Is there any nutritional difference between wild-caught and farm-raised fish? Is one type better for me than the other?

Overview

From both a nutritional and environmental impact perspective, farmed fish are far inferior to their wild counterparts:

- Despite being much fattier, farmed fish provide less usable beneficial omega 3 fats than wild fish.
- Due to the feedlot conditions of aquafarming, farm-raised fish are doused with antibiotics and exposed to more concentrated pesticides than their wild kin. Farmed salmon, in addition, are given a salmon-colored dye in their feed, without which, their flesh would be an unappetizing grey color.
- Aquafarming also raises a number of environmental concerns, the most important of which may be its negative impact on wild salmon. It has now been established that sea lice from farms kill up to 95% of juvenile wild salmon that migrate past them.(Krkosek M, Lewis MA. Proc Natl Acad Sci U S A.)

Nutritional Differences

Omega 3 Fat Content

FDA statistics on the nutritional content (protein and fat-ratios) of farm versus wild salmon show that:

- The fat content of farmed salmon is excessively high--30-35% by weight.
- Wild salmon have a 20% higher protein content and a 20% lower fat content than farm-raised salmon.
- Farm-raised fish contain much higher amounts of pro-inflammatory omega 6 fats than wild fish.

These unfortunate statistics are confirmed in a recent (1988-1990) study conducted by the U.S. Department of Agriculture (USDA) to compare the nutrient profiles of the leading species of wild and cultivated fish and shellfish. Three species of fish that contain beneficial omega 3 fats were included: catfish, rainbow trout, and coho salmon.

Farm-raised Fish are Fattier

In all three species, the farm-raised fish were fattier. Not surprising since farm-raised fish do not spend their lives vigorously swimming through cold ocean waters or leaping up rocky streams. Marine couch potatoes, they circle lazily in crowded pens fattening up on pellets of fish chow.

In each of the species evaluated by the USDA, the farm-raised fish were found to contain more total fat than their wild counterparts. For rainbow trout, the difference in total fat (5.4g/100g in wild trout vs. 4.6 g/100g in cultivated trout) was the smallest, while cultivated catfish had nearly five times as much fat as wild (11.3g/100 g in cultivated vs. 2.3 g/100g in wild). Farm-raised coho salmon had approximately 2.7 times the total fat as wild samples.

Cultivated catfish were the worst, with 5 times the fat content of their wild counterparts. Plus, although the farm-raised catfish, rainbow trout and coho salmon contained as much or even more omega-3 fatty acids as their wild equivalents, in proportion to the amount of omega-6 fats they also contained, they actually provided less usable omega-3s.

Farm-raised Fish Provide Less Usable Omega-3 Fats

The reason for this apparent discrepancy is that both omega 3 and omega 6 fats use the same enzymes for conversion into the forms in which they are active in the body. The same elongase and desaturase enzymes that convert omega-3 fats into their beneficial anti-inflammatory forms (the series 3 prostaglandins and the less inflammatory thromboxanesand leukotriennes) also convert omega-6 fats into their pro-inflammatory forms (the series 2 prostaglandins and the pro-inflammatory thromboxanes and leukotrienes). So, when a food is eaten that contains high amounts of omega 6s in proportion to its content of omega 3s, the omega-6 fats use up the available conversion enzymes to produce pro-inflammatory compounds while preventing the manufacture of anti-inflammatory substances from omega-3s, even when these beneficial fats are present.

Farm-raised Fish Contain More Pro-inflammatory Omega-6 Fats

In all three types of fish, the amount of omega 6 fats was substantially higher in farm-raised compared to wild fish. Cultivated trout, in particular, had much higher levels of one type of omega 6 fat called linoleic acid than wild trout (14% in farm-raised compared to 5% in wild samples). The total of all types of omega 6 fats found in cultivated fish was twice the level found in the wild samples (14% vs 7%, respectively).

Wild Fish Provide More Omega-3 Fats

In all three species evaluated, the wild fish were found to have a higher proportion of omega-3 fats in comparison to omega 6 fats than the cultivated fish. The wild coho were not only much lower in overall fat content, but also were found to have 33% more omega 3 fatty acids than their farm-raised counterparts. Omega 3s accounted for 29% of the fats in wild coho versus 19% of the fats in cultivated coho. Rainbow trout showed similar proportions in fatty acid content; wild trout contained approximately 33% more omega 3s than cultivated trout, however both cultivated and wild trout did have much lower amounts of omega 6 fats than the other types of fish.

