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USE OF NATURAL PRESERVATIVES IN SEAFOOD: PLANT EXTRACTS, EDIBLE FILM AND COATING

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Abstract:

In recent years, the demand and consumption of minimally processed food and additive-free commodities which present few changes at sensory quality have increased. In this regard, natural antioxidants and antibacterial agents obtained from plants were preferred. Also the coating film obtained from natural polysaccharides, lipids and protein to protect the quality of food products was successful. This tendency has also led to research on developing new biodegradable packaging materials from natural polymers in order to achieve a partial alternative to plastic packaging. These applications act as oxygen and water barriers, thereby slowing oxidation reactions and retaining moisture, thus enhancing quality and extending product shelf life. In this paper, the use of natural preservatives and natural/edible film coating applications in seafood products preservation were reviewed.

Keywords:

Fish, Seafood, Natural preservatives, Edible film, Natural coating, Quality, Safety

Introduction

Being highly perishable, seafood has a limited shelf life (Kykkidou et al., 2009). Even if refrigeration or freezing can be applied to the products, these processes may not be enough in terms of preventing lipid oxidation, rancid off-flavors or bacterial growth (Gomez-Guillen & Montero, 2007). In most cases there is an additional need for enhancing seafood quality. By adding or applying to the seafood, plant extracts, edible films and coatings are the successful treatments with the potential to extend the shelf life of foods (Erkan et al., 2011a; Falguera et al., 2011). Plant extracts and essential oils have both antioxidant and antimicrobial properties, while edible films and coatings have the barrier effect against gases, water and microorganisms (Falguera et al., 2011; Mahmoud et al., 2004; Yanishlieva et al., 2006).

Plant Extracts and Essential Oils

In modern food industry the increases in processed food products have raised the use of chemical preservatives which delay or prevent nutritional loss caused by microbiologic, enzymatic or chemical changes, and enhance the shelf life of food. Unfortunately these synthetic additives can be dangerous for public health by the reason of accumulating in tissues and leading to genotoxicity in case of overdose (Özdemir et al., 2012). However, plant extracts and essential oils it was an alternative to synthetic chemicals and preservatives (Sultanbawa et al., 2011), especially for providing natural protection without spoilage and extend shelf life in food of animal origin (Holley & Patel, 2005).

Plant extracts have been used for thousands of years for medical, pharmaceutical, sanitary purposes, aromatherapy, phytotheraphy, perfumery and cosmetic applications besides food and beverage flavoring (Hammer et al., 1999; Bakkali et al., 2008). Today they have been considered as natural preservatives or food additives with strong antibacterial, antifungal and antioxidant activities in food industry for raw and processed food preservation (Benkeblia, 2004; Chouliara et al., 2007).

Fresh seafood has a short shelf life because of being highly perishable (Kykkidou et al., 2009). Through the production chain and during storage, biochemical, physical and microbial deteriorations occur at as a result of complex quality degradation processes (Gonzalez-Fandos et al., 2005; Del Nobile et al., 2009). Refrigeration or freezing it is not enough alone for the preservation of seafood (Gomez-Guillen & Montero, 2007). Therefore, enhancing shelf life of seafood with natural preservatives is an important issue to eliminate economic losses and provide safe and good quality food to consumer and reach to distant markets (Kykkidou et al., 2009). Plant extracts and essential oils treatment with regard the protection of quality and safety sensory, chemical and microbiological of some sea food products are presented in table 1. Plant extracts and essential oils can be derived from all organs or some specific tissues in the organs of the plant like petals, leaves, fruits, peels, stems, roots and xylems. Depending on the plant species, essential oils are found in cavities, secretory villus, ducts or cells and contain aromatic and aliphatic compounds. Carotenoids, retinoids, tocopherols, ascorbic acid, phenolic acids, flavonoids and polyphenols obtained from plant extracts known the antimicrobial activity. Likewise their antioxidant effects are due to terpenoid and phenolic components that plants contain (Bakkali et al., 2008). Moreover there can be differences on the biological activity of plant extracts and essential oils. Factors like climatic, seasonal and geographic conditions; harvest period; plant maturity and distillation technique may influence the chemical composition and cause variability (Lahlou, 2004).

