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Innovative Seafood Preservation Methods and their Recent Developments

Ulaganathan Arisekar
Assistant Professor, Department of Fish Quality Assurance and Management, Fisheries College and Research Institute, TNFU, Thoothukudi, Tamil Nadu

SUMMARY
Riding high in a wave of quest technological developments have influenced fish and fishery products. Nowadays, fresh fishes and seafood products of good quality and safety have high demand in the market. Since they are easily prone to spoilage they should be preserved with high regard.Traditionally, the methods used to extend the shelf-life of fish products include fermentation, smoking, salting, and marinating, or thermal treatments such as chilling, refrigeration, freezing, drying, boiling, steaming, etc. However, all these techniques are associated with undesirable changes, from a reduced nutritional value to worsened sensory attributes, which fight against the increasing demand of consumers for minimally processed foods with high quality. Thus, in recent years some alternative methods have been proposed as innovative processing technologies able to guarantee an extension of shelf-life while minimally affecting their organoleptic properties. These ideas have paved way for this article which discusses the innovative seafood processing technologies used for the preservation and prolonged shelf life while ensuring the safety of the sea food products and also the spoilage mechanisms.

INTRODUCTION

Seafood is any form of sea life regarded as food by humans, prominently including fish and shellfish. It includes molluscs, crustaceans, and echinoderms. Composition of fish is basically composed of water, lipid, and protein which create the nutritional value, functional aspects, and sensory characteristics of the flesh. The fish contains vitamins and minerals playing an important role in post-mortem biochemical changes. The knowledge of the chemical composition of marine species is of fundamental importance in estimating the quality of the raw material, storage stability and application of technological processes. Muscle protein of seafoods are nutritionally valuable and easily digestion with a well-balanced amino acid composition. They are rich in polyunsaturated fatty acids with a higher unsaturated lipid content. The crude protein contents of seafood generally vary between 11% and 28.4% and the content of the lipid in muscle tissue is inversely related to its moisture content. While the amount of fat-soluble vitamins in seafood is higher than those in land animals depends to a large extent on the species whereas the content of water-soluble vitamins in seafood is less dependent upon the species. The content of minerals in seafood is slightly higher than those in terrestrial animals. Fish muscle tissue contains less connective tissue than mammalian muscle. Fish muscle is made of short segments called myotomes. Such fibers are separated by sheets of connective tissue known as myocommata. This is mainly responsible for the flaky texture of fish flesh.

Seafood spoilage

Spoilage of seafood could be a result of microbial activity,autolysis, or chemical oxidation. Microbial activity constitutes more spoilage than others.Spoilage bacteria are commonly gram-negative and produce off odor and flavour in food as a result of their metabolic activity.Dominant spoilage microorganism which causes off-orders include *Photobacteriumphosphoreum*,*Psuedomonas sp* and *Shewanella putrifaciens.*Storage temperature,handling and packaging conditions affect microbial growth and thus the shelf life of the seafood.Spoilage bacteria have the quantitative ability to produce microbial metabolites like trimethyl amine,biogenic amines, or volatile amine in products.More specifically,fish spoilage can be attributed to post-mortem enzymic autolysis,microbial growth, and oxidation of lipids.

Autolytic spoilage

Post-mortem changes occur in fish due to the activity of autolytic enzymes.The endogenous enzymes in fish muscle are responsible for the initial loss of freshness.Inside the fish, many anaerobic processesare activated among them glycolysis is more important which results in the reduction of pH.Reduction in pH can interfere with the structural properties of proteins and enzyme activities in the muscle resulting in the lower water-holding capacity of proteins,texture of fish flesh,colour change etc.Autolytic enzymes of muscle and visceral organs can drive proteolysis during the processing and storage of whole fish,leading to protein decomposition and solubilization.Such degradation also produces peptides and free amino acids via autolysis of fish muscle proteins as well as biogenic amines through the action of decarboxylase leading to spoilage of fish meat. The freshness of fish is indicated using the K value.K value is based on ATP breakdown and subsequent formation of its by-products.The K value measures how far ATP degradation has occurred within the tissues.

Microbial spoilage

Microorganisms are the major cause of spoilage of most seafood products and it results in the formation of amines,sulfides,ketones,aldehydes,alcohols and organic acids with unpleasant and unacceptable odours.Majorly 25% of all food produced is exploited due to microbial spoilage.Unpreserved fish are spoiled as a result of the growth of gram-negative, fermentative bacteria*(Psedomonas spp and Shewanella spp)*.It is therefore important to distinguish between nonspoilage microflora and specific spoilage organisms as they are responsible for fish spoilage.TMA is used as an indicator to determine the extent of spoilage which is formed by the reduction of TMAO(Trimethyl amine oxide).

