The Content of Favorable and Unfavorable Polyunsaturated Fatty Acids Found in Commonly Eaten Fish

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Kelly L. Weaver PhD, Priscilla Ivester MS, Joshua A. Chilton, Martha D. Wilson PhD, Prativa Pandey and Floyd H. Chilton PhD,

FROM ABSTRACT:

Changes in diet during the past century have caused a marked increase in consumption of saturated fatty acids and n-6 polyunsaturated fatty acids (PUFAs) with a concomitant decrease in the intake of n-3 PUFAs.

Increased fish consumption has been shown to be the only realistic way to increase dietary quantities of beneficial long-chain n-3 PUFAs such as eicosapentaenoic acid and docosahexaenoic acid and re-establish more balanced n-6:n-3 ratios in the diets of human beings.

Our objective in this research was to characterize some of the relevant fatty acid chemistry of commonly consumed fish, with a particular focus on the four most commonly consumed farmed fish. To do this, 30 commonly consumed farmed and wild fish were collected from supermarkets and wholesalers throughout the US.
Fatty acid composition of samples from these fish was determined using gas chromatography.

The 30 samples studied contained n-3 PUFAs ranging from fish having almost undetectable levels to fish having nearly 4.0 g n-3 PUFA per 100 g fish.

The four most commonly farmed fish, Atlantic salmon, trout, tilapia, and catfish, were more closely examined.

This analysis revealed that trout and Atlantic salmon contained relatively high concentrations of n-3 PUFA, low n-6:n-3 ratios, and favorable saturated fatty acid plus monounsaturated fatty acid to PUFA ratios.

In contrast, tilapia (the fastest growing and most widely farmed fish) and catfish have much lower concentrations of n-3 PUFA, very high ratios of long chain n-6 to long chain n-3 PUFAs, and high saturated fatty acid plus monounsaturated fatty acid to PUFA ratios.

Taken together, these data reveal that marked changes in the fishing industry during the past decade have produced widely eaten fish that have fatty acid characteristics that are generally accepted to be inflammatory by the health care community.

THESE AUTHORS ALSO NOTE:

"Compelling evidence demonstrating the health benefits of n-3 polyunsaturated fatty acids (PUFAs) in fish together with dwindling supplies of fish caught from the wild have spawned a dramatic expansion in aquaculture."

"Although a great deal of attention has been focused on the contamination of farmed fish populations with methyl mercury, polychlorinated biphenyls, and other organic compounds, little has been published with regard to the effects of rapid changes in the fish industry on PUFA or saturated fatty acid (SFA) levels in emerging, intensively farmed species of fish."

"Our research reveals certain intensively farmed species of fish contain PUFA profiles that have been shown to be detrimental to human health." **[Key Point]**

In the United States the quantity of farmed fish is ranked as follows:
#1 Atlantic salmon
#2 Tilapia
#3 Catfish
#4 Trout

"Long-chain n-3 PUFAs such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) found in oily fish are thought to be critical bioactive components that account for many of the health benefits of fish."

The American Heart Association recommends that patients with hypertriglyceridemia consume 2 to 4 g EPA+DHA per day.

"The ratio of arachidonic acid (AA) to very long-chain n-3 PUFAs (EPA and DHA) in diets of human beings appears to be an important factor that dictates the anti-inflammatory effects of fish oils." **[Key Point]**

Ingestion of fish or fish oil markedly increases EPA in cell membranes and decreases arachidonic acid, reducing the production of pro-inflammatory prostaglandins, thromboxanes, and leukotrienes, while increasing the anti-inflammatory protective chemical mediators known as resolvins and protectins, which are proposed to play a pivotal role in resolving inflammatory response.

The US Department of Agriculture (USDA) reports that farm-raised Atlantic salmon contains more than 1 g dietary arachidonic acid per 100 g (approximately 3.5 oz.) fish, and also states "farmed salmon is by far the richest source of arachidonic acid in most Western diets and raises important questions regarding its consumption, especially by vulnerable populations."

60% of the farmed salmon obtained on the US east coast is from Chile.