Table 1. Application of natural preservatives to improve the quality of seafood products

Seafood	**Plant extracts used / Treatment**	**Effect**	**Reference**
Anchovy (*Engraulis encrasicholus*)	Fish stored in ice containing thyme, oregano or clove extracts.	The shelf life of gutted and beheaded anchovy stored in ice containing thyme (0.04% w/v), oregano (0.03% w/v) or clove (0.02% w/v) extracts were 12 days in comparison to traditional ice which had a shelf life of 5 days.	Bensid et al., 2014
Rainbow trout (*Onhcorynchus mykiss*)	Wrapping fillets with quince seed mucilage edible films (QSMF) containing oregano or thyme essential oil.	Fillets wrapped with QSMF and oregano essential oil (2%) had the lowest TBA value and the strongest antioxidant activity during refrigerated storage (4°C).	Jouki et al., 2014
Silver carp (*Hypophthalmichthys molitrix*)	Effect of grape seed or clove bud extracts on 1% salted fillets.	The addition of 2% grape seed or 2% clove bud extracts delayed lipid oxidation; protected against L* and a* value decreases; salt-soluble protein content and total sulfhydryl group. The sensory shelf life of fillets was extended by 3 days compared to the control.	Shi et al., 2014
Sea bream (*Sparus aurata*)	Flesh quality of fish naturally fed with feeds containing thymol or rosemary.	Adding natural antioxidants to the diet positively affected fish quality, delaying post mortem deterioration. Lower oxidation values in rosemary group and lower bacterial counts in thymol group was observed.	Alvarez et al., 2012
Rainbow trout (*Onhcorynchus mykiss*)	Hot smoked rainbow trout treated with thyme oil (TO) or garlic oil (GO) and vacuum packaged.	According to the sensory scores the limit of acceptance for the untreated, TO and GO treated samples was reached after 5 weeks, 7 weeks and 6 weeks, respectively. Total viable count was also lower in the oil treated groups stored at 2°C.	Erkan, 2012
Rainbow trout (*Onhcorynchus mykiss*)	Thyme oil added liquid-smoked fillets in combination with vacuum packaging.	Addition of thyme oil provided better sensory quality, TVB-N value and lower microbiological growth. Samples containing 10ml/L thyme oil had shorter shelf life than the ones containing 50ml/L thyme oil.	Alçiçek, 2011
Rainbow trout (*Onhcorynchus mykiss*)	Effect of bay leaf, rosemary, black cumin seed and lemon oil (%1) treatments on the shelf life of vacuum packaged hot-smoked rainbow trout stored at 2°C.	According to the overall acceptability of all data, only vacuum packed control group had a shelf life of 4 weeks. The shelf lives of rosemary, black cumin seed, and lemon oil treatment plus vacuum packaged fish and bay leaf oil treatment plus vacuum packaged fish was 6 weeks and 7 weeks, respectively. In addition plant extracts decreased microbiological activity of the fish.	Erkan et al., 2011a

