CHAPTER 9

Foods from the ocean for nutrition, health, and wellness

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9.1 Introduction

Various organizations in the world have emphasized the importance of a varied diet to meet nutritional requirements for achieving the ideal body weight. These varied diets are related among others, to limited intake of saturated fats and cholesterol, and regulation of intake of sodium. In this context, fish and seafood can play a great role in the nutritional picture. Fish provides a good source of protein, vitamins, minerals and relatively low caloric content. In addition, fish are excellent sources of ω-3 polyunsaturated fatty acids (PUFAs) that appear to have beneficial effects in reducing the risk of cardiovascular diseases and are linked with positive benefits in many other pathological conditions, particularly, certain types of cancer and arthritis.

As far as India is concerned, the successful outcome of green revolution has answered the challenges of food security due to rapid growth in population. However, the fact that 35% of the Indian population still falls below the poverty line emphasizes the need to recognize fisheries as an important sector of the National economy for meeting the food and nutritional security. In the days ahead, "blue revolution" will be the buzzword to meet the challenges of food and nutritional security.

Fish and fishery products form an important food component for a large section of the world population. They represent 15.6% of animal protein supply and 5.6% of the total protein supply on a worldwide basis. Fish is the primary source of animal protein

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for over one billion people in developing countries. It is estimated that 60% of people in developing countries obtain 40%–100% of the animal protein in their diets from fish (Lowe et al., 1998). Protein, lipids, and bioactive compounds from seafood have unique features that differ from those of land animals. The uniqueness of fish protein is due to its excellent nutritive value, high digestibility, and presence of all essential amino acids. In general, fish flesh contains 60%–84% water, 15%–24% protein, 0.1%–22% fat, and 1%–2% minerals. It is a good source of PUFAs, especially ω-3 PUFAs, minerals, and vitamins (Fierens and Corthout, 2007).

9.2 Indian fish market—production and consumption

India's economy is the seventh-largest in the world and in the last quarter of 2014, it became the fastest-growing major economy. India made a paradigm shift in food availability by transforming from a begging bowl to breadbasket during the course of seven decades. Its fisheries sector has registered a sustainable growth of over 10% and has contributed over 1% of India's annual gross domestic product during the last decade. The vibrancy of the sector can be visualized by its tremendous growth in recent years.

India's coastline (8129 km) of the exclusive economic zone (2.02 million sq. km) and continental shelf (0.506 million sq. km) contributed to an estimated possible exploitable resource of 4.41 million tons of seafood in 2017–2018, of which approximately 3.40 million tons are being currently exploited. Rivers, canals, reservoirs, ponds, tanks, oxbow lakes, derelict waters, brackish water, and estuaries also contribute to the Indian fish industry. The brackish waters (14%) contribute mainly to shrimp farming. India enjoys the seventh position regarding marine fish production in the world and exported 1,377,244 MT of seafood worth US$ 7.08 billion during the financial year 2017–18, which is considerably higher (21.35% growth) than 1,134,948 MT and US$ 5.77 billion in the preceding fiscal year, with frozen shrimp and fish continuing to dominate the export basket. The Indian seafood industry is known for quality seafood and has become a leading supplier to major markets of the world. Recently, frozen cephalopods also registered a growth and added to the landings of the country. In recent years, dried, chilled, and live fish are also showing an upward trend. Indian aquaculture industry (fresh water and brackish water) currently holds the second position in aquaculture production (7.21 MMT from the inland sector and 3.58 MMT from the marine sector in 2016–17). The freshwater aquaculture sector contributed about 85% of the inland share. The recent improvements in the marine and inland sectors contribute to domestic food security. Nevertheless, the future production and consumption challenges, industrial uses, wastages/discards, and other industrial applications need to be streamlined and price difference based on geographical disparity needs to be controlled.

The fisheries sector offers an attractive and promising future for employment, livelihood, and food security. The fisheries and aquaculture production contribute around 1% to India's gross domestic product (GDP) and over 5% to the agricultural GDP. According to the Food and Agriculture Organization (FAO) report "The State of World Fisheries and Aquaculture 2018" apparent per capita fish consumption in India [average (2013–15)] lies between 5 and 10 kg. Fish has become an integral constituent in the Indian food basket as a healthy food with a high level of edible protein and availability across the states. It is considered as poor man's protein (low-value fishes) ensuring food security and delicacy. It has been estimated that 60% of the Indian populace consume fish and the consumption varies spatiotemporally and across the different social fabric. Indian Council of Medical Research recommends annual per capita consumption to be 12 kg per annum. Sardine and mackerel are the most often consumed fish in the domestic market.

9.3 Fish as healthy food

Fish is a health food, with relatively lesser taboos connected to it, unlike meat. World over fish is considered as a delicious item and from a nutritional point of view, it balances the cereal-based diets. A health food should contain all the principal constituents, viz. carbohydrates, proteins, lipids, minerals and vitamins in the right proportions. Detailed biochemical composition of all-important Indian food fishes (including proximate composition, fatty acid composition of body and liver oils, mineral content, and amino acid composition of muscle proteins) from fresh water, brackish water, and marine and deep-sea waters have been compiled and reported by the Central Institute of Fisheries Technology (Gopakumar, 1997). People are now more health conscious. Diets low in fat and cholesterol with high vitamin and mineral contents are often preferred, especially in the affluent west. For a healthy lifestyle, fish is a good starting point. The importance of fish as a source of high quality, balanced and easily digestible protein is now well understood. For the affluent, it is the best health food with curative properties, whereas for the less privileged section in developing nations, it is the only source of high-quality protein available at affordable cost and in sufficient quantity.

Fish plays a major role in human nutrition. Fish and shellfish form an important part of the human diet, both of the poor and of the wealthy. Good quality fish is an extremely safe food. Meat products are viewed as unsafe after the incidences of illnesses like mad cow disease. Fish is a versatile, tasty, and easy to prepare food. Consumers are increasingly demanding natural foods, which contain no chemical residues and are not genetically manipulated. Fish is organic and is considered as wild, and for the same reason safer, though late farmed fish has posed minor problems of harmful residues. For thousands of years, fish has been an important part of the human diet.

The ancient Assyrians, Romans and Chinese were famous for their fish farming. During the past decades, per capita consumption of fish has gone up globally. Fish is the diet of the poor fishermen and meets most of their nutritional requirements.

Researchers worldwide have repeatedly emphasized the beneficial effect of eating fish, after conducting systematic research for many years. In recent years, the link between fish oil and heart disease has been the subject of thousands of scientific papers. The whole story began following the discovery that coronary heart disease while being one of the biggest killers in the world is practically unknown among the Eskimos. The investigators found that their diet is mostly fish-based and rich in long-chain n-3 PUFAs (Lee and Lip, 2003; von Schacky and Dyerberg, 2001). Eskimos also have a reduced tendency to blood clotting and longer bleeding times compared to other people. Medical researchers carried out detailed investigations and showed that men who ate fish once or twice per week were protected against coronary heart disease (He et. al., 2004: Heikkila et al., 2004). An increase in fish oils in the diet results in a marked reduction in blood cholesterol and triglyceride levels and also prevents thrombosis (Bjerregaard et al., 2004).

9.4 Dietary lipids and disease management

The lipid content in fish varies between species as also within the species depending on many factors. Fish with a fat content as low as 0.5% and as high as 18%–20% is common. Squalene and wax esters are other components found in unusually high concentrations in certain fish. The fatty acid composition of marine lipids is much more complex than others. Lipids of fish and other aquatic animals contain a high proportion of highly unsaturated long-chain fatty acids. Fatty acids with carbon chains varying from 10 to 22 and unsaturation varying from 0 to 6 double bonds are common. Among the saturated acids, palmitic and stearic acids are the important ones, and in the monounsaturated group, palmitoleic and oleic acids are the major constituents. Among the polyunsaturated acids, arachidonic acid, eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) are the major components (Mathew et al., 1998).

Fish oils have no effect on the levels of low-density lipoprotein cholesterol but they do raise high-density lipoprotein (HDL) by about 10%. HDL is a protective type of lipoprotein as it takes excess cholesterol away from the tissue and returns it to the liver. Diseased heart muscle is susceptible to bouts of irregular electrical activity (arrhythmias), which are potentially lethal and often cause sudden cardiac arrests. There is evidence from animal studies that increasing fish oil in the diet helps to reduce cardiac arrhythmias (Sellmayer et al., 2004; Covington, 2004). Fish oils improve the functionality of cell membranes, which helps in proper signal transmission. Fish oil inhibits platelet aggregation, which also reduces the risk of heart disease (Vanschoonbeek et al., 2004). Raised blood pressure is known to be a major risk

factor in coronary heart disease. Most studies on the effects of fish oil given as dietary supplements have shown modest reductions in blood pressure, especially in hypertensive people (Aguilera et al., 2004; Wilburn et al., 2004; Mano et al., 1995).

