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Review Article

An overview of some of the packaging methods for fish

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ABSTRACT

Food packaging is necessary for storage, suitable distribution and maintaining the quality. Fish has a high nutritional value and their consumption is highly recommended. Per capita consumption of fish is low in Iran. This is due to factors such as lack of access to high quality and fresh fish and supplied of without packaging or improper packaging. Marine products are more susceptible to spoilage than other meat products. Packaging is one of the most common and easy methods to maintain the freshness of fisheries products from the catch to consumption. There are different methods for packaging of fish and its products. Some of the methods such as modified atmosphere packaging (MAP) and vacuum packaging are widely used for fisheries products. MAP has become a popular method for packaging of foods as it can extend the shelf life of food. One of the new methods of seafood packaging is the edible films and coating. Edible films and coatings are thin layers which are used both in surface and in between the various layers of food. In this paper, three common packaging methods of seafood i.e. MAP, vacuum packaging and edible films and coatings are reviewed.

Keywords: Edible coating; Fish; MAP; Packaging; Shelf-life.

1. Introduction

Fresh fish may provide a higher quality and nutritious source of protein but this has been facing problems in terms of quality and distribution. Therefore, providing solutions to maintain the quality and systematic distribution of fresh fish is required. In other words, we must find ways to store and transport fresh fish in order to maintain its quality for a longer period and offer it to the remote regions where there is no possibility of farming and production (Mendes & Gonçalves, 2008).

Seafood due to their high protein content, fat-soluble vitamins and omega-3 polyunsaturated fatty acids, which are important in human diets, have attracted much attention (Pérez-Alonso *et al.*, 2004). Seafood products are perishable and are usually spoiled faster than other meat products. Flesh of seafood is susceptible to changes more than other meats, after death. This may be due to different composition of seafood and other meats (Stamatis & Arkoudelos, 2007; Hosseini *et al.*, 2013; Gringer *et al.*, 2015). Fish spoilage occurs through biological reactions including autolysis, lipid oxidation and activity of microorganisms (Gobantes *et al.*, 1998). Fish spoilage rate depends on the quality of primary and storage conditions. Factors such as temperature storage, processing and packaging are the most important factors in the shelf-life of seafood (Moini *et al.*, 2009; Alikhani Chamgordani *et al.*, 2024).

Packaging is a protective method that maintains the quality of goods from production to consumption. Packaging protects the product against climatic changes, injuries, damages, humidity, vibration, odors, pressure, microorganisms and insects (Farjamia & Anoosheha, 2015).

Some common packaging method in the seafood industry include packaging in plastic, glass, metal, modified atmosphere packaging, vacuum packaging, packaging with edible coating, etc. Packaging is the simplest method that can be used from the earliest stage (mean catch) to the consumption. Therefore, it seems necessary to investigate the packaging of fish and marine products and the advantages and disadvantage of these methods. The aim of this study is to review some conventional packaging in aquatic products (Farshbaf Aghajani *et al.*, 2023).

2. Modified atmosphere packaging (MAP)

Modified atmosphere packaging (MAP) is used as a supplement to traditional storage method and will be long term food storage (Arritt *et al.*, 2007). Usually, MAP packaging gases include oxygen (O_2), carbon dioxide (CO_2) and nitrogen (N_2). The proportions of each gas are established, the mixture is introduced into the packaging and no further control is carried out during storage (Silliker & Sk, 1980). Combination gas in MAP packaging depends on the type of food product (Velu *et al.*, 2013). MAP packaging has an important role in increasing the shelf life of susceptible foods to spoilage at refrigerator temperature (Parry, 2012). Reason of this is the effect of CO_2 gas to inhibit the growth of spoilage bacteria (Maqsood & Benjakul, 2010; Provincial *et al.*, 2010). The role of O_2 is inhibition of the growth of absolute anaerobic bacteria (Rutherford *et al.*, 2007). In food presenting high moisture and/or fat amounts, such as fish, beef and poultry, the excessive absorption of CO_2 may lead to a phenomenon known as "packaging collapse" (Parry, 2012). Increase in dripping is caused by the dissolution of gases on the muscles surface in atmospheres containing high CO_2 levels (>60%), reduced pH and, consequently, low protein water retention ability (Randell *et al.*, 1995; Parry, 2012; Farshbaf Aghajani *et al.*, 2024).

