Omega-3 and fatty acids in fish and their impact on human health: A Literature Review

Corresponding author: Fathia A.H Lazrag

Kastamonu university

Department Aquaculture

tdebbek@yahoo.com

Abstract:

Omega-3 is a type of unsaturated fatty acid found in foods such as fish (salmon, sardines, and krill) as well as plant sources like flaxseeds, walnuts, and almonds. It can also be taken as dietary supplements such as fish oil and krill oil, with the addition of phospholipid krill oil to enhance absorption. Omega-3 fatty acids are known for their ability to reduce the risk of Alzheimer's disease and memory loss, as well as their role in preventing various diseases such as heart disease, cancer, inflammation, and rheumatoid arthritis. They are also beneficial for individuals with diabetes and those with prevalent coronary heart disease. It is important to monitor common indicators of omega-3 fatty acid supplements to prevent clinical events related to heart and vascular diseases. Additionally, there is a need to determine the impact of these supplements on clinical events for patients with prevalent coronary heart disease and provide recommendations for other individuals, including those with diabetes, stroke, heart failure, and atrial fibrillation.

Keywords: Health; Fish; Omega-3; Anesthesia; Coronary Heart Disease; Risk.

1. Introduction

Omega-3 fatty acids, especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), are essential fatty acids that play a crucial role in human health. They contribute to lowering blood cholesterol, preventing cardiovascular diseases, promoting brain cell growth and strengthening the immune system, as well as reducing the risk of cancer. *(Sajad Tajeddini etc.,.al 2022)* While the body can produce omega-3 fatty acids, the quantities are often insufficient and need to be obtained from the diet. Their consumption is particularly crucial for individuals with depression, and it is one of the few medical supplements recommended by the US Food and Drug Administration (FDA). *(Ibrahim M. Dighriri etc,.al 2022*) Omega-3 is a family of fats that are important for health. Omega-3 fats come in different forms:

• ALA (alpha-linolenic acid) cannot be made in the body so must be eaten in our diet. It has important functions and is needed to make other omega-3 fats. ALA is found mainly in vegetable oils, rapeseed and linseed (flaxseed), nuts (walnuts, pecans and hazelnuts) and green leafy vegetables. *(James, M J; etc., al. 2000) Douglas R Tocher. etc., al 2019),*

• EPA (eicosapentaenoic acid) and DHA (docosahexaenoic acid) are long-chain fats that can be made from ALA in our bodies. They have the most direct health benefits. omega-3 fats come from. (John Nowicki, etc,.al 2020)

Making EPA and DHA from ALA happens slowly and only small amounts are formed. The best way of ensuring we are taking enough EPA and DHA is to eat foods rich in these fats. Fish and especially oily fish are good sources of EPA and DHA. Oily fish have the highest levels so we should try and include these in our usual diet. *(Douglas R Tocher. etc., al 2019*), (James, M J; R A Gibson, L G Cleland, 2000). White fish contains some omega-3 but at much lower levels than oily fish. white fish also contain omega-3 and Examples include: cod, haddock, plaice, pollack, coley, dover sole, dab, flounder, red mullet and gurnard. Information about Omega-3 Fats:(*F Thies etc,.al.2001)*

Omega-3 fats have many functions in our body and are important for good health. There are three kinds of

• omega-3 fats:

ALA (alpha-linolenic acid).

DHA (docosahexaenoic acid).

EPA (eicosapentaenoic acid).

ALA is an essential fat so it must be consumed in the diet.

- Our bodies can make EPA and DHA from ALA, but this is very limited. Therefore, it is important to include
- foods rich in DHA and EPA in your diet.

While many people perceive all dietary fat as 'bad' or unhealthy, the body actually requires a moderate amount of fat (or fatty acids) to function properly. *(Ibrahim M. Dighriri etc,.al 2022*) In addition to serving as an energy source, fatty acids play a crucial structural role in all cell membranes, helping to maintain cell integrity. They also aid in the transportation, breakdown, and excretion of cholesterol in the body. Fatty acids are utilized in the production of important hormone-like compounds called eicosanoids, which regulate various bodily processes including inflammation and blood clotting. Furthermore, fatty acids contribute to the maintenance of healthy hair and skin, protect vital organs, and provide insulation for the body. *(Douglas R Tocher. etc., al 2019)* They are also essential for the transportation of fat-soluble vitamins A, D, E, and K from food into the body. In essence, without some fats in the diet, the body cannot function effectively. (*Selamoglu 2018, Selamoglu, 2021)*

3-Sources of omega:

A-Botanical sources.