Sea bream (*Sparus aurata*)	Hot-smoked sea bream inoculated with *Listeria monocytogenes, Staphylococcus aureus* or *Escherichia coli* and treated with grape seed (GSO) or sage oils (SO) before vacuum packing (VP).	Microbial counts in treated samples decreased over time stored at 2°C. The results indicated that the GSO was the best treatment for the inhibition of *E. coli* and *S. aureus.* In controlling the growth of *L. monocytogenes*, only VP was the most effective, while SO+VP was second most effective, and GSO+VP was the least effective.	Erkan et al., 2011b
Bluefish (*Pomatomus saltatrix*)	Bluefish treated with thyme and laurel essential oils during storage in ice at 2°C.	According to the sensory evaluation the shelf life of control and treated bluefish stored in ice were 9 and 11 days, respectively. Lipid oxidation, rancidity, off-flavours and microbial growth in the oil treated samples were lower than the control group. As a result bluefish with oil treatment had an increase in the shelf life by 3–4 days compare to the control samples.	Erkan et al., 2011c
Sea bream (*Sparus aurata*)	Thyme powder on fillets packed in polyethylene films.	Sprinkled thyme powder (1% w/w) on fillets before storing in ice extended shelf life for 5 more days.	Attouchi & Sadok, 2010
Chub mackerel (*Scomber japonicus*)	The effect of bay leaf (BLO), thyme (TO), rosemary (RO), black seed (BSO), sage (SO), grape seed (GSO), flaxseed (FSO) and lemon (LO) essential oil on chub mackerel.	Mainly according to the sensory scores, the shelf-lives of frozen chub mackerel were determined as 6 months for the untreated and TO, RO, BSO, SO, LO treated samples while 7 months for the samples treated with BLO, GSO and FSO at -20°C.	Erkan & Bilen, 2010
Rainbow trout (*Onhcorynchus mykiss*)	Coating fillets with chitosan and cinnamon oil.	Coating fillets with chitosan and cinnamon oil successfully inhibited lipid oxidation and microbial growth extending shelf life during the refrigerated storage (4°C).	Ojagh et al., 2010
Rainbow trout (*Onhcorynchus mykiss*)	Combined of oregano essential oil on fresh salted MAP fillets.	0.2% oregano essential oil treated fillets had better sensory scores in compare with 0.4% treated ones because of strong odour. However the synergistic effect of MAP and oregano oil extended shelf life by 7 to 8 days.	Pyrgotou et al., 2010
Mackerel:Hake (70:30) (*Scomber japonicus*): (*Merluccius merluccius*)	Thymol, lemon extract and grapefruit seed extract (GFSE) in blue fish burgers in combination with MAP.	As a result of antimicrobial effect of plant extracts (thymol: 110 ppm; GFSE: 100 ppm and lemon extract: 120 ppm) and high CO_2-concentration the microbial acceptability of fish burgers were ensured until the 28th day of storage at 4°C.	Del Nobile et al., 2009
Sea bass (*Dicentrarchus labrax*)	Combined effect of MAP and thyme essential oil on the fillets.	According to sensory evaluation, MAP (60% CO_2: 30% N_2: 10% O_2) in combination with thyme oil (0.2%) treatment had the longest shelf life (17 days) as compared to control samples (6 days) which are only air packed.	Kostaki et al., 2009
Mediterranean swordfish (*Xiphias gladius*)	Thyme essential oil applied on fillets in combination with MAP.	Addition of 0.1% thyme essential oil in combination with MAP enhanced shelf life (15½) of the fillets as compare to control (aerobic conditions; 8 days) according to sensory scores during cold storage.	Kykkidou et al., 2009