The presence of oxygen may cause oxidative rancidity problems in fish presenting high lipids amounts, promoting the formation of low molecular weight aldehydes, ketones, alcohols and carboxylic acids. Thus, the use of O_2 in modified atmospheres is generally avoided with this kind of fish, in order to minimize such effects. Davies and Slade (1995) stated that there are evidences showing that the use of O_2 reduces the exudation in fish during storage. In addition, other factors such as the characteristics of packaging and fish species are effective on the shelf life of product (Otwell *et al.*, 2008). As a consequence, high CO_2 concentrations promote organoleptic changes as, for example, texture alterations in meat. N_2 can be used as an inert gas in smaller proportions than CO_2. Nitrogen has low solubility in water and has no taste, color and odor. Nitrogen plays a role in delaying oxidative rancidity and inhibiting aerobic bacterial growth. However, it is not capable in inhibiting anaerobic bacterial growth. The oxygen can also be employed, providing fish does not undergo color alterations (Cann *et al.*, 1983). Although studies have shown that the MAP packaging increases the shelf life of seafood, but given that the composition of fish and storage conditions in different regions and seasons, therefore the combination of these gases and their effects in order to achieve optimum condition are different. Hence, to achieve the best condition for longer storage and delivering safe product to consumers is necessary (Otwell *et al.*, 2008). Özogul *et al.* (2004) had investigated the effect of MAP (CO_2/N_2: 60/40) on total viable count and histamine forming bacteria count in sardines (*Sardina pilchardus*) kept at 4°C. The outcome illustrated the lowest total viable count (TVC) in MAP compared to vacuum packaging and air.

3. Vacuum packaging

Vacuum packaging is a suitable way to retard the spoilage of marine products which increases the shelf life and preserving the quality of fish for longer duration. Exhaust of O_2 of this package not only will be delaying microbial spoilage, but also delay the non-microbial spoilage of product. Thus this method increases the shelf life of meat products and preserves their quality and freshness during storage (Sahoo & Kumar, 2005). The gaseous atmosphere of the vacuum packaging is reduced, but it is probably altered during storage, thus considered modified due to a 10 to 20% increase in the CO_2 amount produced by microbial activity. This CO_2 may inhibit the growth of undesirable microorganisms (Silliker & Sk, 1980). It is reported that, the solubility of produced CO_2 in muscles has stabilizing effect on the pH in this packaging. Therefore, it prevents the increase of the volatile nitrogenous compound and produced ammonium by bacteria that effect on the pH (Mendes & Gonçalves, 2008). Farjamia and Anoosheha (2015) investigated the effect of vacuum packaging on the properties of chemical, microbial and sensory of *Rutillus frisii kutum*. Their results showed that the vacuum packaging increases the shelf life and preserves chemical, microbial and sensory quality of fish fillet on the ice. Özogul *et al.* (2004) investigated the effect of MAP and vacuum packaging on the chemical, microbial and sensory changes of *Sardin pichardus*. Their results showed that the bacteria had the fastest growth in stored sardine in combination with normal air and the lowest count of bacteria occurred in the MAP with gas mixture (40% N_2 and 60% CO_2). Kosak and Toledo (1981) studied the combination of a chlorine solution (1000 mg/mL free chlorine) with vacuum polyethylene packaging for mullet (*Mugil cephalus*) stored at −2 °C. All treatments were organoleptically acceptable up to 14 days of storage.