Antibiotic and Pesticide Use

Disease and parasites, which would normally exist in relatively low levels in fish scattered around the oceans, can run rampant in densely packed oceanic feedlots. To survive, farmed fish are vaccinated as small fry. Later, they are given antibiotics or pesticides to ward off infection.

Sea lice, in particular, are a problem. In a recent L.A. Times story, Alexandra Morton, an independent biologist and critic of salmon farms, is quoted as beginning to see sea lice in 2001 when a fisherman brought her two baby pink salmon covered with them. Examining more than 700 baby pink salmon around farms, she found that 78 percent were covered with a fatal load of sea lice while juvenile salmon she netted farther from the farms were largely lice-free.

While salmon farmers have discounted Morton's concerns saying that sea lice are also found in the wild, at the first sign of an outbreak, they add the pesticide emamectin benzoate to the feed. According to officials, the use of pesticides should pose no problem for consumers since Canadian rules demand that pesticide use be stopped 25 days before harvest to ensure all residues are flushed from the fish.

Scientists in the United States are far more concerned about two preliminary studies-one in British Columbia and one in Great Britain-both of which showed farmed salmon accumulate more cancer-causing PCBs and toxic dioxins than wild salmon.

The reason for this pesticide concentration is the salmon feed. Pesticides, including those now outlawed in the United States, have circulated into the ocean where they are absorbed by marine life and accumulate in their fat, which is distilled into the concentrated fish oil that is a major ingredient in salmon feed. Salmon feed contains higher concentrations of fish oil-extracted from sardines, anchovies and other ground-up fish-than wild salmon normally consume. Scientists in the U.S. are currently trying to determine the extent of the pesticide contamination in farmed salmon and what levels are safe for human consumption.

Research on this issue published July 30, 2003, by the Environmental Working Group, indicates that levels of carcinogenic chemicals called polychlorinated biphenyls (PCBs) found in farmed salmon purchased from U.S. grocery stores are so much higher than levels of PCBs found in wild salmon that they pose an increased risk for cancer. PCBs have been banned in the US for use in all but completely closed areas since 1979, but they persist in the environment and end up in animal fat.

When farmed salmon from U.S. grocery stores was tested, the farmed salmon, which contains up to twice the fat of wild salmon, was found to contain 16 times the PCBs found in wild salmon, 4 times the levels in beef, and 3.4 times the levels found in other seafood. Other studies done in Canada, Ireland and Britain have produced similar findings.(September 8, 2003)

Flame Retardants: Another Reason to Avoid Farmed Salmon

Flame-retardant additives used widely in electronics and furniture are appearing in increasing amounts in fish, and farmed salmon contain significantly higher levels of these polybrominated diphenyl ether (PBDE) compounds than wild salmon, according to research published in the August 11, 2004 issue of *Environmental Science and Technology*.

PBDEs are endocrine disrupters that have been shown to have reproductive toxicity, and are also suspected to play a role in cancer formation. As with other toxins, it is thought that farm-raised salmon contain higher PBDE levels than wild due to the "salmon chow," a mixture of ground fish and oil, they are fed.

The authors of this new study, Ronald Hites of Indiana University and colleagues, analyzed the same group of 700 wild and farmed salmon collected from around the world from which the data was drawn for their initial research on other contaminants in salmon, which was published in *Science* in January 2004.

As was the case with the 14 contaminants described in the earlier report-which included pesticides such as toxaphene and dieldrin-the researchers found the highest levels of PBDEs, on average, in farm-raised salmon from Europe. But while European farmed salmon had the highest levels, farmed North American salmon came next with significantly higher amounts of PBDEs than were found in farmed salmon from Chile, which, in turn, were higher than the average levels seen in wild salmon.