Rainbow trout (*Onhcorynchus mykiss*)	Oregano essential oil treated fillets packed with oxygen absorber.	The inhibitory effect on the microorganisms of oregano essential oil (0.4%) enhanced with oxygen absorber. The shelf life of the fillets was 4 days for the control samples and 17 days for the samples packed with oxygen absorber containing oregano oil.	Mexis et al., 2009
Chilean jack mackerel (*Trachurus murphyi*)	Oregano and rosemary plant extract icing in the preservation of fish.	Both plant-extract icing systems had significant antioxidant effects according to peroxide and TBA values and free fatty acid formation development in comparation to traditional icing.	Quitral et al., 2009
Anchovy (*Engraulis encrasicholus*)	Brining with 15% NaCl and treated with myrtle, rosemary or nettle extracts.	The highest antioxidant effect was observed in brined anchovies with rosemary and myrtle extracts, slowing down the lipid oxidation at 4°C for 28 days.	Turhan et al., 2009
Kutum (*Rutilus frisii kutum*)	Fillets brined with 10% NaCl and treated with onion extracts in combination with vacuum packaging.	Onion balanced the oxidation of lipids occurring from salt. With lower microbial load lightly salted, onion extract (2% and 4%) treated and salted fillets had a shelf life of 16 days while salted air packed control had only 6 days at low temperature (4°C).	Zolfaghari et al., 2009
Shrimp (*Parapenaeus longirostris*)	Rosemary extract treated marinated shrimp.	Marinated shrimp with rosemary extract (300 ppm) was good quality for consumption while rancidity limited shelf life of control group after 75 days stored at 1°C.	Cadun et al., 2008
Silver carp (*Hypophthalmicthys molitrix*)	Tea polyphenols (TP) dip treatment during iced storage.	TP (0.2%) solution dip treatment provided longer shelf life compared to control enhancing shelf life from 28 to 35 days during iced storage.	Fan et al., 2008
Mediterranean swordfish (*Xiphias gladius*)	Oregano essential oil applied on fillets in combination with MAP.	Applying oregano oil (0.1%) on fillets with MAP was effective to inhibit the microbial and sensory spoilage, and extended shelf life from 5 days (control) to 14 days at refrigerated storage.	Giatrakou et al., 2008
Sardine (*Sardina pilchardus*)	Cold-smoked butterfly fillets coated with gelatine-based functional edible films enriched by adding oregano or rosemary extracts in combination with high pressure (HP).	HP treatment in combination with edible films containing oregano or rosemary extracts increased the migration of phenols to the flesh and succeeded both preventing oxidation and inhibiting microbial growth.	Gómez-Estaca et al., 2007
Sea bream (*Sparus aurata*)	Oregano essential oil applied on lightly salted fillets in combination with MAP.	With the antioxidant activity oregano essential oil (0.8%) decreased the adverse effect of salting which accelerated oxidation during cold storage. According to sensory scores, the shelf lives of raw fillets and oregano oil in combination with MAP were found as 15-16 and 33 days respectively. Oregano oil had a distinct but pleasant flavour and slowed down deterioration.	Goulas & Kontominas, 2007

Mackerel (*Scomber scombrus*)	Flax seed extract soaking of the fillet for frozen storage.	Aqueous flax seed extract was useful for inhibition of rancidity development in fatty fish. According to the sensory analyses soaked fillets (20 min.) had good quality while non-soaked ones had fair quality after 1 month. However the soaked fillets were rejectable after 5 months while non-soaked ones only after 3 months.	Aubourg et al., 2006
Carp (*Cyprinus carpio*)	Convectional air-drying of fillets with combined treatment of electrolyzed NaCl solutions and thymol essential oil and carvacrol.	Treatment with electrolyzed NaCl cathodic and anodic solutions and 1% oil (0.5% carvacrol + 0.5% thymol) had stronger antimicrobial and antioxidant effects during oven drying and better sensory scores. In addition reduced the peroxide values and TBA values were observed.	Mahmoud et al., 2006
Salmon (*Salmo salar*)	Rosemary extract applied to fillets in combination with MAP.	The application of rosemary extract (0.2%) to the fillets improved sensory quality and, delayed lipid oxidation and colour deterioration in MAP fillets stored at 1°C.	Gimenez et al., 2005
Sea bream (*Sparus aurata*)	Rosemary extract treated fillets in combination with MAP.	The application of rosemary extract (0.2%) to the MAP fillets delayed lipid oxidation and had good sensory assessment. TBARS values and the sensory evaluations presented that addition of rosemary was found to be effective until the end of the storage period (day 26) at 1°C.	Gimenez et al., 2004
Cod (*Gadus morhua*)	Oregano,cinnamon,lemongrass, thyme, clove, bay, marjoram, sage and basil oils in combination with modified atmosphere packaging (MAP).	Oregano and cinnamon oils had the strongest antimicrobial activity. Addition of 0.05% oregano oil to the fillets reduced the growth of *Photobacterium phosphoreum* and extended shelf life up to 15 days at 2°C.	Mejlholm & Dalgaard, 2002