Samples of farmed tilapia, catfish, trout, and salmon were also obtained from farms in Wisconsin, Idaho, North Carolina, Ecuador, Honduras, Norway, New Zealand, western Canada, and Chile.

In this study, fish species were divided into three categories based upon omega-3 fatty acids per 100 g of fish (3.5 oz.):

1) Those that contained >500 mg (Category 1)
2) Those that contained between 150 and 500 mg (Category 2)
3) Those that contained <150 mg n-3 fatty acids per 100 g fish (Category 3)

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Category 1 Fish, more than 500 mg / 100 g (3.5 oz)

<u>Rank of omega-3 fatty acids, from lowest to highest:</u>

Bronzini, Sockeye Salmon, Copper River Salmon, Toothfish, Coho Salmon

"Sockeye salmon contained both high concentrations of n-3 PUFAs and low concentrations of n-6 PUFAs resulting in a very favorable n-3 to n-6 ratio."

"Coho salmon, Copper River salmon, and farmed rainbow trout also contained beneficial concentrations and ratios of n-3 PUFAs and n-6 PUFAs."

"Although farmed Atlantic salmon contained high concentrations of n-3 PUFAs, they also contained much higher concentrations of n-6 PUFAs."

The graph shows that of the wild fish assessed, Coho Salmon significantly had the greatest amount of omega-3 fatty acids, with a very low level of omega-6 fatty acids.

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<u>Category 2</u> Fish, between 150 - 500 mg / 100 g (3.5 oz)

<u>Rank of omega-3 fatty acids, from lowest to highest:</u>

Croakers, Perch, Cod, Sole, Halibut, Flounder, Hake, Haddock, Farmed Tilapia, Black Bass, Swordfish, Farmed Catfish, Escolar

"Both farm-raised tilapia and farm-raised catfish had considerably higher concentrations of n-6 PUFAs when compared to n-3 PUFAs. In both cases, this resulted in n-6 to n-3 ratios >2."

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<u>Category 3</u> Fish, less than 150 mg / 100g (3.5 oz)

<u>Rank of omega-3 fatty acids, from lowest to highest:</u>

Tuna, Red Snapper, Corvina, Triggerfish, Monkfish, Skate, Wahoo, Blue Fin Tuna, Grouper, Mahi-Mahi

"Tuna, the second most consumed fish in the United States falls into this category and contains slightly more n-6 PUFAs relative to n-3 PUFAs."

Additionally, the graph shows that tuna has almost no omega-3 fatty acids, coming in absolutely last on the list.

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Farm-raised salmon and trout contained the highest concentrations of n-3 PUFAs.

"There were relatively low concentrations of n-3 PUFAs in both tilapia and catfish. This is important because the vast majority of tilapia and catfish available for consumption in the United States is farmed, not wild."

18-carbon n-3 or n-6 PUFAs such as alpha-linolenic acid [as from flax seed oil] and linoleic acid [as from corn, soy, cotton, peanut, sunflower, safflower], are poorly converted to very long-chain n-3 or n-6 PUFAs by humans.

Both farmed tilapia and catfish contained high arachidonic acid.

The average AA/EPA ratio in farm-raised tilapia was approximately 11/1, and samples from Central America contained more than 20/1.

The amount of arachidonic acid per 100-g portion was as follows:

Central America farmed tilapia	>300 mg
Other farmed tilapia	134 mg
Farmed catfish	67 mg
Pork bacon	191 mg
80% lean hamburger	34 mg
A doughnut	4 mg

"For individuals who are eating fish as a method to control inflammatory diseases such as heart disease, it is clear from these numbers that tilapia is not a good choice."

"The inflammatory potential of hamburger and pork bacon is lower than the average serving of farmed tilapia."

Other studies note "farm-raised Atlantic salmon contains much higher levels of arachidonic acid (1,152 mg/100g) and an arachidonic acid to EPA ratio of 1.9/1."

DISCUSSION

"The most rapidly expanding fish in terms of world and US consumption, tilapia, as well as farmed catfish, have several fatty acid characteristics that would generally be considered by the scientific community as detrimental."