In both farmed and wild salmon, approximately 50% of the total PBDEs were in the form of one compound: brominated diphenyl ether (BDE) 47. This chemical is associated with the Penta formulation used in polyurethane foam in furniture, which, together with another formulation known as Octa, has been banned in Europe and is being discontinued in the United States. Unfortunately, (BDE) 47 can also be derived from the breakdown of the Deca formulation, which is extensively used in Europe with no plans to discontinue its use either there or in the U.S.

Researchers both in Europe and the U.S. think the problem is not just in the "salmon chow", but the environment as a whole and that PBDEs are probably reaching the open ocean and getting into the marine food web through atmospheric deposition.

To underscore this point, Ake Bergman of Stockholm University's department of environmental chemistry, one of the first scientists to present evidence that PBDEs were bioaccumulating in humans, says he has found the PBDE levels in wild European salmon are on a par with those Hites has reported for farmed European salmon.

And the environmental contamination is not limited to Europe. Wild chinook salmon from British Columbia were found to have the highest levels of PBDE contamination of any of the salmon Hites tested. He thinks this may be due to the chinooks' tendency to feed higher in the food chain throughout their adult life, eating mainly fish, unlike other salmon species that tend to consume more invertebrates and plankton.

On the other hand, wild Alaskan Chinook tested in Hites' study contained significantly lower PBDE levels, suggesting that the waters the wild chinook inhabit are more contaminated.

Surprisingly, the PBDE content patterns seen in the world's salmon do not match up with the levels found in people; samples of blood and fat from North Americans contain levels 10 times higher, on average, than Europeans, another reason to think some other source of exposure is also at work. Bergman thinks the high U.S. levels are due to inhalation of these substances.

What you can do: Beginning September 2004, U.S. supermarkets are required to label salmon as farmed or wild. We suggest that you choose wild, rather than farmed salmon, and if purchasing chinook salmon, choose Alaskan chinook.(October 10, 2004)

Synthetic Pigment Colors Flesh Pink

In the wild, salmon absorb carotenoids from eating pink krill. On the aquafarm, their rich pink hue is supplied by canthaxanthin, a synthetic pigment manufactured by Hoffman-La Roche. Fish farmers can choose just what shade of peach their fish will display from the pharmaceutical company's trademarked SalmoFan, a color swatch similar to those you'd find in a paint store. Without help from Hoffman LaRoche, the flesh of farmed salmon would be a pale halibut grey.

European health officials have debated whether the canthaxanthin added to the feed to give farmed salmon their pink hue poses any human health risk. Canthaxanthin was linked to retinal damage in people when taken as a sunless tanning pill, leading the British to ban its use as a tanning agent. (In the U.S., it's still available.)

As for its use in animal feed, European health officials have debated whether the canthaxanthin added to the feed to give farmed salmon their pink hue poses any human health risk. The European Commission Scientific Committee on Animal Nutrition (SCAN) issued a warning several years ago about the pigment and urged the industry to find an alternative. In 2002, SCAN reviewed the maximum levels of canthaxanthin in fish feeds and determined that the allowable level of 80 milligrams of canthaxanthin per kilogram in feed was too high, and that consumers who ate large amounts of salmon were likely to exceed the Acceptable Daily Intake of 0.03 milligrams per kilogram human body weight. In 1997, the EU's Scientific Committee on Food recognized a link between canthaxanthin intake and retinal problems, so in April 2002, SCAN suggested lowering the level of canthaxanthin to 25 milligrams per kilogram in feed for salmonids (baby salmon). To date, no government has banned canthaxanthin from animal feed.

Canthaxanthin was linked to retinal damage in people when taken as a sunless tanning pill, leading the British to ban its use as a tanning agent. (In the U.S., it's still available.) Consumed In high amounts, canthaxanthin can produce an accumulation of pigments in the retina of the eye and adversely affect sight.

Environmental Impact of Farm-raised Fish

A Threat to Small Commercial Fisheries

Salmon farmed in open pen nets are now the source of 50% of the world's salmon (hatchery fish account for about 30%, and wild fish provide the remaining 20%). Flooding the market with fish-farm salmon has resulted in a drop in the fisherman's asking price for wild salmon-a price decrease that has forced many small fishing boats off the water.

Polluting the Immediate Environment

Aquafarms, called "floating pig farms," by Daniel Pauly, professor of fisheries at the University of British Columbia in Vancouver, put a significant strain upon their surrounding environment. According to Pauly, "They consume a tremendous amount of highly concentrated protein pellets and they make a terrific mess."

