CHAPTER 7

SUMMARY AND CONCLUSION
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Seaweed has gained popularity and market shares in most of the countries due to being exotic, tasty, light and healthy. This trend has been questioned by another trend as consumers are becoming more aware of safety and food poisoning. Quality has increasingly included concern on safety and this has highlighted the importance of temperature effects on bacteria and their activities in fish and shellfish. Production of biogenic amines especially histamine, is both a spoilage and a safety concern, and much progress has been made in identifying the factors controlling the process and the bacteria which may be involved.

Indian mackerel as a fatty fish has all necessary proteins, vitamins and minerals in the desired proportion along with the high content of PUFA like EPA and DHA. Like any other fatty fishes, the commercial use of mackerel has been limited by the susceptibility of the fish to oxidative reactions. The presence of many pro oxidants in the muscle tissue of mackerel, especially in the dark muscle, accelerates the lipid oxidation process.

The present study describes the inhibitory effect of the selected spices viz rosemary, ginger, pepper and clove on the biogenic amine production in mackerel and also their role as a potent antioxidant source in the preservation of mackerel and its products. The thesis contains seven chapters.

Chapter 1 is an introduction about the importance of Indian mackerel, its value as a whole fish item and its area of distribution in the Indian Exclusive Economic Zone. It also deals with the various aspects of mechanism of lipid oxidation and the ways and means to prevent oxidation of fish. It also gives an account of the role of spices as antioxidant during the post mortem changes and the inhibition of biogenic amine formation.

Chapter 2 deals with a review of the antioxidant components of the selected spice ingredients. The spices selected for the study are rosemary, ginger, pepper and clove. This chapter provides information regarding the geographical distribution and description of these spices and the extraction methods of their active constituents and structures of the active antioxidants. It also deals with the procedures for isolation and fractionation of the various active ingredients present in the spices. There are 9 active ingredients of rosemary, and of them carnosol and carnosic acid are found to possess the antioxidant properties. Ginger has the active constituents, gingerols and shogals. Pepper has the effective constituent piperine; and in clove, the effective antioxidant is eugenol.
Chapter 3 deals with the study to assess the role of spices on chilled and frozen storage. It also deals with the two kinds of treatment methods, commonly practiced in the seafood industry namely, dip treatment and glaze treatment, at two different spice oleoresin concentrations (0.02% and 0.05%). The study was conducted to assess the antioxidant effect of these spices on treated samples of whole fish and fish products a synthetic antioxidant, BHA (0.02%) treated sample along with a control without any antioxidant. The various parameters analyzed are the peroxide value (PV), thiobarbituric acid value, heme iron content, met myoglobin content, and total heme pigments as acid hematin. The peroxide values of treated, chilled samples at 0.02% concentration, there was significant difference between treatments. The studies on the various parameters of the fat oxidation indices revealed that the samples treated with rosemary oleoresin gave lower peroxide values on chilled storage condition upto 12 days, confirming its antioxidant property.

On the whole, from the results of various lipid oxidation parameters of samples given, different treatments with spice extracts in comparison with a synthetic antioxidant, BHA and control samples, the spices used could be graded as Rosemary > Clove > Ginger > Pepper, for their antioxidant properties. Among the various pretreatments given as glaze and dip of whole fish and frozen stored at -18°C, the glazed samples with 0.02% spice treatment is found to be most effective. Fillets dip treated with 0.005% concentration and frozen stored gave the optimum results. In this case also, the antioxidant properties was maximum for rosemary followed by clove, ginger, pepper and synthetic antioxidants as confirmed by the TBARS and Peroxide values. The retention of heme iron, metmyoglobin and acid pigments were also maximum in rosemary treated samples followed by clove explaining the protective effect of the treatment in maintaining the colour and other textural profiles of the samples. The synthetic antioxidant treated samples on frozen storage gave low values of pigments compared to spice treated samples, showing a bleaching action and hence loss of sensory qualities. The fact that the active constituents of rosemary and clove can be made use of for effectively preventing oxidation, thereby maintaining the original characteristics of mackerel has been confirmed.

Chapter 4 deals with the analysis of the various parameters of texture profile in treated samples of mackerel. The whole mackerel was dip treated with two different concentrations of spices (0.02% and 0.05%) with dip time of 5 minutes and 10 minutes. The dip treated samples were cooked for 3 minutes, at three different temperatures of 45°C, 70°C and 100°C and cook loss was assessed.
Samples with 0.02% concentration dip treatment for 5 minutes, gave better results of springiness parameter of texture. Among the four spices, pepper showed a good result for springiness. Cook loss studies revealed that in samples cooked at 100°C, a higher cook loss than those cooked at 70°C. Though rosemary and clove showed good antioxidant properties, their contribution to textural parameters seems to be limited. Further work in the case of prolonged frozen storage, needs to be done so as to assess the effect of spices on textural parameters during frozen storage.