Antimicrobial compounds can disrupt cell membrane integrity, by interacting with membrane proteins of the bacteria. Increasing the permeability of the cell membrane, these compounds make potassium ions and other cytoplasmic structures leave the cell and cause the death of bacteria cells (Bajpai et al., 2008). Following the researches of the inhibitory effects of various essential oils on various microorganisms it is asserted that gram-positive bacteria are a bit more susceptible than gram-negative organisms (Hammer et al., 1999; Burt, 2004). The hydrophilic lipopolysaccharide cell wall of gram-negative bacteria blocked the penetration of hydrophobic essential oils into the cell membrane. On the other hand essential oil accumulates more easily to the gram-positive bacteria which do not have such cell wall structures (Bajpai et al., 2008).

The increasing demand for natural products that are potential antioxidants has led to the use of phenolic compounds instead of synthetic ones (Alvarez et al., 2012). Moreover, plant extracts are claimed to have potential health effects also, because of their antioxidant properties (Proestos et al., 2006). With metal chelation and redox properties phenolic compounds in plant extracts and essential oils are antioxidants, acting as reducing agents, hydrogen donors, and singlet oxygen quenchers (Proestos et al., 2006). Seafood, containing substantial amount of polyunsaturated fatty acids, is highly vulnerable to lipid oxidation, rancidity and color loss (Alvarez et al., 2012) and the use of plant extracts offers an alternative for the food industry. However, the anti-oxidative effects of plant extracts depend on the processing and storage conditions as much as the lipid content of food (Yanishlieva et al., 2006).

From *Allium* crops especially scallion, onion and garlic are common for food preservation extracts and contain sulfur and other numerous phenolic compounds which have strong antibacterial and antifungal activities. Alliums can also be used for the control of pathogens such as *Staphylococcus aureus, Salmonella* Enteritidis because of their inhibitory effects. Various garlic and onion essential oils extracts are proposed as natural antimicrobial additives for seasoning of several food products (Benkeblia, 2004). Thyme, oregano, savory, sage, rosemary, lemon balm and other members, *Labiatae* (*Lamiaceae*) family is also known as source of natural additives and frequently used in food industry due to their potential antimicrobial and antioxidative effects (Baydar et al., 2004; Yanishlieva et al., 2006; Gutierrez et al., 2009). There are also studies with other plant extracts like bay, clove, cinnamon, pine, crowberry, blackcurrant, grape and quince seeds investigating and revealing the antimicrobial effects (Rauha et al., 2000; Smith-Palmer et al., 2001) and antioxidant properties (Bajpai et al., 2008; Bensid et al., 2014; Jouki et al., 2014; Shi et al., 2014).

Considering the organoleptic properties, the concentrations of plant extracts and essential oils should be evaluated under realistic conditions prior to practical use in the food industry (Yanishlieva et al., 2006). Plant extracts offers an alternative to synthetic chemicals in the efficient preservation of seafood with their antimicrobial and antioxidant effects.