Flax seeds are a rich source of omega-3 fatty acids, particularly alpha-linolenic acid (ALA), making flaxseed oil an abundant botanical source of omega-3. It contains approximately 55% ALA and is six times richer in omega-3 than most fish oils. Flax seeds have a higher ratio of omega-3 to omega-6 compared to other sources like chia. When consumed, 15 grams of flaxseed oil provides around 8 grams of ALA, which the body converts to EPA and DHA at an efficiency of 5-10% and 2-5%, respectively. vegetable oil-derived alpha-linolenic acid in providing sufficient levels of DHA and EPA for human consumption. It also explores the potential of microbial EPA/DHA production and genetically modified plant sources to meet the increasing global demand for omega-3 fatty acids. The review concludes that fish and vegetable oil sources may not be adequate to meet future needs, but algal oil and genetically modified terrestrial plants could potentially address the increased world demand for these essential nutrients. (*Norman Salem Jr and Manfred, Eggersdorfer,.2015)*

B-Animal sources:

Cold water oily fish such as salmon, herring, mackerel, anchovies, and sardines are rich sources of EPA and DHA omega-3 fatty acids, with a profile of about seven times more omega-3 than omega-6. Tuna and other oily fish also contain omega-3, albeit in lesser amounts. However, consumers should be cautious about potential heavy metal and pollutant accumulation in fish. Despite being a dietary source of omega-3 fatty acids, fish do not produce them; they acquire them from algae or plankton in their diet. Additionally, eggs from chickens fed a diet rich in greens and insects have higher levels of omega-3 fatty acids, primarily ALA, compared to those fed corn or soybeans.

Benefits of Omega-3 to health:

a-Cardiovascular Disease (CVD).

The consumption of omega-3 fatty acids has been linked to a significant reduction in the incidence of cardiovascular disease (CVD). Studies have shown that supplementing with EPA and DHA can lower plasma triglyceride levels, with reductions ranging from 18.3% to 30% in patients with hypertriglyceridemia.

(Sajad,Tajeddini,etc,.al.2022). This reduction is attributed to increased expression of lipoprotein lipase (LPL), which helps hydrolyze lipids, and decreased production of very-low-density lipoproteins (VLDL). Fish oil supplementation has also been associated with decreased body weight, blood pressure, low-density lipoprotein cholesterol, and C-reactive protein in patients with metabolic syndrome. Additionally, it has been found to reduce both systolic and diastolic blood pressure in hypertensive individuals.

In terms of cancer incidence, epidemiological studies have suggested that consuming fish oil may decrease the risk of developing certain types of cancer. For example, Norwegian women who consumed poached fish at least five times per week were 30% less likely to develop breast cancer. Similarly, women with high fish intake had a 30% reduction in mortality from breast cancer. Other studies have indicated a reduced risk of endometrial, ovarian, and prostate cancer

with higher intake of omega-3 fatty acids. Overall, omega-3 fatty acids from fish oil have shown potential benefits in reducing the risk of cardiovascular disease and certain types of cancer, as well as in managing conditions such as hypertriglyceridemia, metabolic syndrome, and hypertension.

Benefits It is better to eat more foods containing omega-3

Fish and shellfish are rich in essential vitamins and minerals such as iodine, calcium, selenium, as well as vitamins A, D, and protein. They offer various health benefits, including protecting the heart and blood vessels from diseases, supporting healthy development during pregnancy and breastfeeding, and potentially aiding in maintaining good memory and preventing/treating depression. However, the main source of omega-3s is from marine fish oils, and some fish species are experiencing declining stocks, such as wild salmon and trout. *(D. N. Kaplan, Z. Selamoglu 2021), (Song, Cai;etc.al 2003)* Therefore, it is important to choose fish from sustainable sources whenever possible. This can be achieved by looking for products approved by the Marine Stewardship Council (MSC) or referring to The Good Fish Guide from the Marine Conservation Society. Additionally, some omega-3 supplements are now derived from microalgae, and ongoing research aims to find sustainable methods for producing omega-3 from plant sources.

Fish and seafood are good sources of omega-3 fatty acids, including mackerel, herring, bluefish, striped bass, salmon, whitefish, swordfish, and sardines. However, certain fish, such as shark, swordfish, and marlin, may contain high levels of mercury, which can be harmful to the developing nervous system of fetuses and young children. Therefore, pregnant women, those planning to become pregnant, and children under 16 should avoid these types of fish.