"The concentrations of n-6 PUFAs and more specifically the long-chain n-6 PUFA arachidonic acid in farmed tilapia and catfish are very high. In fact, these fish contain some of the highest levels of arachidonic acid found in human beings' food chain."

"Increased dietary arachidonic acid can cause a more than four-fold increase in the production of leukotriene B4, which plays a central role in the pathology of disease in human beings, especially inflammatory disease." **[Important]**

A large proportion of asthmatics overproduce leukotrienes.

There is a strong correlation between arachidonic acid consumption and production of prostaglandin E2 and a significant irreversible aggregation of platelets.

The USDA National Nutrition Database notes that farm-raised salmon has 1,150 mg arachidonic acid and 618 mg EPA per 100 mg portion.

Increasing EPA relative to arachidonic acid blocks pro-inflammatory prostaglandin formation from arachidonic acid by inhibiting cyclooxygenase.

A critical effect of increasing EPA is that it enhances the formation of prostaglandin E3 (PGE3) by utilizing COX-2. PGE3 blocks inflammation, whereas arachidonic acid derived PGE2 promotes inflammation.

"Both EPA and DHA have been shown to be converted into anti-inflammatory mediators known as resolvins and protectins."

Tilapia is a very hardy fish that grows rapidly on formulated feeds that contain lower protein levels and higher carbohydrate levels. They are easy to breed and their nutrition is exclusively dependent on commercially formulated diets, typically high in the n-6 fatty acid linoleic acid from vegetable oils, which is efficiently converted to arachidonic acid.

Unfortunately, aquaculture, "can give rise to detrimental and potentially harmful PUFAs when fatty acid precursors of those PUFAs fed to fish are not taken into account."

Since 2000, shipments of frozen tilapia from China to the US have risen from 4 million to 140 million lbs, now comprising 66% of all tilapia imports.

"Despite recommendations from organizations such as the AHA to increase fish consumption in general, this study shows that not all fish are created equal."

"Farmed tilapia and catfish have low levels n-3 fatty acids along with levels of arachidonic acid so high they can be considered detrimental."

KEY POINTS FROM DAN MURPHY:

1) "Changes in diet during the past century have caused a marked increase in consumption of saturated fatty acids and n-6 polyunsaturated fatty acids (PUFAs) with a concomitant decrease in the intake of n-3 PUFAs."

2) "Increased fish consumption has been shown to be the only realistic way to increase dietary quantities of beneficial long-chain n-3 PUFAs such as eicosapentaenoic acid and docosahexaenoic acid."

3) There is compelling evidence demonstrating the health benefits of n-3 polyunsaturated fatty acids (PUFAs) in fish.

4) All farmed fish is contaminated with methyl mercury, polychlorinated biphenyls, and other organic compounds.

5) "Our research reveals certain intensively farmed species of fish contain PUFA profiles that have been shown to be detrimental to human health." **[Key Point]**

6) In the United States, the most farmed fish are:
#1 Atlantic salmon
#2 Tilapia
#3 Catfish
#4 Trout

7) "Long-chain n-3 PUFAs such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) found in oily fish are thought to be critical bioactive components that account for many of the health benefits of fish."

8) The American Heart Association recommends that patients with hypertriglyceridemia consume 2 to 4 g EPA+DHA per day.

9) "The ratio of arachidonic acid (AA) to very long-chain n-3 PUFAs (EPA and DHA) in diets of human beings appears to be an important factor that dictates the anti-inflammatory effects of fish oils." **[Key Point]**

10) Ingestion of fish or fish oil markedly increases EPA in cell membranes and decreases arachidonic acid, reducing the production of pro-inflammatory prostaglandins, thromboxanes, and leukotrienes, while increasing the anti-inflammatory protective chemical mediators known as resolvins and protectins, which are proposed to play a pivotal role in resolving inflammatory response.

11) The US Department of Agriculture (USDA) reports that farm-raised Atlantic salmon contains more than 1 g dietary arachidonic acid per 100 g (approximately 3.5 oz.) fish and also state "farmed salmon is by far the richest source of arachidonic acid in most Western diets and raises important questions regarding its consumption, especially by vulnerable populations."