Lipid oxidation

Lipid oxidation has been deeply studied in the course of the past recent decades, and its complex mechanisms, kinetics, and products are now to a large degree well established. As reported by Schaich (1992), mechanisms frequently proposed are based on kinetics, usually a prerequisite of either oxygen consumption or appearance of peroxides (indicated as peroxide value, PV), malondialdehyde (MDA, expressed as thiobarbituric acid reactive substances, TBARS), free fatty acids (FFAs) and/or volatile compounds, therein assuming standard radical chain reaction sequences. Lipid oxidation indeed is a very important event leading to the quality of foods, especially those containing highly unsaturated fats. Quality losses, production of unpalatable flavor and odour, shortening of shelf life, losses of nutritional values (e.g. loss of polyunsaturated fatty acids, PUFAs) and possible production of unhealthy molecules are some of the extensive consequences of lipid oxidation in foods. Fish lipid differs from mammalian lipid. The main difference is that fish lipids include up to 40% of long-chain fatty acids (14–22 carbon atoms) which are highly unsaturated. Mammalian fat will rarely contain more than two double bonds per fatty acid molecule while the depot fats of fish contain several fatty acids with five or six double bonds.

Innovative seafood preservation methods

Natural preservatives

Fresh fish is highly perishable, and even if it can be refrigerated or frozen to extend its shelf life, these processes may not be sufficient to prevent lipid oxidation, rancidity or bacterial growth. In most cases, it is also necessary to improve the quality of fish. For this reason, it is required that preservatives should be properly added to fish during storage.Natural preservatives generally come from three sources: microorganisms, animals, and plants. In addition, various bio-active compounds extracted from algae, mushrooms, and so on can also provide a potential source of new natural preservatives in the food industry.

Organic acids

Organic acids extend the shelf-life of fish while investigating the quality attributes such as sensory, peroxide values, pH, and microbial loads of the fish fillets during 9 days of refrigerated temperature storage (40C). Acetic acid and ascorbic acid are found to have strong antibacterial activities against different microorganisms. Fish fillet samples were treated with alone or in combination with acetic acid and ascorbic acid spray while keeping one group of fish fillets untreated. Total Viable Count (TVC) was found greater in the samples kept untreated and treated alone with acetic acid and ascorbic acid. However, fish fillets treated with acetic acid and ascorbic acid in combination were reported with a lesser number of microbial counts. Moreover, Peroxide Value (PV) and pH were significantly lower in the sample treated with in combination of acetic acid and ascorbic acid. Sensory analysis revealed that fish fillets treated with combined treatment had better quality retention at the end of 9 days storage period. The findings suggest that the application of acetic acid and ascorbic acid alone or in different combinations have the potential to decrease microbial loads while facilitating the shelf-life of fish fillets during the 9 days of refrigerated temperature (40C) storage period.

Essential oil and plant/algal extracts

The short shelf-life of fresh seafood is a practical issue in industries and distribution chain systems. Short shelf-life caused by chemical and microbial spoilage reactions can be stopped by traditional preservation methods but there is increasing interest in natural preservation methods. EOs are natural antioxidants and antimicrobials by which the shelf-life of seafood can be extended alone or in combination with other techniques. However, the reduction of the antimicrobial effect of EOs in a food system due to some components of food and also the reverse action of EOs as antioxidant agents in some cases has slowed down their use of them in practical systems.

Combination of EOs exhibit the synergistic antimicrobial activity. Thus, using of EOs in packaging can be a safe approach to food preservation technology. The antimicrobial activity of gelatin-chitosan films incorporated with oregano essential oil exhibited a great inhibitory effect by reducing the *E. coli, S. aureus, B. subtilis* and *B. enteritidis* growth. Its inhibition zone was larger for Gram-positive bacteria compared with Gram-negative bacteria. \\\It seems the high percentage of carvacrol, eugenol, and thymol as phenolic components are responsible for this antimicrobial activity by damaging the cell membrane or interferingwith the enzyme functionality located on the cell wall. Moreover, the TVB-N value of the sample packaged with the gelatin-chitosan-EOs film was lower compared with the control and the shelf life of grass carp muscle packaged with the film containing EOs was extended to 12 days. The same observation was gained from the gelatin-chitosan film incorporated with other EOs including clove, fennel, cypress, lavender, thyme, herb-of-cross, pine, and rosemary for cod fillet preservation. Among all EOs, the high antimicrobial effect was obtained from clove against a wide range of food pathogen and spoilage bacteria such as *Salmonella, Lactobacillus, Listeria, Citrobacter, Escherichia, Yersinia, Brochothrix, Staphylococcus, Bacillus, Listeria, Clostridium, Aeromonas, Shewanella, Vibrio,* and *Photobacterium*. In addition, the film containing the clove essential oil used for the preservation of cod fillets, lowered the microorganisms in particular, Enterobacteria. Further, by delaying the formation of TVB-N, can extend the shelf life of chilled stored fish.

Biopreservation

Biopreservation is a powerful and natural tool to extend shelf life and enhance the safety of foods by applying naturally occurring microorganisms and/or their inherent antibacterial compounds of defined quality and at certain quantities. In this context, lactic acid bacteria (LAB) possess a major potential for use in biopreservation because most LAB are generally recognized as safe, and they naturally dominate the microflora of many foods. The antagonistic and inhibitory properties of LAB are due to different factors such as the competition for nutrients and the production of one or more antimicrobially active metabolites such as organic acids (prevailingly lactic and acetic acid), hydrogen peroxide, and antimicrobial peptides (bacteriocins).

Chitosan

Chitosan as a natural preservative has been used to extend the shelf life of whole fish, fish fillets, shrimp, and chicken meat which are used as a coating and antibacterial agent. Chitosan is polyelectrolytic, non-toxic, can react with other organic substances such as protein, and is easily biodegradable. The properties possessed by chitosan so that it can be used as a preservative, namely that it can inhibit the growth of destructive microorganisms, chitosan also coats preserved products or coatings, so that there is minimal interaction between the product and the environment Protein food ingredients are generally decomposed by anaerobic bacteria that cause "putrefaction" or putrefaction. This putrefaction is caused by the breakdown of proteins by proteolytic enzymes. Proteins are broken down into amino acids and subsequently into compounds containing sulfur and nitrogen with low molecular weight such as mercaptans, hydrogen sulfide, ammonia, and amines which cause foul odours . The compounds in chitosan that play a role in its application as preservatives and color stabilizers are the presence of amino reactive groups and hydroxyl groups. Chitosan has an active group that binds to microbes, so chitosan is able to inhibit microbial growth. a preservative because it contains the enzyme lysozyme and aminopolysacharida groups. Chitosan can interact directly with the cell membrane so that it disrupts membrane permeability and causes leakage of cell protein material. In addition, chitosan also has a very strong affinity with microbial DNA so that it binds to DNA which then interferes with mRNA and protein synthesis. The positive charge of the NH_3 + group on chitosan can interact with the negative charge on the surface of the bacterial cell. Any damage to the cell wall results in weakening of the cell wall strength, the shape of the cell wall becomes abnormal, and the pores of the cell wall become enlarged. This results in the cell wall being unable to regulate the exchange of substances from and into the cell, then the cell membrane becomes damaged and undergoes lysis so that metabolic activity will be inhibited and, in the end, it will die.

With these properties, chitosan can inhibit bacterial growth so that it can be used as an antimicrobial. Chitosan also functions as a chelating agent that can bind trace elements and essential nutrients for microbial growth. In addition, chitosan is also thought to have a function as a cryoprotectant. Cryoprotectants are used to slow protein denaturation and are also used to protect cells from slow cooling in the event of a solution effect that can damage cell structure.

Non-thermal atmospheric plasma (NTAP)

NTAP technology has been widely used for the preservation of various food products, such as meat and fresh agricultural products, while its use in fish and seafood is still limited. The effectiveness of this technology obviously depends on many factors, such as voltage, frequency, treatment time, working gas composition (WGC), post-treatment/exposure time, and sample surface area. The type and concentration of reactive species (RESPE) produced, such as reactive nitrogen species (RNS) and reactive oxygen species (ROS), including ozone, peroxide, singlet oxygen, and different types of nitrogen oxides (NxOy), are mainly responsible for the inactivation of microorganisms and depend on the above parameters.