Uneaten feed and fish waste blankets the sea floor beneath these farms, a breeding ground for bacteria that consume oxygen vital to shellfish and other bottom-dwelling sea creatures. A good sized salmon farm produces an amount of excrement equivalent to the sewage of a city of 10,000 people.

Polluting the Food Chain

Sulfa drugs and tetracycline are used to prevent infectious disease epidemics in the dense aquafarm populations are added to food pellet mixes along with, in farm-raised salmon, the orange dye canthaxanthin, to color their otherwise grey flesh. These food additives drift to the ocean bottom below the open net pens where they are invariably recycled into our food stream.

A Threat to Wild Fish

Pesticides fed to the fish and toxic copper sulfate used to keep nets free of algae are building up in sea-floor sediments. Antibiotic use has resulted in the development of resistant strains that can infect not only farm-raised but wild fish as they swim past. Sea lice that infest captive fish beset wild salmon as they swim past on their migration to the ocean.

Perhaps the most serious concern is a problem fish farms were meant to alleviate: the depletion of marine life from over-fishing. Salmon aquafarming increases the depletion because captive salmon, unlike vegetarian catfish which thrive on grains, are carnivores and must be fed fish during the 2-3 year period when they are raised to a marketable size. To produce one pound of farmed salmon, 2.4 to 4 pounds of wild sardines, anchovies, mackerel, herring and other fish must be ground up to render the oil and meal that is compressed into pellets of salmon chow.

Similar to the raising of cattle, farming fish creates a problematic redistribution of protein in the food system. Removing such immense amounts of small prey fish from an ecosystem can significantly upset its balance. According to Rosamond L. Naylor, an agricultural economist at Stanford's Center for Environmental Science and Policy, "We are not taking strain off wild fisheries. We are adding to it. This cannot be sustained forever."

Salmon Farms Kill Wild Salmon

New research, conducted by PhD. student Martin Krkosek and colleagues from the University of Alberta, Canada, has established that sea lice from farms kill up to 95% of juvenile wild salmon that migrate past them.

Adult salmon are the primary hosts of sea lice. In natural conditions, adults are located far offshore when the juveniles are migrating out to sea, but fish farms put adult salmon in pens along the migration routes of juveniles, producing a cloud of sea lice through which the juveniles must migrate. Since juveniles are only one to two inches long, it takes just one or two sea lice to kill a juvenile pink or chum salmon.

The University of Alberta team concentrated on 3 migration routes along the Broughton Archipelago in British Columbia, counting sea lice on 14,000 juvenile salmon as they migrated past 7 farms along the 80 km route, and conducted mortality experiments with more than 3,000 fish.

They found an increasing number of salmon were killed over the migration season, from 9% in early spring when the sea lice population was low to 95% cent in late spring when the sea lice population was higher.

"The work is of an impeccably high standard, and will be very difficult to refute," said Dr. Andy Dobson, a Princeton University epidemiologist specializing in wildlife diseases.

"Everyone knows that only a small fraction of juvenile salmon survive to return as adults," said study co-author Dr. Mark Lewis. "The fish-farm sea lice are reducing that fraction even more."

The study's implications may be severe for wild salmon. "Even the best case scenario of an additional 10% mortality from farm-origin sea lice could push a fish stock into the red zone," said biologist Dr. John Volpe, a study co-author at the University of Victoria.

"The debate is over," said study co-author Alexandra Morton, a biologist with the Raincoast Research Society. "This paper brings our understanding of farm-origin sea lice and Pacific wild salmon to the point where we know there is a clear severe impact."

Although the study was conducted in British Columbia, the results apply globally. "This study really raises the question of whether we can have native salmon and large scale aquaculture -- as it is currently practiced -- in the same place," said Dr. Ransom Myers, a fisheries biologist at Dalhousie University. The Alberta scientists are concerned that many people may be consuming farmed fish under the false impression that they are conserving wild fish, which they say is not the case.

