, and from wheat gluten, a mixture of the prolamin and glutelin fractions of wheat proteins, has been studied extensively (Gennadios and Weller, 1991). Other cereal proteins, particularly the prolamin fractions, are also known film-formers. For example, recent studies have evaluated properties of films from sorghum kafirin and rice bran protein (Buffo and Weller, 1995). As mentioned, corn zein has been used in commercial coating formulations for shelled nuts, candy, and pharmaceutical tablets.

The use of corn zein as an edible coating or packaging film for cooked meat and poultry has recently been suggested. Corn zein coatings on precooked pork chops did not reduce moisture loss but decreased lipid oxidation (significantly lower thiobarbituric acid values) after storage at 4°C for 6 and 9 d (Klose et al., 1990).

3.5 Oilseed proteins

Edible films and coatings from the globulin protein fractions of soybeans and peanuts have been reviewed (Coleman and Creswick, 2003). A process was described where dehydrated meat was stabilized with protein coatings, preferably made from mixtures of soy protein isolate and egg albumen (Folk, 1993). Lean meat was mechanically reduced into fibers and mixed in aqueous protein solutions. Formed slurries were extruded, cut in pieces, and heated to coagulate the protein.

Meat flavor was retained by the protein coatings while the product had good texture and rehydration characteristics. Use of soy protein as microencapsulating medium has been reported (Torres, 1994). Functionality of soy protein or peanut protein-based edible coatings on other food products has yet to be explored.

CONCLUSION

Several types of edible coatings have been applied on meats, poultry, and seafoods over the years. However, all of these systems presently have exhibited certain shortcomings and have not received substantial commercial acceptance. The numerous benefits to be afforded to food processors and consumers by effective edible coating formulations justify further research in this field. As more edible biopolymers are investigated for film formation and as new concepts related to multicomponent edible coating systems are developed, wide commercial exploitation of edible packaging for meats, poultry, and seafoods may be realized.

References: