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The Value of Aquatic Food for the Human Metabolic Functions

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Abstract

Since organic food products derived from terrestrial ecosystems are negatively affected by global climate changes, it is predicted that aquatic ecosystems may be the first and most important source that will compensate for the food resources coming from this area. Today, it has been stated in the literature that the decreases in macro, micro elements and vitamin compositions in nutritional content of plants and animals of terrestrial origin due to sunlight cannot fully meet the needs of humans and other high-level trophic species and observing various health problems. The purpose of this review is to evaluate the importance of high-nutrient species in the aquatic ecosystem for human nutrition and their role in regulating human metabolism. From the simplest aquatic form, microalgae, which is important as a single-celled protein, to the highest structured vertebrate aquatic species, aquatic ecosystem organisms have become the most important potential food sources for human. They are also a rich source of macro, micronutrients and vitamins necessary to advance the anabolic and catabolic steps of human health and regulate the immune system. In recent clinical studies, omega-3 Fatty Acids (FA), taurine, chitin, squalene, phytosterols, vitamins, iodine, carotenoids and collagen have been identified as the main elements regulating vital molecular-based metabolic functions. This study provides a brief contribution to the understanding of the benefits of feeding aquatic organisms on the main factors in human nutrition.

Keywords: Aquatic ecosystem; Aquatic products; Food; Human nutrition; Metabolic regulation.

Introduction

Aquatic ecosystems form an enormous biome on Earth. These biomes support many aquatic species in various habitats such as freshwater and brackish water, apart from saltwater systems. Fish, which constitute the largest class of vertebrates in aquatic biomes, comprise the most consumed consumption group [1]. They are valuable sources of nutrient in terms of both macro (proteins, lipids) and micro content (vitamins, minerals) for many people, especially in developing countries [2]. Seafood consumption has increased significantly, especially in the last two decades [3]. In order to meet the protein demand of the increasing world population, the Food and Agriculture Organization data showed that aquaculture production included 54.1 million tons of fish, 17.1 million tons of molluscs, 7.9 million tons of shellfish and 938.500 tons of other aquatic species [4]. It is estimated that one billion people worldwide earn their living from fish production, processing and trade [2]. Seafoods have been reported to provide high-value compounds functional and nutraceutical food products that may provide various beneficial effects on human health [5]. Shellfish form a diverse group of species subdivided into crustaceans and molluscs [6,7]. In addition, crustaceans as well as shrimp, crabs, and lobsters, are systematically classified as arthropods, along with mites, spiders, and insects [8]. The fact that the amount of nutrients required during the life cycle of shellfish is higher than that of terrestrial species has enabled their protein levels to be significant and high. This is due to the low carbohydrate content in contrast to the high levels of protein and lipase in the aquatic habitat [9]. These nutritional ingredients in aquatic organisms have an important place in the nutrition list due to their energy support, body repair, metabolic regulation and easily sustainable health advantages [10]. This review focuses on the consumption procedures of various species of unique forms in marine ecosystems and their valuable contributions to human nutrition.

Overview of the place of aquatic food in human nutrition and health

Organic low-fat diet and weight loss: Generally known for the quality and abundance of essential fatty acids in seafood tissues [11,12]. According to this phenomenon, it has been thought that when the n-3 long chain fatty acids produced in algae are included in the food chain of fish and invertebrate species, the nutritional value of these organisms in terms of fatty acids increases [12]. This has led to the idea that aquatic algae and aquatic animals may be important as human food (Figure 1). The livers of some fish species, such as cod and shark, are used commercially in the production of fish oil, and the livers and hepatopancreas of both fish and shellfish are used as by-products in the seafood industry [13]. It has been observed that fish oil obtained from fish head, backbones, internal organs and skin has lower phospholipid content compared to eggs and milk [14]. Fish consumption supports post-exercise nutrition. It is stated that fish component nutrients are extremely important in helping athletes reduce fatigue and muscle regeneration [15]. Seafood is vital as a source of energy for human body and is an excellent nutrient with its lean protein properties that help regenerate damaged cells and build muscle. They are low in calories and play an important role in maintaining a healthy weight [15]. It has been determined that six weeks of fish oil supplementation and 3 hours of exercise increases the production of Interleukin (IL)-2 and the cytotoxic activity of killer cells in the body defense system [16]. Algae has been a part of the human diet for thousands of years, based on archaeological evidence. Aquatic algae communities convert sunlight, water and carbon dioxide into nutritional compounds and have a high antioxidant effect thanks to these compounds. The carotenoids and phytosterols in aquatic microalgae are used as food supplements and are responsible for the regulation of important biochemical pathways in human health and disease prevention [17].