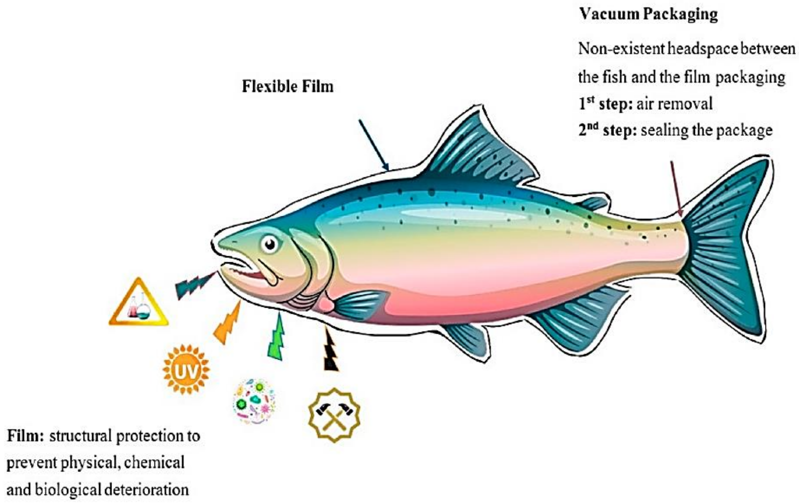

Figure 2 .NTAP technology for extending the shelf life of fish

Electrolyzed water

Among the relatively new proposals, electrolytic water (EW) is attracting interest as a non-thermal technique in the food industry and agriculture. Similar to all the innovative methods mentioned above, EW is safer and more effective than traditional chemical agents, to which microorganisms are becoming increasingly resistant. In fact, it is considered as a new non-thermal and environmentally friendly sanitizer.The antimicrobial activity of EW has been widely demonstrated against various food-borne microorganisms, such as *Pseudomonas aeruginosa , S.aureus , E.coli O157:H7 , S. Typhimurium , L.monocytogenes and V.parahaemolyticus* .

It is also effective against spores, fungi and viruses present in food, environment, and food processing plants. The antimicrobial activity and mechanism of action of EW against bacteria are not yet been fully described. However, it is known that chlorine and active oxygen can break down the microbial cell membrane.

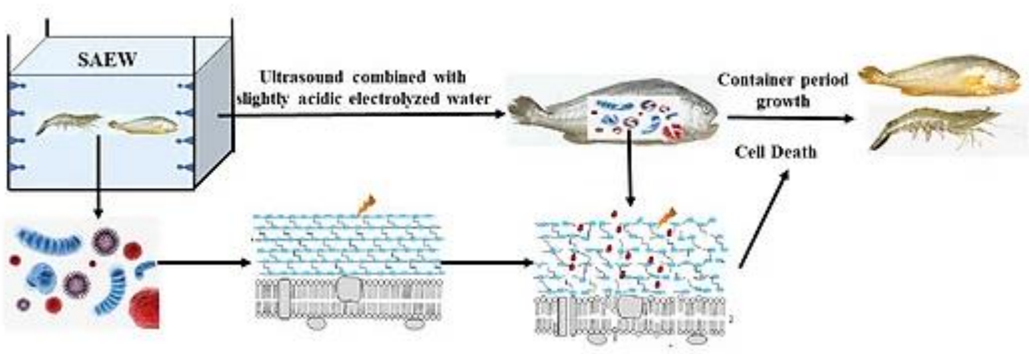

Figure 2. Electrolysed water used for seafood preservation

CONCLUSION

Here, we have presented a short overview of several novel seafood preservation interventions along with the effect they have on bacterial cells, seafood quality, and possible hazards. The purpose of an optimal preservation method should be counteracting the causes of food deterioration and maintaining its chemical (its composition), physical (its condition), organoleptic (taste, smell and colour), and nutritional (presence of proteins, fats and carbohydrates, vitamins, mineral salts, and water) properties. Therefore, besides traditional preservation methods, the great challenge of modern food technology is to develop less aggressive preservation processes, which keep the product 'natural', although with a lower shelf-life.

REFERENCES

Jennifer Ronholm,Fiona Lau,and Banerjee. 2016.Emerging Seafood Preservation Techniques to Extend Freshness and Minimize Vibrio Contamination.

Advances in Processing and Preservation Techniques to Produce Safe Seafood Products, https://www.frontiersin.org/research-topics

Hultion, 2011. Oxidation of lipids in seafoods,Chapter 727

Michael G Kontominas, Anastasia V Badeka, Ioanna S Kosma and Cosmas I Nathanailides. 2021. Innovative Seafood Preservation Technologies: Recent Developments,Pubmed