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Effect of Omega-3 Fatty Acids from Fish as an Antibacterial and Anticancer Agent- A Review

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Abstract

Fish contain many essential compounds that are important for human health. The presence of omega-3 fatty acids which includes eicosapentaenoic acid and docosahexaenoic acid increases the beneficial aspect of fish. This review intends to briefly describe the antibacterial and anticancer of fish oil extract. Several fish species which are enriched with omega-3 fatty acids content inhibits the growth of several pathogenic bacteria and cancer cell lines. Consumption of these types of fish also helps in control or reduction of health problems such as asthma and inflammation.

Key words: Antibacterial activity, Anticancer effect, Docosahexaenoic acid, Eicosapentaenoic acid, Fatty acids

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Introduction

Omega-3 fatty acids are polyunsaturated fatty acids (PUFA) especially α-linolenic acid (ALA), eicosapentaenoic acid (EPA), and docosahexaenoic acid (DHA) with important role in human health. Plants are the major source of ALA and fish oils are the source of EPA and DHA. This review summarizes the recent finding that shows the antibacterial and anticancer effect of omega-3 fatty acids that are obtained from different fish species.

Fish contain almost all the major nutrients which are beneficial for humans including proteins, essential amino acids, essential fatty acids and also provide minerals and vitamins and it could be considered as a treasure store of nutrients.[1] The essential fatty acids such as PUFAs especially EPA and DHA have been mainly contributed by fishes and other aquatic foods which must be consumed in the diet.[2]

Linoleic acid and alpha-linolenic acid which act as the precursors of essential fatty acids, omega-3 fatty acid, and omega-6 fatty acid cannot be synthesized in the body but can only be obtained through diet.[3] In the human body, omega-3 fatty acids play a number of essential functions like formation of phospholipids, reduce the propensity to form thrombus and several studies reported that the tolerable and high intake of long chain omega-3 fatty acids helps in the reduction of asthma incidence in young adults and reduce the amount of inflammation causing agents such as eicosanoids, cytokines, reactive oxygen species, and the expression of adhesive molecules.[4-7]

Caygill *et al*. (1996) were able to find significant relation between the intake of fish and fish oil and reduction in risk of colorectal and breast cancer.[8] Simplice *et al.* (2018) identified the presence of saturated, monounsaturated, and poly saturated fatty acids having antibacterial activity against both gram-positive and gram-negative food poisoning bacteria in freshwater fish oil.[9] Clinical study that conducts with omega-3 PUFAs against protozoon *Toxoplasma gondii* which causes the infection toxoplasmosis, reported that the supplementation of fatty acids restricts the growth and survival of *T. gondii* through autophagy.[10]

Fatty Acid Profile

The fatty acid profiles of fishes from marine, freshwater, and brackish water habitat have been studied by several researchers from different countries. A study from Cameroon on fatty acids in freshwater fishes revealed the presence of high amount of palmitic acid, oleic acid and long chain PUFA including linolenic acid, DHA, and EPA.[9] Swapna *et al.* (2010) delineated the distribution of palmitic acid, oleic acid, and saturated fatty acid in Indian freshwater fishes such as *Labeo rohita*, *Cirrhinus mrigala*, *Catla catla*, *Oreochromis mossambicus*, and *Cyprinus carpio*.[11] They found that the distributions were prominent in head and visceral portions. Paul *et a*l. conducted a fatty acid analysis of *Clarias batrachus* and *Heteropneustes fossilis* and founded that *C. batrachus* contain more PUFA content which includes DHA and EPA and *H. fossilis* with higher content of monounsaturated fatty acids such as oleic acid.[12] Paul *et al*. found that in *Anabas testudineus*, the saturated fatty acid such as palmitic acid and stearic acid, monounsaturated fatty acid such as palmitoleic acids and in case of PUFA, linolenic and DHA were high in content.[13] Studies conducted by Narayan *et al*. reported that the major fatty acid components of marine fish as PUFAs such as EPA and DHA.[14] Study on the marine catfish, *Arius subrostratus* by Ambily and Nandan (2018) reported that the major fatty acids present in the species were PUFA components such as linoleic acid, linolenic acid, EPA, DHA and also the saturated fatty acid such as palmitic acid.[15] Som and Radhakrishnan were able to distinguish differences in PUFA compositions in two species of Sardinella. *Sardinella fimbriata* extract with high DHA and *Sardinella longiceps* with high EPA content.[16]

The comparative study in several marine and freshwater fish species of Malaysia showed that marine fishes have more content of

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PUFAs such as EPA and DHA.[17] Fatty acid profile of different fish species from Kerala marine water and brackish water indicated high amount of omega-3 fatty acids especially, EPA and DHA content in comparison with fresh water cultured *Etroplus suratensis* which contain more omega-6 fatty acid.[18] Innis, and Strobel *et al*. were able to correlate the consumption of higher amount of omega-6 fatty acid than omega-3 in western diet for some diseases.[19,20] They found that consumption of diet that included high omega-6 containing pre-fried fishes and low omega-3 containing farmed fish led to chronic cardio metabolic and inflammatory disease and neurological problems. As compared with omega-6 fatty acids, omega-3 fatty acids play an important role as anticancer agent in both *in vivo* and *in vitro*.[21] Omega-3 fatty acids such as EPA were reported with higher effectiveness than DHA for the treatment of mild or moderate depression.[22]