Chapter 5 deals with the role of spices in preventing the formation of biogenic amines in mackerel. Biogenic amine content of 0.05% oleoresin treated samples and kept at ambient temperature were analysed at three different time intervals of 4 hours, 9 hours and 20 hours. The quantitative determination of biogenic amines was performed using a Waters HPLC system and data analysis was performed using EMPOWER 2 chromatography software. The chapter also deals with the antimicrobial activity of the spices. The bacteriological analysis for both total plate count and histidine decarboxylating bacteria reveals that rosemary had the maximum inhibitory effect on bacterial growth; confirming its antimicrobial activity. It was further observed that, after a certain period (9 hours), the amine level showed decrease in all the treated samples, which may be due to the amine oxidase activity of bacteria. The present study confirms to the earlier published work, highlighting the strong antimicrobial activity of rosemary. Biogenic amines index as a sum of putrescine, cadaverine and histamine determined by a simple method carried out in this work could be effectively employed for the early detection of quality deterioration, as well as for the evaluation of acceptable stage for mackerel. Determination of biogenic amines using the methods developed in the study can be applied to other fish products as part of quality assurance methods.

Chapter 6 deals with value added and dried products of mackerel incorporated with spice extract. The study revealed the strong antimycotic activity clove; while rosemary showed a strong antioxidant activity. The treated samples were stored at room temperature and at 15°C. The spice treated sample at 15°C showed better organoleptic qualities. Peroxide values of the control samples kept at 15°C were comparatively lower than that at room temperature. All treated samples had lower value than control. The samples treated with rosemary had lower values when compared to control. This again highlights the antioxidative role of the spices in dry products. While comparing the effect of treatment of the sample, clove had recorded a minimum TBA value after a storage period for eight weeks. Studies also showed that there is an increase in TBARS for samples stored...
at room temperature than those stored at 15°C. This reinforces the effect of temperature control on 
the quality of dried stored fish. form.

Of all the spices used in this study rosemary and clove have shown to be the most effective natural 
antioxidants on salt cured fish. As there is great demand for seafood and seafood based products, 
large number of diversified and ready to eat products can be prepared from low priced fish like 
mackerel by incorporating proper additives of natural origin. To popularize the products, this 
technology can be extended to society for gainful employment of women. Taking into consideration 
health aspects involved by the use of synthetic antioxidant, the qualities of rosemary has to be 
popularized for preparing value added products.

Even though strong antioxidant activities of many plant extracts and spices have been reported, 
the need for novel natural antioxidants is obvious and food industries continue to look for them. It 
is possible that the more polar antioxidants to be more active in pure lipids, and non-polar 
antioxidants to be most active in a polar substrate like oil – in – water emulsions. This may partially 
explain the variation of antioxidative activity for different spices in different foods. It is also known 
that there is a reduced antioxidant activity in extracts prepared from an equivalent amount to spice 
as opposed to that prepared from the all spices, confirming that a wide range of compounds act 
together as antioxidants in the plant material, which may act synergistically. The stabilization 
effect of the spices depends strongly on the composition of the lipids present in fatty fishes like 
mackerel. Spices need to be evaluated at concentration accepted by the senses and with all interfering 
and synergistic compounds present. Modern fish processing technologies such as Modified 
Atmosphere Packaging, refrigerated/frozen storage, reduction in time between catch and 
consumption along with the use of natural antioxidants can promote the quality fatty fishes for 
human consumption. Also novel products from high fat fishes like mackerel with natural antioxidant 
content will probably help people suffering from arteriosclerosis or similar diseases which can 
also scavenge free radicals in blood plasma.

Some of the more popular synthetic antioxidants used are phenolic compounds such as Butylated 
Hydroxy Anisole (BHA), Butyleed Hydroxy Toluene (BHT), Tertiary Butyl Hydroxy Quinone 
(TBHQ) and Propyl Gallate (PG). The synthetic antioxidants in use are subjected to a limit of 
0.02% of the fat or oil content of the food. They have been very thoroughly tested for their
toxicological behaviors and still new toxicology data impose some caution in their use. In this context, natural products appear as healthier and safer than synthetic antioxidants.

The use of preservatives is therefore, an important factor of food product regulation and ensuring food safety. In recent times, as demand increased for a wide range of different, often processed fishery products and challenging lifestyles, require products with longer shelf lives and use of natural preservatives has become essential. However, the current trend is to use chemical preservatives in food in minute quantities, which has implications for the storage and safety of food products. Many countries have strict regulatory controls on use of chemical preservatives. In this context, the present study will be of immense significance.

**Future Prospects**

The future research and development in food preservatives should contribute to solving the food preservation and food safety problems in the areas of culture of fish, handling, processing, trade and distribution of fishery products. Risk analysis for food borne pathogens is a new emerging discipline and according to this the main objectives of food preservation are to prolong shelf life and to guarantee safety of the consumer. In this respect further study on the effect of natural antioxidants and antimicrobials from spices and herbs on the storage stability of fatty fishes like mackerel is needed to be emphasized with a risk analytical approach.