A Threat to Other Marine Life

Other reported environmental impacts from salmon aquaculture include seabirds ensnared in protective netting and sea lions shot for preying on penned fish. Penned salmon also directly threaten their wild counterparts, preying on migrating smolts (immature wild salmon) as they journey to the sea and competing for the krill and herring that nourish wild fish before their final journey home to their spawning grounds. Escapes of farm fish also create problems by competing with wild fish for habitat, spawning grounds and food sources. (About 1 million Atlantic's have escaped through holes in nets from storm-wracked farms in the Pacific Northwest's Puget Sound)

A Threat to Biodiversity

The interbreeding of wild and farm stocks also poses a threat of dilution to the wild salmon gene pool.

Biologists fear these invaders will out-compete Pacific salmon and trout for food and territory, hastening the demise of the native fish. An Atlantic salmon takeover could knock nature's balance out of whack and turn a healthy, diverse marine habitat into one dominated by a single invasive species.

Recently, Aqua Bounty Farms Inc., of Waltham, Mass., has begun seeking U.S. and Canadian approval to alter genes to produce a growth hormone that could shave a year off the usual 2.5 to three years it takes to raise a market-size fish. The prospect of genetically modified salmon that can grow six times faster than normal fish has heightened anxiety that these "frankenfish" will escape and pose an even greater danger to native species than do the Atlantic salmon.

A Possible Contributor to Antibiotic Resistance

Rearing fish in such high densities present problems. Infectious disease outbreaks pose financial threats to operators so vaccines and antibiotics are often used to prevent potential epidemics. Sulfa drugs and tetracycline are often added to food pellet mixes as well as canthaxanthin (an orange dye) to impart a rich red-orange color to an otherwise pale gray flesh. Antibiotics are also given to speed growth and increase profits.

In some of the more progressive salmon-rearing operations, fish farmers are raising their Chinook and other species in closed, floating pens so that antibiotics and other wastes can be filtered from the water before it's released back into the environment.

In the majority of aquafarms, however, these drugs and additives, which quickly build up in the sediment, -will invariably find their way into our food stream. In a paper published in 2002, Bent Halling-Sørensen and his colleagues at the Royal Danish School of Pharmacy noted that one

such growth-promoting antibiotic-oxytetracycline-has been found in the sediment of fish-farming sites at concentrations of up to 4.9 milligrams per kilogram. These scientists are concerned that "Antibiotic resistance in sediment bacteria are often found in locations with fish farms"-and may play a growing role in the development of antibiotic resistant germs generally. Should their fears be true, aquafaming may be eroding the efficacy of life-saving drugs, argues Stuart Levy, the director of the Center for Adaptation Genetics and Drug Resistance at the Tufts Medical School in Boston.

Which type of wild salmon should I purchase? Which is best, both for me and for the environment?

When buying salmon, we suggest that you ask for line-caught Alaskan fish first. The healthiest populations and habitats exist in Alaska. In fact, due to the successful efforts of conserving and protecting wild salmon habitats, the Alaska Salmon Fishery recently received the Marine Stewardship Council's label for sustainability.

Fresh-caught, wild salmon is available nearly eight months of the year, with high quality "frozen at sea" (FAS) line-caught fish available during the interim. The Marine Stewardship Council's labels are designed to guide consumers to species that are not being over-harvested.

Plus, in a recent blind taste test hosted by Chefs Collaborative in May 2000, at the French Culinary Institute in New York City, wild Alaskan Coho salmon, frozen at sea, ranked first in flavor, texture and aroma.. Wild Oregon Chinook (also called King) salmon, fresh, came in a close second.

One caveat: Fresh "Atlantic" salmon is generally farm-raised-the name refers to the species, not the fish's origin.

Essential Fatty Acid Ratios in Wild and Farmed Fish

100 grams (3.5 ounces fresh filet of:	Total Omega 3 Fats	Total Omega 6 Fats	Ratio of Omega 3 to Omega 6 Fats*
Wild Coho Salmon	0.92 grams	.06 grams	15.3
Farmed Coho Salmon	1.42 grams	0.46 grams	3.1
Wild Rainbow Trout	.77 grams	.33 grams	2.3
Farmed Rainbow Trout	1.00 grams	.71 grams	1.4
Wild Channel Catfish	.29 grams	.24 grams	1.2
Farmed Channel Catfish	.37 grams	1.56 grams	.2

*The higher the ratio of omega 3 to omega 6 fats, the more able the body is to use the omega 3 fats. A lower ratio means that the enzymes that convert these fats into the forms in which they are active in the body are more likely to be used up by the omega 6 fats.