Epidermis quality for healthy skin: Collagen, the main molecule of gelatin, is a fibrous protein found abundantly in all multicellular animals as a major component of connective tissues [18,19]. The molecular weight of collagen is approximately 330 kDa, and gelatin is the fraction of collagen that exceeds the minimum molecular weight of 30 kDa after-heat hydrolysis [17]. To date, 27 types of collagens have been identified and some differences have been observed in the amino acid composition of collagen obtained from different sources [20,21]. The amino acid composition of fish gelatin is closer to that of its precursor gelatin, and its suitability as an alternative to continental animal gelatin has been discussed [22]. In addition, collagen and gelatin, which have an important place in human health and the food industry day by day, have become natural organic solutions by boiling the bones of large fish, consuming fish skin and consuming fish fins [23]. Some cold-water bony fish have been evaluated in the pharmaceutical industry by providing large amounts of antifreeze protein in their body fluids and have been considered valuable sources of many bioactive compounds such as antioxidants and bioactive peptides [22]. Various studies have shown that fish in cold water ecosystems have stronger digestive enzymes than land animals [22]. Because it has adapted to keep its body temperature below the environmental temperature in order to perform metabolic functions efficiently. For this reason, fish digestive enzymes have become a model in the food industry [24,25].

Cardiovascular regulation: A meta-analysis of cohort studies has found that people who consume fish regularly have a lower risk of heart attack, stroke, and death from heart disease [26,27]. It has been shown in clinical studies to reduce blood clot formation, as well as lowering the heart rate in adults who eat fish [28]. It has also been reported that it protects cardiovascular health by supporting the regulation of cardiovascular constriction [28]. Seafood rich in omega-3 FA can help combat joint and muscle pain by reducing inflammation and symptoms of arthritis [29]. According to the results of a clinical study followed for two years, increased fish consumption reduced deaths from cardiovascular diseases and other diseases by 33% and 29%, respectively [30,31].

Immune system and disease prevention: Lowering cholesterol levels has been shown to be among other reported health benefits of consuming fish oil [29]. It has been indicated that quality fish and polyunsaturated fat intake help increase air flow to our lungs and protect the body against colds, flu and rhinitis [32,33]. Iodine is one of the important trace elements in the daily diet. Iodine, which has been found to be important in preventing the formation of breast, thyroid and prostate cancer cells, in the secretion of thyroid hormones necessary for human growth and development, is also very important in supporting the immune system elements [34].

Neurological balance and mental health: Small indigenous fishes are especially rich in iron, zinc, potassium, magnesium, calcium, selenium, vitamins A, B12, and D. These fish also have a high content of omega-3 FA, which is important in maintaining the optimal function of body neurons and reducing the risk of many diseases [35]. The relationship between low n-3 fatty acid dietary and dementia status in older were evaluated, and the decrease in dementia was associated with the amount of seafood consumed [35]. Additionally, studies have found that people who eat fish more regularly have more gray matter in the parts of the brain that control memory and emotion [36]. A study determined that grilled fish consumption was positively associated with gray matter volumes in the hippocampus, precuneus, posterior cingulate and orbital frontal cortex [36]. In addition, it has been reported in studies that fish consumption reduces anxiety and other depression symptoms [37,38]. On top of these, it has been stated that adequate intake of Eicosatetraenoic Acid (EPA), Docosahexaenoic Acid (DHA) is important in preventing attention deficit and hyperactivity disorder and increasing academic performance skills in preschool children as well [39].