Antibacterial Effects

Som and Radhakrishnan found the antibacterial effect of PUFA extract from *S. longiceps* and *S. fimbriata* on different bacterial strains.[16] They affirmed that *S. fimbriata* extract exhibited remarkable inhibitory effect on *Pseudomonas aeruginosa* and *Enterococcus faecalis* and marginal effect with *Staphylococcus aureus* and *Escherichia coli*. The effect was higher than *S. longiceps*, and it was attributed to the presence of high DHA content. *In vitro* and *in vivo* study of DHA revealed that it could be useful for the control of multi-resistant bacteria that cause pulmonary infections in cystic fibrosis patients.[23] Several studies reported the antibacterial activity of long chain fatty acids can be used against human pathogenic gram-positive bacteria. *S. aureus* and *Bacillus cereus* that leads to skin disease and food borne diseases were inhibited by the action of EPA by cell lysis through disrupting the cell membrane.[24-26] Simplice *et al.* (2018) studied the antibacterial activity of freshwater fishes *Chrysicthys nigrodigitatus* and *Hepsetus odoe* against food poisoning bacteria such as *S. aureus*, *E. faecalis*, *Klebsiella pneumoniae*, *Salmonella paratyphi A*, and *Salmonella paratyphi S* and have been justified with the presence of different classes of fatty acids including PUFA.[9] Study reported that the intake of omega-3 fatty acids reduces the bone resorption and tissue destruction that caused by periodontitis and also supress osteoclast differentiation.[27] DHA and EPA exhibited antibacterial activity against gum disease causing bacteria such as *Porphyromonas gingivalis* and *Fusobacterium nucleatum* by inhibiting planktonic growth, biofilm formation and by decreasing the gene expression of virulence factor.[28]

Anticancer Effects

Different studies reported that essential fatty acids especially omega-3 fatty acids have the ability to inhibit or control the growth of lung, colon, breast, prostate cancer cells and also cause the enhancement of chemotherapy drug efficacy.[29] Recent study by Lauritano *et al.* found that the Mediterranean mesopelagic fish species have anticancer activity against lung, breast and liver cell lines.[30]

The studies conducted by El-Ashmawy *et al.* and Parada *et al.* in bladder cancer cells which induced by chemical carcinogen N-butyl-N-(4-hydroxybutyl) nitrosamine revealed that the administration of omega-3 fatty acids with the ability to inhibit tumor, produce apoptotic bodies, and inhibited the premalignant and malignant lesions.[31,32] In different stages of cancer development omega-3 fatty acids exerted the anticancer activity by influencing different mechanisms.[33] The investigation on anticancer effect of DHA on xenograft model colon cancer cell revealed that DHA down regulated several genes that induce cancer cell growth and migration.[34] Fish oil derived omega-3 fatty acid, EPA displayed the ability to inhibit the non-small cell lung cancer which is correlated with cyclooxygenase-2 enzyme expression and production of PGE3 helps in cell growth inhibition.[35] Som *et al.* detected that the PUFA extract of *S. longiceps* with more EPA content that exhibited more potent cytotoxic activity against breast cancer and prostate cancer cells even at lower concentration.[36]

The use of omega-3 fatty acids along with medicines used for anticancer treatment such as 5-flurouracil in colon cancer, 1α,25-dihydroxyvitamin D3 in liver cancer cause increase in cancer growth inhibition and reduce the side effects of drugs.[37-39] The diet supplementation of omega-3 fatty acids, Vitamin E and Vitamin C have increased the chemotherapic effect of cisplatin against lung cancer and reduced the side effects caused by the drug.[40] Study conducted by Siddiqui *et al.* with propofol-DHA and propofol-EPA, the conjugated forms of DHA and EPA along with a general anesthetic agent reported these compounds helped in inhibition of cell migration, adhesion and induction of apoptosis in certain breast cancer cell lines.[41]

The epidemiological study of association of omega-3 fatty acid from marine foods and prostate cancer reported that omega-3 fatty acid content such as linolenic acid in blood with ability to reduce the risk of prostate cancer.[42] Torfadottir *et al*. found that the consumption of fish oil can be protective against the prostate cancer development in elderly men and the use of smoked or salted fish create adverse effect in advanced stage of prostate cancer.[43]

However, the studies done by Brasky *et al*. and Szymanski *et al.*, they couldn't find any relation between high fish or fish oil consumption with reduction in risk of prostate cancer cell growth or mortality reduction.[44,45]

Conclusion

Both the marine and fresh water fish species contain omega-3 fatty acids in different concentrations and with many beneficial abilities. They can be included to control the growth of several pathogenic bacterial strains, inhibit the growth and metastasis of several cancer cell lines such as lung, colon breast, and prostate. From different studies, it can be concluded that the use of omega-3 fatty acids along with already existing anticancer drugs makes the drug more effective in controlling cancer cell growth. However, there were some studies that failed to correlate the effect of omega-3 fatty acids on cancer cells especially in prostate cancer. Hence, intensive investigations are needed to establish a clear idea about the functioning of omega-3 fatty acids against bacterial and cancer cells.

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