It is recommended that all adults, including breastfeeding women, consume more than one serving of these oily fish per week. Women of childbearing age or those not intending to have children, as well as men and boys, should have four servings of other oily fish per week. (Gunnarsdottir,.etc,.al 2005)

Pregnant or breastfeeding women, or those who may become pregnant, and girls who may become pregnant in the future, are advised to have two servings of oily fish per week.

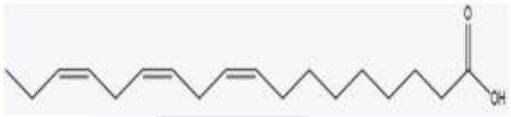
Type of Omega fatty acids:

A-Omega-3 fatty acids.

They are a type of polyunsaturated fat (such as omega-6), which is considered an essential fatty acid because it cannot be manufactured by the body. Such as fish, nut, and plant-based oils such as canola oil and sunflower oils *(Das, U N; Fams .2003)*

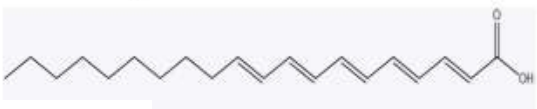
Types of omega-3 fatty acids:

ALA –or alpha-linolenic acid, is an 18-carbon chain and three cis double bonds. The first double bond is located in the n-3 position or at the omega end of the fatty acid. Thus, ALA is considered a polyunsaturated n−3 (omega-3) fatty acid. *(Douglas R Tocher. etc., al 2019),(Saravanan, P,.2010)*



Alpha linolenic acid

EPA –or eicosapentaenoic acid contains a 20- carbon chain and five cis double bonds; the first double bond is located at the third carbon from the omega end. Therefore, EPA also is considered an omega-3 fatty acid. DHA – DHA or docosahexaenoic acid is a 22-carbon chain with six cis double bonds; the first double bond is located at the third carbon from the omega end of the fatty acid. *(Douglas R Tocher. etc., al 2019)*



Eicosapentaenoic acid

DHA or docosahexaenoic acid is a 22-carbon chain with 6 cis double bonds. The first double bond is located at the third carbon from the delta an end of fatty acid sources of DHA: Oily fishes such as Cod liver, Herring, Mackerel, Salmon, and Sardines and also are produced from algal fermentation *(Lands, M. 2005).*

Docosahexaenoic acid

sources of these omega-3 fatty acids:

Foods provide omega-3s, Omega-3s are found naturally in some foods and are added to some fortified foods You can get adequate amounts of omega-3s by eating a variety of foods, including the following:

• Fish and other seafood (especially cold-water fatty fish, such as salmon, mackerel, tuna, herring, and sardines).

• Nuts and seeds (such as flaxseed, chia seeds, and walnuts).

• Plant oils (such as flaxseed oil, soybean oil, and canola oil).

• Fortified foods (such as certain brands of eggs, yogurt, juices, milk, soy beverages, and infant formulas).

ALA – Canola, Soybeans, Walnuts, and Flaxseed

EPA – Oily fishes such as Cod Liver, Herring, Mackerel, Salmon, and Sardines

DHA – Oily fishes such as Cod Liver, Herring, Mackerel, Salmon, and Sardines, and also are produced from algal fermentation.

b-Omega-6 fatty acids:

Omega-6 fatty acid is also a polyunsaturated fat, essential for human health because it cannot be made in the body. For this reason, people must obtain omega-6 fatty acids by consuming foods such as meat, poultry, and eggs as well as nut and plant-based oils such as canola and sunflower oils.

The types of omega-6 fatty acids,

LA –or linolenic acid is an unsaturated omega-6 fatty acid. Chemically, it is an 18-carbon chain. The first double bond is located at the sixth carbon from the omega end of the fatty acid.

Linoleic acid

AA –or Arachidonic acid is a 20-carbon chain. Its first double bond is located at the sixth carbon from the omega end of the fatty acid. *(Douglas R Tocher. etc., al 2019)*

The sources of omega-6 fatty acids:

LA – Soybean oil, Corn oil, Safflower Oil, Sunflower Oil, Peanut Oil, Cottonseed oil, and Rice Bran Oil.

AA – Peanut Oil, Meat, Eggs, and Dairy Products

C-Omega-9 fatty acids:

Oleic acid is a 18-carbon chain with 9 cis double bonds The first double bond is located at the ninth carbon from the omega end of fatty acid.