Vision: Adult individuals who consume more fish have been found to have a much lower risk of AMD, or age-related macular degeneration, which is one of the leading causes of visual impairment and blindness [39]. This is because our eyes need intense omega-3 FA content to maintain their health and functions [39]. Omega-3 has been found to be important especially in preventing dry eye, macular degeneration and cataract diseases.

Body development and fertility: Seafood has an important portion in diets due to its protein and especially the quality of EPA, DHA and Arachidonic Acid (AA) from multiple fatty acids [40,41]. In addition, these nutrients, which are needed for daily energy needs, are very important for proper growth and physical development, especially in children and adolescents, as well as for maintaining health and preventing some diseases in adults [42]. It has been stated that the risk of premature birth is 4 times lower in expectant mothers who take Omega-3 fatty acid as a food supplement during pregnancy [43]. EFA and DHA are most easily provided by seafood. It has been determined

that the mental processing skills, psychomotor development and eye-hand coordination of 4-year-old babies of mothers fed with these fatty acids are higher [39]. Therefore, it is often recommended that pregnant, breastfeeding women and preschool child ensure they consume adequate omega-3 FA [39]. It has also been stated that fish helps with concentration and attention in adolescents [39]. Squalene ($C_{30}H_{50}$) is a polyunsaturated hydrocarbon, and its extraction and characterization studies from shark livers using traditional medical methods have become increasingly important [44]. According to studies, it is known that alcohol causes lipid peroxidation in the organism. On the other hand, it has been determined by various studies that squalene protects cells from lipid peroxidation. In this context, the protective effect of squalene against high alcohol consumption in embryos during pregnancy was studied and it was observed that the harmful effects on lipid composition and retinal structure were reduced in high alcohol toxicity [45].

Others: Some of chitin, chitosan, glucosamine, carotenoids and proteins resource in shellfish species have been researched seriously in human health nowadays [6]. Chitosan is a polysaccharide derived from the deacetylation of chitin. And chitin is the biopolymer composed of N-acetyl glucosamine. They are used extensively in the food industry to precipitate water-soluble proteins, food packaging, food preservation, food additives and other fields [46,47]. Taurine (2-aminoethane sulfonic acid), a β-amino acid found free or in some simple peptides, is important in human nutrition as a conditionally semi-essential amino acid [48]. Taurine, formerly known as an end product of cysteine metabolism, has been determined to be important for many physiological processes in clinical nutrition studies. Important roles in these physiological processes include membrane balance, detoxification of chemicals, regulation of antioxidation defense system and osmoregulation, continuity of calcium homeostasis and stimulation of glycolysis-glycogenesis [49]. Taurine is quite sufficient in human cell membrane, but due to various unpredictable factors such as surgical injury and numerous pathological conditions such as cancer, trauma and sepsis, taurine in plasma decreases. Therefore, it has been determined to be important in pharmacology, but its potential place in dietary supplementation is still under study. Although free taurine has not been isolated from plants, it has been determined to be present in breast milk, especially in dairy products, poultry and fish [49]. Although we have mentioned only a few of the aquatic organisms, researched in various literatures, with their use in the food industry and their effects on human health in this study, it is obvious that aquatic-derived foods have many yet unknown benefits (Table 1). Species living in different aquatic habitats may have different species-specific macro and micro element levels, vitamin values and fatty acid profiles. Therefore, there is a need to conduct more studies including the structural features of different organisms and determine their importance in human nutrition.