The lipid composition of fish is unique having long long-chain PUFAs in the form of arachidonic and eicosapentaenoic acids with many potential effects of adult health and child development. Among fish species that are cheaper and often traded in developing countries, small pelagic fish such as anchovy and sardine are perhaps some of the richest sources of long-chain PUFAs. The amount of PUFAs in large fresh water fish such as carp and tilapia is lower. EPA and DHA reduce vasoconstriction by competing with arachidonic acid for the enzyme cyclo-oxygenase (Sametz et al., 2000). EPA, the main n-3 acid is converted by platelet cyclooxygenase to thromboxane A3, which is a very weak vasoconstrictor, unlike thromboxane A2, which is formed by the action of cyclooxygenase on arachidonic, the n-6 acid, and is a strong vasoconstrictor (Tapiero et al., 2002; Akiba et al., 2000). The American Heart Association recommends including fatty fish at least twice a week in the diet (Kris-Etherton et al., 2002; Krauss et al., 2000). Institute of Human Nutrition in New York also recommends eating plenty of fish. Italian study involving 985 people who survived heart attacks, also proved the beneficial effect of fish oil (Tavani et al., 2001). The new slogan in the west is that a tuna sandwich a day keeps heart problems at bay (Mozaffarian et al., 2004; O'Neill, 2002). It is also stated that if a person wants to reduce the risk of heart attack by more than 20%, he has to eat a tuna sandwich just once a month. No wonder they say, "Seafood is heartfood."

Recently, the inhibitory role of n-3 PUFAs in the development and progression of a range of human cancers has been established by researchers worldwide. Studies have found that the antitumor effect of EPA is mainly related to its suppression of cell proliferation (Pham and Ziboh, 2002; Yuri et al., 2003). The effect of DHA appears to be related to its ability to induce apoptosis or cell death (Baumgartner et al., 2004; Chiu et al., 2004). The dietary n-3/n-6 fatty acid ratio, rather than the quantity administered, appears to be the principal factor in the antitumor effect of n-3 PUFAs.

Apart from heart disease and cancer, fish oil is proved to be effective for preventing a wide variety of diseases. In several observational studies, low concentrations of n-3 PUFAs were predictive of impulsive behaviors and severe mental depression (Ruxton, 2004; Freeman et al., 2004). The importance of PUFAs in the maintenance of insulin in the blood has also been proven experimentally (Holness et al., 2004). Clinical and biochemical studies have shown that fish oil and to a lesser extent fish can be used as a source of n-3 fatty acids in the treatment of rheumatoid arthritis (Ruxton, 2004; Remans et al., 2004). Supplementations with fish oils can markedly reduce interleukin-1β production and result in a significant reduction in morning stiffness and the number of painful joints in arthritis patients. Studies have shown fish oil to be effective in the treatment of acute respiratory distress syndrome (Pacht et al., 2003),

psoriasis (Mayser et al., 2002), and also in multiple sclerosis (Nordvik et al., 2000). Older people who eat fish at least once a week may reduce their risk of Alzheimer's disease by more than half (Yazawa, 2004; Morris et al., 2003). Other diseases that are reduced due to the consumption of PUFAs include primary Raynaud's disease (Di Giacomo, 1989; Swanson, 1986), gastric ulcer (Olafsson et al., 2000; Manjari and Das, 2000), and Crohn's disease (Geerling et al., 2000).

Along with fish oils, proteins in fish also have a positive role in reducing blood cholesterol (Ait Yahia et al., 2004). Studies have shown that fish proteins have a clear protective effect in diabetic renal diseases (Mollsten et al., 2001). Fish proteins are of high biological value, as they contain all essential amino acids in the right proportion. Plant proteins, although rich in certain essential amino acids, do not always offer all essential amino acids in a single food. Legumes lack methionine, while grains lack lysine. Fish protein is also an excellent source of lysine as well as the sulfur-containing amino acids, methionine and cysteine. Amino acid scores of fish protein agree well with the FAO reference pattern. In the studies conducted in the Central Institute of Fisheries Technology, Kochi, it was seen that the amino acid composition of the protein is crucial in determining its hypocholesterolemic properties. The alanine/proline ratio in a protein was found to be a significant factor determining its hypocholesterolemic properties (Ammu et al., 1994).

9.5 Other dietary components and their health significance

The protein content of fish muscle ranges between 16% and 20% depending on the species, the nutritional condition, and the type of muscle. The crude protein calculated on the basis of the total nitrogen content represents proteins and other nitrogenous compounds, such as nucleic acids, nucleotides, trimethylamine and trimethylamine oxide, free amino acids, and urea. Protein from fish is easily digested, with most species showing a protein digestibility greater than 90%. Chemical score or amino acid score of fish compares very well with that of whole egg protein. The chemical score of finfish is 70, an indication of its high quality, beef is 69, and cow's milk is 60. The protein efficiency ratio, another measure of protein quality of fish is around 3.5, which is much higher than beef (2.30) and milk proteins (2.5) and close to that of an egg (3.92). Fish is a good dietary source of taurine, a nonprotein amino acid with multiple functions like neurotransmission in the brain, stabilization of cell membranes and in the transport of ions such as sodium, potassium, calcium, and magnesium (Franconi et al., 2004; Birdsall, 1998; Del Olmo et al., 2000). Nutritional quality of protein is generally determined by factors such as essential amino acid composition, digestibility, and biological value. Fish protein is rated high in all the above qualities and is considered as a good dietary protein in all respects.