Oleic acid

Omega-9 fatty acids, Omega-9 fatty acids are from a family of unsaturated fats that commonly are found in vegetable and animal fats. This monounsaturated fat is described as omega-9 because the double bond is in the ninth position from the omega end. These fatty acids are also known has oleic acids or monounsaturated fats and can often be found in canola, sunflower, olive, and nut oils. Unlike omega-3 and omega-6 fatty acids, omega-9 fatty acids are produced by the body, but are also beneficial when they are obtained in food.

The types of omega-9 fatty acids:

Oleic acid –is a main component of canola oil, sunflower oil, olive oil, and other monounsaturated fats, many of which are used as a solution for reducing bad fats in cooking oils.

The sources of omega-9 fatty acids:

Oleic acid – Canola oil, Sunflower Oil, and Almonds Specially developed oils for foodservice, such as Omega-9 Canola and Sunflower Oils, are uniquely high in monounsaturated fats (>70 percent) and reduces key factors that contribute to heart disease and diabetes. Omega-9 fatty acids are found in various animal and plant sources. Canola, sunflower, olive, and nut oils have significant levels of omega-9 fatty acids, which are also known as high-oleic acids, or monounsaturated fats. Oils produced from these sources have emerged as healthier, highly functional replacements for partially hydrogenated cooking oils, which are often laden with unhealthy trans and saturated fats. (*F Thies,.etc.al.2001*)

Fatty acids profile of freshwater fish species

Cyprinus carpio Common carp

Fatty acids (%)	
0.4 ± 0.0	C12:00
0.19 ± 0.0	C13:00
1.28 ± 0.02	C14:00
0.67 ± 0.0	C15:00
15.9 ± 0.3	C16:00
1.47 ± 0.04	C17:00
6.18 ± 0.27	C18:00
0.19 ± 0.0	C20:00
0.31 ± 0.02	C22:00
1.33 ± 0.05	C23:00
0.0 ± 0.0	C24:00
28.0	ƩSFA
6.39 ± 0.14	C18:2n6
0.25 ± 0.02	C18:3n6

3.36 ± 0.28	C18:3n3
0.4 ± 0.01	C18:4n3
0.12 ± 0.01	C20:2cis
9.16 ± 0.17	C20:3n6
0.46 ± 0.14	C20:4n6
5.86 ± 0.07	C20:5n3
0.09 ± 0.08	C22:2cis
8.21 ± 0.07	C22:6n3
34.3	ƩPUFA

Fatty acid profiles and fat contents of commercially important seawater and freshwater fish species of Turkey: A comparative study Yesim O¨ zogul a, *, Fatih O¨ zogul a, Sibel Alagozb

Fatty Acid Composition of Species of Fish from the Black Sea and the Marmara Sea

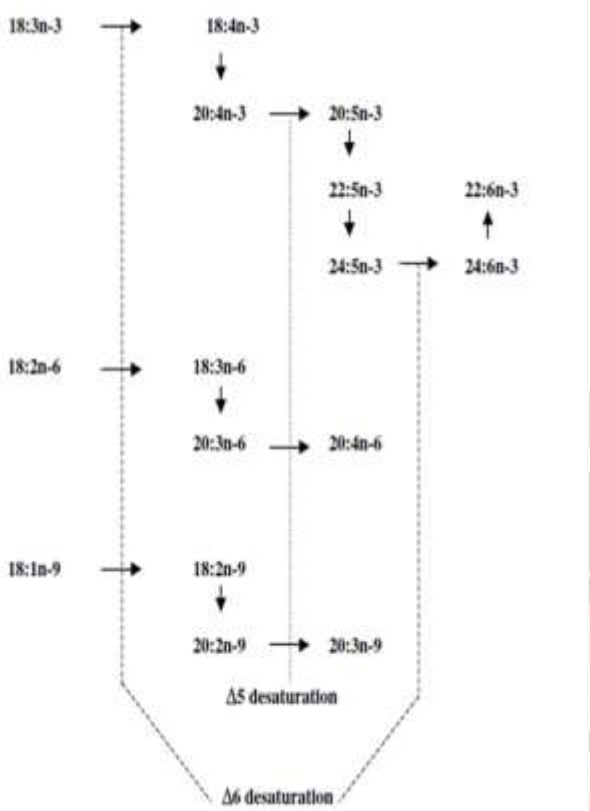
Dicentrarchus labrax Sea bass	Sparus auratus Sea bream	Fatty acids (%)
15.9 ± 0.08	20 ± 0.18	C18:1n9
3.21 ± 0.04	0.14 ± 0.01	C20:1
0.07 ± 0.01	0.13 ± 0.12	C22:1n9
0.0 ± 0.0	0.0 ± 0.0	C24:1
24.6	28.0	ƩMUFA
14.0 ± 0.09	7.46 ± 0.07	C18:2n6
0.19 ± 0.0	0.17 ± 0.0	C18:3n-6
1.61 ± 0.05	1.22 ± 0.03	C18:3n-3
0.02 ± 0.0	0.39 ± 0.51	C18:4n-3
0.65 ± 0.0	0.20 ± 0.01	C20:2cis
0.14 ± 0.0	0.12 ± 0.01	C20:3n-6
0.89 ± 0.03	0.41 ± 0.05	C20:3n-3
0.08 ± 0.0	0.40 ± 0.02	C20:4n-6
.02 ± 0.037	6.77 ± 0.13	C20:5n3
0.04 ± 0.05	0.0 ± 0.0	C22:2cis
14.7 ± 0.21	17.4 ± 0.71	C22:6n3
39.3	34.5	ƩPUFA