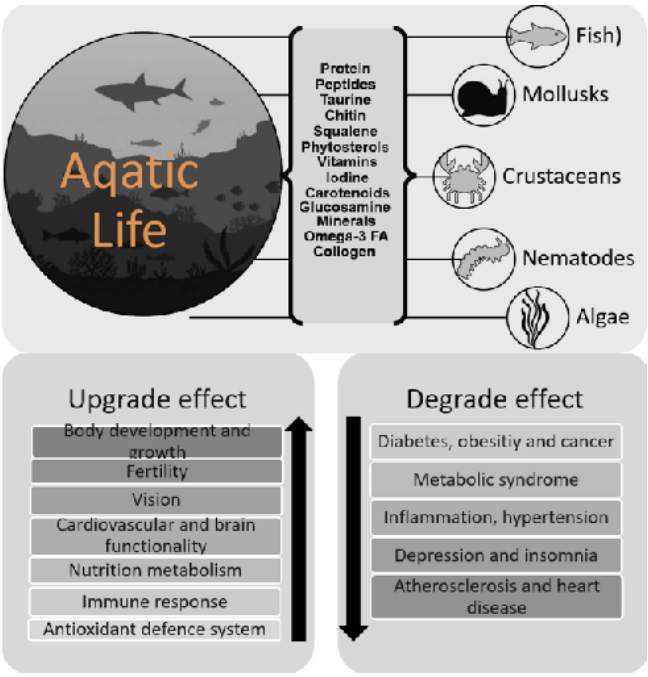

Figure 1: Metabolic effects of aquatic organisms observed in various research articles after dietary.

Table 1: Identified aquatic species and their food characteristics.

Common name	Latin name	Habitat	Food characteristics	Ref.
Bullhead shark	*Heterodontus francisci*	*Gulfs and coastal sea areas*	High level of collagen: 50.1% in skin tissue	[50]
Japanese sea-bass	*Lateolabrax japonicus*	*Inshore rocky reefs, rivers*	High level of collagen: 51.4% in skin tissue	[50]
Chub mackerel	*Scomber japonicus*	*Sea and pelagic areas*	High level of collagen: 49.8% in skin tissue	[50]
Haddock	*Melanogrammus aeglefinus*	*Demersal zone*	Low level of cholesterol: 0.4% High level of triacylglycerol: 98.6% in liver tissue	[51]
Atlantic cod	*Gadus morhua*	*Demersal zone*	Low level of cholesterol: 1.2% High level of triacylglycerol: 96.2% in liver tissue	[51]
Coalfish	*Pollachius virens*	*Rocky areas in sea area*	High level of FA: 33.7% in viscera	[51]
Tusk	*Brosme brosme*	*Moderately deep of marine*	High level of FA: 37.4% in liver tissue	[51]
Blue crab	*Callinectes sapidus*	*Shallow areas, brackish waters and deeper, saltier waters*	High level of chitin: 14%	[52]
Mola carplet	*Amblypharyngodon mola*	*Freshwater, benthopelagic*	High levels of vitamins A, D, E, K	[53]
European eel	*Anguilla anguilla*	*Lagoon*	High level of FA: 52.17% (monounsaturated fatty acids)	[40]
Herring	*Clupea harengus*	*Marine area*	High level of FA: 29.44% (saturated fatty acids)	[40]
Nile tilapia	*Oreochromis niloticus*	*Lake water*	High level of iodine: 864 µg/kg	[54]
Sardine	*Sardina pilchardus*	*Open sea or near the coast*	High level of FA: 32.8% (EPA+DHA)	[34]
Small-spotted catshark	*Scyliorhinus canicula*	*Coastal marine waters*	High level of triacylglycerols and low level of cholesterol: 96.2 and 3.8%	[34]

Conclusion

In general, oxidative stress, which can develop due to many general reasons, may appear as the primary symptoms of various health problems in people. It has been observed in many studies that fish support cellular resistance against the harmful effects of oxidative stress with routine and adequate nutrition. These results indicate that aquatic derived food provide sufficient and diverse benefits in human metabolic regulation. Protein, omega-3 FA, taurine, chitin, squalene, phytosterols, vitamins, iodine, carotenoids and collagen from aquatic origin may indeed be beneficial due to cholesterol and inflammation that can be observed in continental animals cause of climatic stress and death.

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