Table Reference:

Nettleton JA. (2000). Fatty Acids in Cultivated and Wild Fish. Presented paper, International Institute of Fisheries, Economics and Trade (IIFET), IIFET 2000 Conference: Microbehavior and Macroresults. Oregon State University, Corvallis, OR, July 10-14, 2000.

Some Differences in Pesticides and Toxic Chemicals between Wild and Farmed and Fish

Contaminant	Farmed	Wild	Type of Fish
Tributyltin (pesticide, used to keep barnacles and algae off the paint used on hulls of ships	39 micrograms	28 micrograms	mussels
Dibutyltin	26 micrograms (maximum observed amount)	4 micrograms (maximum observed amount	mussels
PCBs (symthetic coolants	146-460 ppb		salmon

Table References:

Amodio-Cocchieri, R.; Cirillo, T.; Amorena, M.; Cavaliere, M.; Lucisano, A., and Del Prete, U. Alkyltins in farmed fish and shellfish. *Int J Food Sci Nutr*. 2000 May; 51(3):147-51.

Jacobs, M. N.; Covaci, A., and Schepens, P. Investigation of selected persistent organic pollutants in farmed Atlantic salmon (Salmo salar), salmon aquaculture feed, and fish oil components of the feed. *Environ Sci Technol* 2002 Jul 1; 36(13):2797-805.

Rueda, F. M.; Hernandez, M. D.; Egea, M. A.; Aguado, F.; Garcia, B., and Martinez, F. J. Differences in tissue fatty acid composition between reared and wild sharpsnout sea bream, Diplodus puntazzo (Cetti, 1777). *Br J Nutr*. 2001 Nov; 86(5):617-22.

REFERENCES

Adler J. The Great Salmon Debate, *Newsweek*, October 28, 2002

Nettleton JA. (2000). Fatty Acids in Cultivated and Wild Fish. Presented paper, International Institute of Fisheries, Economics and Trade (IIFET), IIFET 2000 Conference: Microbehavior and Macroresults. Oregon State University, Corvallis, OR, July 10-14, 2000.

Analysis of PCBs in Farmed versus Wild Salmon. Environmental Working Group, July 30, 2003.

Betts K. Salmon flame retardant research raises new questions. *Science News* Environmental Science and Technology, August 11, 2004.

Dietary Guidelines Advisory Committee, US Department of Agriculture and US Department of Health and Human Services, Nutrition and Your Health: Dietary Guidelines for Americans, Washington, DC: US Government Printing Office, 2000.

George R, Bhopal R. Fat composition of free living and farmed sea species: implications for human diet and sea-farming techniques, *Br. Food J*. 97:19-22, 1995.

Harvey D., Aquaculture outlook, in Aquaculture Outlook, Economic Research Service, U.S. Dept. Agriculture: Washington, DC, October, 1999.

Hites RA, Foran JA, Carpenter DO, Hamilton MC, Knuth BA, Schwager SJ. Global assessment of organic contaminants in farmed salmon. *Science*. 2004 Jan 9;303(5655):226-9.

Krkosek M, Lewis MA, Morton A, Frazer LN, Volpe JP. Epizootics of wild fish induced by farm fish. *Proc Natl Acad Sci U S A.* 2006 Oct 17;103(42):15506-10. Epub 2006 Oct 4.

Nettleton, J.A. and Exler, J., Nutrients in wild and farmed fish and shellfish, *J. Food Sci.* 57: 257-260, 1992.

Simopoulos, A.P., Leaf, A. and Salem, N. Jr., Essentiality of and Recommended Dietary Intakes for Omega-6 and Omega-3 Fatty Acids, *Ann. Nutr. Metab.* 43:127-130, 1999.

van Vliet T. and Katan M.B., Lower ratio of n-3 to n-6 fatty acids in cultured than wild fish, *Am. J. Clin. Nutr.* 51:1-2, 1990.

Weiss K. Fish farms become feedlots of the sea. *L. A. Times*, Dec. 9, 2002.