Edible film and coating

Coating the foods with edible materials has been researched as an effective method to improve the food quality (Song et al., 2011). Edible films are a good barrier for oxygen and carbon dioxide and possess suitable mechanical properties at low relative humidity (Lee, 2010; Song et al., 2011). Edible films and coatings have a range of advantages, such as edibility, biodegradability, biocompatibility, aesthetic appearance and barrier properties, as well as being nontoxic and non-polluting. Basic components of edible coatings include hydrocolloids such as proteins, cellulose derivatives, alginates, pectins, starches, and other polysaccharides (Lee, 2010). Edible coatings and films generally can be defined as thin layers of edible materials applied on or even within foods by immersing, brushing, spraying or wrapping (Gómez-Estaca et al., 2009). Edible film coatings in combination with refrigeration or other packaging system has proved to be an effective preservation method for the extension of shelf-life of foods and quality retention of a wide variety of fresh chilled food products. Another function of edible coatings could be as a carrier of antimicrobial compounds (Quintavalla & Vicini, 2002; Zhou et al., 2010). Many studies have shown that edible coatings made of protein, polysaccharide, and oil-containing materials help prolong the shelf life and preserve the quality of fish (Stuchell & Krochta, 1995; Jeon et al., 2002; Sathivel, 2005; Fan et al., 2009). Polysaccharide based materials, especially chitosan and alginate treatments in preservation of fish and fish products are shown in table 2.

Chitosan, which is mainly obtained from crustacean shells, is the second most abundant natural polymer in nature after cellulose (Shahidi et al., 2002) and has a wide application range since it is a natural, nontoxic, degradable in nature and commercially obtainable product (Tharanathan & Kittur 2003; Alishahi & Aïder 2012). This biopolymer has the ability to provide perfect film and coating solution when dissolved in acidic water solutions (Yingyuad et al., 2006). Hence, it has a wide potential to be used as a food packaging material (Tual et al., 2000; Sathivel et al., 2007) and numerous studies carried out with different fish species to evaluate the effects of chitosan coating on quality changes of sea foods under various storage conditions (Jeon et al., 2002; Gómez-Estaca et al., 2007; Sathivel et al., 2007; Duan et al., 2010; Ojagh et al., 2010; Günlü & Koyun 2013; Günlü et al., 2014). Many researches have studied chitosan as an edible coating material for fishery products to enhance quality. Jeon et al. (2002) demonstrated that chitosan-coated Atlantic cod and herring reduced moisture loss and lipid oxidation. Augustini and Sedjati (2007) reported that chitosan treatment significantly reduced the bacterial counts of salted dried anchovy and improved the shelf life. Kester & Fennema (1986) reported that chitosan coatings may function as moisture-sacrificing agents instead of moisture barriers, thus moisture loss from the product could be delayed until the moisture contained within the chitosan coating had been evaporated. Chitosan treatment was effective in reducing drip loss and prolonging the shelf life of sardine as reported for cod fillets by Jeon et al. (2002) and Mohan et al., (2012). Increasing drip loss was also reported for catfish (Mohan et al., 2012), mackerel and Japanese sardine (Hamada-Sato et al., 2002) and whiting, mackerel and salmon fillets (Fagan et al., 2004) with the storage period.

The antimicrobial properties of chitosan coating have been reported in the literature (Jeon et al., 2002; López-Caballero et al., 2005). Jeon et al. (2002) described how bacterial growth (total counts on plate count agar at 20ºC) reached the stationary phase in all chitosan-coated cod and herring samples after 6 days, and also how there was a reduction of up to three log cycles between coated samples and controls after 12 days of chilled storage. López-Caballero et al. (2005) reported that a coating consisting of a blend of chitosan dissolved in acetic acid and gelatine exerted an inhibitory effect on the gram-negative flora of fish patties. Various factors affect the antimicrobial action of chitosan and its mechanism of action appears to be related to interactions between the positively charged chitosan molecules and the negatively charged microbial cell membrane (Shahidi et al., 1999) as well as to its function as a barrier against oxygen transfer (Jeon et al., 2002). Günlü & Koyun (2013) stated that the shelf life of chitosan coated sea bass fillets was prolonged approximately 20 days under chilled conditions (4±1°C). Similarly, chemical and microbiological quality of chitosan coated vacuum packed and high pressure processing (HPP) applied rainbow trout fillets were determined under chilled conditions (4±1 °C). Application of these two methods prolongs the shelf life of the fillets up to 24 days (Günlü et al., 2014).