12) "Sockeye salmon contained both high concentrations of n-3 PUFAs and low concentrations of n-6 PUFAs resulting in a very favorable n-3 to n-6 ratio."

13) "Although farmed Atlantic salmon contained high concentrations of n-3 PUFAs, they also contained much higher concentrations of n-6 PUFAs."

14) Tuna is the second most consumed fish in the US and has low levels of n-3 PUFAs and "contains slightly more n-6 PUFAs relative to n-3 PUFAs."

15) "There were relatively low concentrations of n-3 PUFAs in both tilapia and catfish. This is important because the vast majority of tilapia and catfish available for consumption in the United States is farmed, not wild."

16) Both farmed tilapia and catfish contained high arachidonic acid.

17) The average AA/EPA ratio in farm-raised tilapia was approximately 11/1, and samples from Central America contained more than 20/1.

18) The amount of arachidonic acid per 100-g portion (3.5 oz.) was as follows:

Central America farmed tilapia	>300 mg
Other farmed tilapia	134 mg
Farmed catfish	67 mg
Pork bacon	191 mg
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A doughnut	4 mg

19) "For individuals who are eating fish as a method to control inflammatory diseases such as heart disease, it is clear from these numbers that tilapia is not a good choice."

20) "The inflammatory potential of hamburger and pork bacon is lower than the average serving of farmed tilapia."

21) Studies note "farm-raised Atlantic salmon contains much higher levels of arachidonic acid (1,152 mg/100g) and an arachidonic acid to EPA ratio of 2/1."

22) "The most rapidly expanding fish in terms of world and US consumption, tilapia, as well as farmed catfish, have several fatty acid characteristics that would generally be considered by the scientific community as detrimental."

23) "The concentrations of n-6 PUFAs and more specifically the long-chain n-6 PUFA arachidonic acid in farmed tilapia and catfish are very high. In fact, these fish contain some of the highest levels of arachidonic acid found in human beings' food chain."

24) "Increased dietary arachidonic acid can cause a more than four-fold increase in the production of leukotriene B4, which plays a central role in the pathology of disease in human beings, especially inflammatory disease." **[Important]**

25) A large proportion of asthmatics overproduce leukotrienes.

26) There is a strong correlation between arachidonic acid consumption and production of prostaglandin E2 and a significant irreversible aggregation of platelets.

27) Increasing EPA relative to arachidonic acid blocks pro-inflammatory prostaglandin formation from arachidonic acid by inhibiting cyclooxygenase.

28) A critical effect of increasing EPA is that it enhances the formation of prostaglandin E3 (PGE3) by utilizing COX-2. PGE3 blocks inflammation, whereas arachidonic acid derived PGE2 promotes inflammation.

29) "Both EPA and DHA have been shown to be converted into anti-inflammatory mediators known as resolvins and protectins."

30) Tilapia is a very hardy fish that grows rapidly on formulated feeds that contain lower protein levels and higher carbohydrate levels. They are easy to breed and their nutrition is exclusively dependent on commercially formulated diets, typically high in the n-6 fatty acid linoleic acid from vegetable oils, which is efficiently converted to arachidonic acid.

31) Unfortunately, aquaculture, "can give rise to detrimental and potentially harmful PUFAs when fatty acid precursors of those PUFAs fed to fish are not taken into account."

32) Since 2000, shipments of frozen tilapia from China to the US have risen from 4 million to 140 million lbs, now comprising 66% of all tilapia imports.

33) "Despite recommendations from organizations such as the AHA to increase fish consumption in general, this study shows that not all fish are created equal."

34) "Farmed tilapia and catfish have low levels n-3 fatty acids along with levels of arachidonic acid so high they can be considered detrimental."

35) Of the wild fish assessed, Coho Salmon significantly had the greatest amount of omega-3 fatty acids, with a very low level of omega-6 fatty acids.

36) Tuna is the second most consumed fish in the US, and the graph shows that tuna has almost no omega-3 fatty acids, coming in absolutely last on the list at zero.

SPECIAL NOTE: Although this study showed high levels of omega-3 fatty acids in farmed salmon and especially in farmed trout, other studies we have reviewed claim that farmed fish may also contain contaminants that make them carcinogenic.