Fatty acids (%)	**Sparus auratus Sea bream**	**Dicentrarchus labrax Sea bass**
C18:1n9	20 ± 0.18	15.9 ± 0.08
C20:1	0.14 ± 0.01	3.21 ± 0.04
C22:1n9	0.13 ± 0.12	0.07 ± 0.01
C24:1	0.0 ± 0.0	0.0 ± 0.0
ƩMUFA	28.0	24.6
C18:2n6	7.46 ± 0.07	14.0 ± 0.09
C18:3n-6	0.17 ± 0.0	0.19 ± 0.0
C18:3n-3	1.22 ± 0.03	1.61 ± 0.05
C18:4n-3	0.39 ± 0.51	0.02 ± 0.0
C20:2cis	0.20 ± 0.01	0.65 ± 0.0
C20:3n-6	0.12 ± 0.01	0.14 ± 0.0
C20:3n-3	0.41 ± 0.05	0.89 ± 0.03
C20:4n-6	0.40 ± 0.02	0.08 ± 0.0
C20:5n3	6.77 ± 0.13	.02 ± 0.037
C22:2cis	0.0 ± 0.0	0.04 ± 0.05
C22:6n3	17.4 ± 0.71	14.7 ± 0.21
Ʃ PUFA	34.5	39.3

Fatty Acid Composition of Species of Fish from the Black Sea and the Marmara Sea

Refik Tanakola, *, Zeliha Yazıcıb, Erdal ,Senerc, and Ergin Sencera a Department of Endocrinology, 2006Metabolism and Nutrition, Istanbul Faculty of Medicine, University of Istanbul,

Fatty Acid Composition of the Flesh Lipid of the Fish a form the Black Sea, the Marmara Sea, and Freshwater



Third Edition Fish Nutrition Edited by John E. Halver School of Aquatic and Fishery Sciences University of Washington Seattle, Washington and Ronald W. Hardy Hagerman Fish Culture Experiment Station University of Idaho Hagerman, Idaho 2002

Pathways of biosynthesis of C20 and C22 PUFA from n-3, n-6, and n-9 C18 precursors. Vertical downward arrows represent fatty acid chain elongation reactions. Horizontal arrows represent fatty acyl desaturations. The single vertical upward arrow represents peroxisomal chain shortening. Note that fatty acid _6 desaturation occurs at two steps in the scheme; fatty acid _5 desaturation occurs at only one step.

Conclusion

The health benefits of consuming oily fish outweigh the risks from pollutants. It is recommended for most people to increase their intake of fish from sustainable sources, especially for women of childbearing age and children under 16. While supplement use is not currently recommended for healthy adults and children, recent evidence suggests that omega-3 fats play a role in preventing heart disease and treating other illnesses. Omega-3 fatty acids have diverse health effects, including reducing cardiovascular issues and benefiting patients with various conditions such as dyslipidaemia, atherosclerosis, hypertension, diabetes, metabolic syndrome, obesity, inflammatory diseases, neurological disorders, and eye diseases. Consuming omega-3 fatty acids during pregnancy reduces the risk of premature birth and enhances fetal intellectual development. Fish, fish oils, and some vegetable oils are rich sources of omega-3 fatty acids, and according to UK guidelines, a healthy adult should consume a minimum of two portions of fish per week to obtain these health benefits. This review provides an overview of the health implications, dietary sources, deficiency states, and recommended allowances of omega-3 fatty acids in human nutrition.

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