Table 2. Application of edible coatings to improve the quality of seafood products

Hydrocolloid	Seafood	Effect	Reference
Alginate coating	Hot-smoked rainbow trout	The shelf life and acceptability of the vacuum packaged hot smoked rainbow trout fillets with a coating containing 3% sodium alginate were extended at least for 3 weeks compared to the control samples.	Erkan & Yeşiltaş, 2014
Protein based coating	Sea bass	Shelf life of approximately 9 and 10 days for control and soy protein, whey protein, 13 days for egg powder, zein, gelatin, 24 days for collagen, 28 day for wheat gluten, 29 days fish protein coating	Erkan et al., 2013
Protein based coating	Hot-smoked rainbow trout	Soy protein isolate, corn zein, collagen, fish protein coatings obtained from trout and Bonito were not reached to up 7 log cfu/g during 8 weeks according to microbiological analysis results	Dursun, 2012
Chitosan coating	Sea bass	Chitosan-based coating significantly reduced TVB-N and TMA-N values and inhibited the growth of psychrotrophic and mesophilic aerobic bacteria during cold storage.	Günlü & Koyun, 2013
Chitosan coating	Sardine	Shelf life was extended to 30 days during cold storage.	Mohan et al., 2012
Sodium alginate coating	Sea bream	Coating treatments predominantly reduced chemical spoilage, reflected in TVB-N, pH, and TBA, retarded water loss.	Song et al., 2011
Alginate coating	Cold smoked salmon	Approximately 2 log lower than the bacterial load of salmon fillets at the end of storage (30 day).	Neetoo et al., 2010
Chitosan coating	Silver carp	Total aerobic mesophilic counts decreased and shelf life was extended to 30 days during frozen storage.	Fan et al., 2009
Alginate–calcium coating	Northern snakehead fillets	Alginate–calcium coating treatments efficiently enhanced the quality of northern snakehead fillets during storage.	Lu et al., 2009
Chitosan coating	Herring, cod	Reduced lipid oxidation, and microbial growth was observed. Moisture loss was prevented.	Jeon et al., 2002

Table 3. Application of antimicrobial edible films and coatings to improve the quality of seafood products

Antimicrobial	Hydrocolloid	Seafood	Effect	Reference
Oregano essential oil	Potato peel waste-based edible films	Cold-smoked salmon	*Listeria monocytogenes* was inhibited.	Tammineni et al., 2013
Thyme oil	Gluten	Hot-smoked trout	According to sensory analysis the shelf life of vacuum packaged samples were found acceptable quality during 3 weeks. The sensory quality was maintained up to 5 and 6 weeks for gluten and containing antimicrobial agent (thyme oil) gluten coated samples. The growths of microorganisms were significantly reduced in gluten film coated samples.	Akçay, 2012
Chitosan	Chitosan	Herring, cod	Reduced lipid oxidation, and microbial growth was observed. Moisture loss was prevented.	Mohan et al., 2012
Thyme oil	Sodium alginate	Hot-smoked trout	Shelf-life of samples, as determined by overall acceptability sensory scores, microbiological data and chemical analysis result, is 2 week for control samples, 5 week coated samples.	Yeşiltaş, 2012
Cinnamon oil	Chitosan	Rainbow trout	Successful inhibition of lipid oxidation and microbial growth was obtained; shelf life was extended compared to the control group 4 days at 4°C.	Ojagh et al., 2010
Chitosan	Chitosan	Silver Carp	Total aerobic mesophilic counts decreased and shelf life was extended compared to the control group 30 days during frozen storage.	Fan et al., 2009
Chitosan,	Chitosan, chitosan – starch	Salmon	Microbial growth of aerobic mesophilic and psychrotrophic decreased and global quality was extended to 6 days at 2°C.	Vásconez et al., 2009
Oyster and lisozyme, nisin	Calcium alginate	Smoked salmon	Microbial growth was delayed.	Datta et al., 2008
Oregano and rosemary extracts	Gelatine, gelatin – chitosan	Cold-smoked sardine process by high pressure	Microbial growth and lipid oxidation was decreased.	Gómez-Estaca et al., 2007
Lactoperoxidase system	Whey protein	Cold-smoked salmon	*Listeria monocytogenes* growth was prevented.	Min et al., 2005
Thyme oil, cynamaldehyde	Soy and whey protein, carboxy-methyl cellulose	Cooked shrimp	Microbial growth was delayed.	Ouattara et al., 2001