In general, both water-soluble and fat-soluble vitamins are present in fish. Fat-soluble vitamins A, D, K, and E are present in fish in varying amounts—often in higher concentrations than in land animals. The content of vitamins and minerals is species-specific and can vary with season. Fish compared to other foods is known to be an important source of essential micronutrients and minerals such as calcium, copper, phosphorus, iodine, zinc, iron, and selenium. Salt-water fish are rich in iodine. The iodine in marine fish ranges from 300 to 3000 μg/kg. Fish is a good source of almost all the minerals present in seawater (Nair and Mathew, 2000). The total content of minerals in the raw flesh of fish and aquatic invertebrates is in the range of 0.6%−1.5% of wet weight. Certain seafood such as snails and tuna are a good source of the macromineral magnesium. Seafood, especially tuna, is an important source of the essential antioxidant trace element selenium, which provides protection against heavy metal poisonings and a variety of carcinogens. As it contains vitamin E, selenium is a vital factor in the protection of lipids from oxidation as part of the enzyme glutathione peroxidase, which detoxifies products of rancid fat. The carbohydrate content of finfish is insignificant, but certain shellfish store some of their energy reserves as glycogen, which contributes to the characteristic sweet taste of these products.

The flesh of lean white fish, such as cod, haddock, and pollock, contains from 25 to 50 IU of vitamin A per 100 g, while in the fatty species such as herring, the amount ranges from 100 to about 4500 IU per 100 g. The content of vitamin D in sardines and pilchards and in tuna is in the range of 530−5400 and 700−2000 IU per 100 g, respectively. The contents of vitamin E in the edible parts of fish and marine invertebrates range from about 0.2 to 270 mg/100 g. Fish is a good source of B vitamins. The red meat has a higher content of vitamin B than white meat. Fish liver, eggs, milk, and skin are good sources of thiamine (B_1), riboflavin (B_2), pyridoxine (B_6), folic acid, biotin, and cyanocobalamine (B_{12}).

9.6 Nutritional superiority of fish in Indian scenario

Fish is highly favored in West Bengal, Assam, Kerala, and the coastal regions of India. It is included in almost every meal as it is one of the healthiest foods. Fish has a unique flavor and taste, which is specific to each variety. It is easy to cook, and the flesh becomes really soft upon cooking. It can be grilled, poached, steamed, baked, or boiled, and it pairs well with every Indian staple, whether rice or wheat.

Different from other meat sources, it contributes greatly to human health by improving metabolism, sleep quality, skin quality, and concentration and prevents inflammation. Fish contains components such as protein, which is healthy, cheap, and readily available; hence, it will help in curtailing malnutrition and prevent noncommunicable diseases. Indian coastal lines can provide apt nutritional security to the Indian population, specifically in the coastal areas. Fatty fishes such as salmon, trout,

sardines, tuna, and mackerel are rich sources of ω-3 fatty acids, which are extremely important for the proper functioning of the brain and eyes. It is also recommended for pregnant women. The absence of saturated fatty acids makes fish apt heart food. It keeps cholesterol at bay and reduces the risk of cardiovascular diseases. The abundance of vitamins specifically vitamin D in fish aids in the absorption of other nutrients during metabolism. Consequently, fish becomes a necessary food that has a superior place and is inevitable in our daily diet. ω-3 fatty acids (DHA) and vitamin D help in maintaining mental health and act as an antidepressant. Further, it reduces the risk of autoimmune diseases such as diabetes and rheumatoid arthritis. Hence, fish could be considered as a one-stop source of all vital nutrients that maintain a healthy balance in the human system and curb all major diseases.

When the beneficial effects of dietary fish are considered, vegetarianism in dietary habits does not seem to be wise. When one decides to become an obligate vegetarian and cuts out meat/dairy/fish out of the diet, he/she decides to cut out some of the major nutrients body needs on a daily basis for effective functioning. The argument that fish lives in unhygienic habitat and polluted waters is also not valid, as pollution is a universal phenomenon, affecting air, land, and water. Fish is the heart food that gives you both satisfaction and health and it is the word for nutritional security.

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