4. Edible films and coatings

Nowadays, pollution of synthetic polymers has focused public attention on the use of biodegradable material. During the past two decades, the application of biodegradable material from the protein and carbohydrates has been widely studied. These macromolecules can potentially be used as an alternative to synthetic polymers from petroleum derivatives (Ghanbarzadeh *et al.*, 2007). Edible biodegradable packaging are divided into two categories of edible films and coatings (Ghanbarzadeh & Oromiehi, 2008). Edible films are produced as a thin layer before use in food packaging and used as synthetic polymers for packaging (Ghanbarzadeh *et al.*, 2006). Films can be created as a wrapper, capsule and bags. These products are molded thick. Unlike films, edible coatings are formed on the food. Therefore, the coating is part of the product and remains on the product in using time. This can be done by methods such as polish, spray and immersion (Ghanbarzade et al., 2007). Various edible coatings of polysaccharides, proteins and fats can increase the shelf life of food products and play a key role as barrier against the transfer of moisture, gases and dissolved substances. These coatings due to their biodegradable characteristic have a lot of popularity among consumers and can be used as an alternative to the existing plastic material in the packaging industry (Wang *et al.*, 2010). Numerous studies have been conducted on the application of edible films and coatings for packaging and storage of aquatic products. (Mohan *et al.*, 2012) investigated the effect of chitosan film on the quality of *Sardinella longiceps*. Their results showed that the sensory quality was maintained during storage. Also, the microbial growth, oxidation of lipids, total volatile nitrogen bases (TVB-N), drip and water-holding capacity were reduced. Soares *et al.* (2013) studied the effect of chitosan coating and glazing on the salmon fish. Results showed that this coating controlled the lipid oxidation and microbial growth. Also, chitosan and glazing increase the shelf life and decrease drip. Chitosan has antioxidants (López-Caballero *et al.*, 2005), antimicrobial properties (Jeon *et al.*, 2002) and ability to connect (Shahidi *et al.*, 1999). The antioxidant effect of chitosan is due to amine groups of chitosan that constitute a stable compound with volatile aldehydes such as malondialdehyde (Weist & Karel, 1992; Shahidi *et al.*, 1999). Also, the chitosan can reduce lipid oxidation by chelating the Fe^{2+} ions present in fish protein. Therefore it eliminates the peroxidation activity by converting to the Fe^{3+} (Jeon *et al.*, 2002). Several factors affect the antimicrobial action of chitosan (Cuero, 1999). Some of these factors are the reaction between the molecules of positively charged of chitosan and negatively cell membranes of microbes (Shahidi et al., 1999). Also, chitosan is a barrier against O_2 (Jeon *et al.*, 2002). In addition, the antimicrobial effect of chitosan related to the elimination of the lipopolysaccharide of outer membrane of Gram negative bacteria (Nikaido, 1996; Helander *et al.*, 2001). Rodriguez-Turienzo *et al.* (2011) examined the whey protein concentrate on the *Salmo salar*. This coating reduced the lipid oxidation, microbial growth and drip and preserved the sensory quality of fish. Franssen *et al.* (2004) indicated that the whey protein has excellent protective properties against O_2. In study of Hasanzati Rostami *et al.* (2010), reducing the amount of peroxide in Kilka covered with the whey may be due to the protective properties of whey against O_2. Khanehdan (2011) investigated the effect of sodium alginate film on the Kilka. The results showed that total number of bacteria of fish reduced. Alginate has antioxidant properties, antimicrobial and protection against penetration of water vapor. Song *et al.* (2011) reported that alginate plays the role of a barrier against O_2 transfer and prevents the growth of aerobic bacteria. It also delays the lipids oxidation. Alginate has gel-forming properties. Thus, it produces a semi-permeable layer and traps the microorganisms, effectively. Khanehdan (2011) concluded that should be used in the lipid-based materials in combination with sodium alginate film to prevent the loss of moisture in stored Kilka in the freezer (Dehghani *et al.*, 2018).

5. Conclusions and perspectives

Consumer demand for MAP has increased due to its technical opportunity with a significant effect in extending the shelf life of fishery products, providing good quality food products, and avoiding or lessening usage of chemical preservatives. The use of MAP can delay the growth of many spoilage microorganisms and inhibit their toxin production. Vacuum packaging effectively controls the production of volatile nitrogenous base but cannot control the lipid oxidation during storage in ice. According to previously researches, vacuum packaging in comparison with packaging in normal conditions can maintain the quality and freshness of fish in longer term (Moini *et al.*, 2009).

Biopolymers such as polysaccharides, proteins and lipids are used to produce edible films and coatings. Some of the properties of edible films and coatings include preventing migration of moisture and exit of volatile compounds of food, delaying of dehydration, a barrier against microbial growth, lipid oxidation and drip and protecting the quality of marine products against physical damage. There are several materials that are used to produce edible films and coatings but, more studies are needed to improve the production methods of films and their applications in aquatic food packaging (Hosseini *et al.*, 2009; Bahmani *et al.*, 2011; Dehghani *et al.*, 2019).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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