Alginate is a salt of alginic acid, a polymer of D -mannuronic acid and L -guluronic acid, and is isolated from brown algae (Lu et al., 2009). Alginate has unique colloidal properties. Such biopolymer-based films can keep good quality and prolong shelf life of foods by strengthening the water barrier, preventing microbe contamination, maintaining the favour, reducing the degree of shrinkage distortion and retarding fat oxidation. Studies have shown that coating of fish, shrimp, scallop and pork with sodium alginate showed that it can prolong their shelf life, reduce thawing loss, cooking loss, weight loss and maintain the functional properties of these species during cold and frozen storage (Wanstedt et al.,, 1981; Wang et al., 1994; Zeng & Xu, 1997; Yu et al., 2008). According to Song et al. (2011) fresh sea bream (*Megalobrama amblycephala*) were coated with alginate and stored at 4°C for 21 days. Coating treatments predominantly reduced chemical spoilage, reflected in TVB-N, pH, and TBA, retarded water loss and increased the overall sensory quality of fish compared to uncoated sea bream. Lu et al. (2009) studied Northern snakehead fillets (*Channa argus*) which were separated into samples untreated (control), or were treated with 1000 IU mL^{-1} nisin and 150 µg mL^{-1} EDTA (group 1), alginate–calcium coating (group 2), or alginate–calcium coating incorporating 1000 IU mL^{-1} nisin and 150 µg mL^{-1} EDTA (group 3). Compared with the control, all treatments significantly inhibited the growth of mesophilic and psychrophilic bacteria in northern snakehead fillets during the storage period. Group more efficiently inhibited the growth of mesophilic and psychrophilic bacteria than did the group 2 and group 3 treatments. A few antimicrobial agents and antioxidant have been incorporated into edible coatings to suppress quality changes during storage (Kang et al., 2007; Fan et al., 2008; Chidanandaiah et al., 2009). The research results regarding to edible coatings are presented in table 3. In accordance with results of the conducted studies chemical, microbiological and sensory quality of the chitosan coated sea foods could be enhanced while stored in ice or refrigerated conditions. By taking into account the advantages of the edible films such as being proper for human consumption, not requires high technologies, harmless for the environment, low cost for the production and sequestering agent, this material is being popular in food science field, particularly seafood processing technology area. On the other hand, low mechanical strength, highly effectiveness from the environmental conditions (i.e. drying) making the usage of edible films more complex in seafood. However, the most significant disadvantages of the edible films are being the difficulties during preparation and application process and the increased effects on workload and the cost of the final product.

Conclusion

Plant extracts, essential oils and edible film coating treatments are proven to extend the shelf life of seafood by the use of natural sources. The potential effects of these treatments are delayed lipid oxidation, inhibited microbial growth and enhanced sensorial properties. Due to their antimicrobial and antioxidant properties, plant extracts and essential oils are promising their use instead of synthetic chemicals. Edible films and coatings also offer advantages over plastic packages such as edibility, biodegradability, biocompatibility, aesthetic appearance and barrier properties, besides being nontoxic and non-polluting. For the protection of natural sources and providing safe food to the future generations, there are further studies needed for the investigation of minimally processed and additive free seafood and its products.

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