9 Fish and shellfish
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9.1 Introduction

Most fish are caught from the wild in nets or with lines of baited hooks. Some die before being hauled from the water, some suffer physical damage and, farmed or wild, all are inevitably stressed before death. These, and other differences owing to biological condition, structure, composition and post-mortem change, present fish processors and distributors with a raw material that is very different from other food materials used in modern processing industries.

As with other raw meats, fish at retail sale requires some form of wrapping to protect the food from contamination, and the purchaser from soiling their hands and clothing. Wrapping in greaseproof (kraft) paper or, later, polyethylene film has long satisfied the need in small shops and markets. Demand from higher volume stores for conveniently pre-packaged products led to some ‘in-store’ production of cellophane-overwrapped fish and shellfish products (Anon., 1956) and, eventually, centralized factory production of overwrapped, chilled portions on trays (Almaker, 1965) and frozen portions in bags (Anon., 1967). Apart from some chilled, high-value products such as smoked salmon, vacuum packaging was adopted more as a means of protecting frozen fish from dehydration (Anon., 1967). Whilst plastic films were appreciated as a necessary component in the growth of the market for frozen fish, Gibson and Soulsby (1970) found that the need for similarly convenient pre-packaging of wet fish continued to be challenged through the 1960s. Limited shelf life was aggravated by problems of poor temperature control in storage, distribution and display systems. Instead, the products were often frozen for distribution and buffer storage and then thawed for retail sale. Centralized factory pre-packaging of chilled retail fish products continued to develop but injection of preservative gas mixtures did not appear on a significant commercial scale for another decade.

Interest in CO$_2$ as an aid in the preservation of fish has a longer history than the plastic films which eventually made practical the MAP of retail products. Developments that started in the 1930s were summarized by Shewan (1950), who concluded that gas storage on board fishing vessels was only worthwhile for fish that would be more than 14 days in ice before
landing at the quayside. Subsequent interest turned to the use of CO\textsubscript{2} in modified refrigerated seawater systems, on board catching vessels and lorries, as an alternative to the use of iced storage for small fish and shellfish (Nelson and Barnet, 1971; Hiltz et al., 1976; Barnet et al., 1978; Bullard and Collins, 1978). Interest in the technically more difficult task of transporting chilled, whole fish in CO\textsubscript{2} atmospheres then reappeared. With diminishing supplies and higher prices of fish, more recent studies of wholesale fish in MAP have included cod (Villemure et al., 1986; Einarsson and Valdimarsson, 1990; Wignall et al., 1990) and cod fillets (Leblanc and Leblanc, 1992), as well as salmon (Sorensen et al., 1990) and some shellfish, including octopus and squid (Morales et al., 1995), and Norway lobster (Moral et al., 1995). Salmon was of most concern in earlier studies conducted by Nelson and Tretsven (1977), which were followed, in 1977, by commercial trials with specially constructed containers (Barnett et al., 1982). This was a period when all variables associated with manipulation of storage atmospheres were keenly examined. Reductions in rates of deterioration of several species of fish have been recorded in tests using pressure chambers under both hyperbaric (Charm et al., 1977) and hypobaric (Haard et al., 1979; Varga et al., 1980; Haard and Lee, 1982) conditions.

The earliest use of CO\textsubscript{2} atmospheres in retail products exploited its high solubility to produce a ‘snuggling down’ effect (Douglas, 1970), regarded as characteristic of CO\textsubscript{2} packs. Ironically, in view of the later developments in MAP, the ‘vacuum appearance’ and prevention of movement of the product was seen as being advantageous, but there was only a small amount of kipper fillet being packed in this way, with no application to white fish or other fish products (Abbey, 1970). Earlier, vacuum packaging had been adopted more as a means of protecting frozen fish from dehydration (Anon., 1967). For unfrozen material, flushing of O\textsubscript{2}-sensitive products with N\textsubscript{2} was recommended and applied to shrimps and prawns but was not recommended ‘for meat and fish which are susceptible to spoilage by anaerobic bacteria’ (Anon., 1966).

At first, development and application of controlled gas mixtures for consumer packaging was concerned mostly with foods other than fish (Anon., 1970; 1977). Georgala and Davidson (1970) did, however, include fish, but the example given paid little regard to any need for different gas mixtures to be applied. According to Kimber (1984), the technology of gas packaging was first perfected and patented in 1963 by Böhme and Kalle Films but it took until 1977 to produce gas-flushed packs successfully. UK manufacturers were slow to adopt the process but appear to have been more willing to widen the range of products and include fish. The first UK application to fish products was in 1979 in Northern Ireland (Kimber, 1984), with a few speciality products. The technique became more widespread as manufacturers of vacuum-packaging equipment adapted