Fish

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HEAVY METAL INDEX · INGREDIENT PROFILE

October 2026

DOI 10.83376/hmi.ingredient.fish

CITE AS

Pendergrass, K. (2026). Fish. Heavy Metal Index. https://doi.org/10.83376/hmi.ingredient.fish

CORRESPONDENCE

Corrections are logged publicly on the article page, each with its date, the affected value, and the source that resolved it.

KEYWORDS

heavy metals, food safety, dietary exposure

PUBLICATION HISTORY

This revision 2026-10-22.

Abstract

Mercury decides most questions about fish, and the species on the plate matters far more than anything else that has been measured. Across European monitoring results compiled by EFSA, mean total mercury in fish muscle ran from about 31-35 µg/kg in salmon and trout and 32-44 µg/kg in sardine, through 91-96 µg/kg in cod and whiting and 286-291 µg/kg in tuna, to 688-695 µg/kg in shark and 1,210-1,214 µg/kg in swordfish (lower- to upper-bound means, wet weight). WHO GEMS/Food submissions from Europe show the same order, with a median of about 184 µg/kg for tuna against 80 µg/kg for cod and 18-30 µg/kg for sardine.

1 | Fish overview

Most of the mercury in fish muscle is methylmercury, the form that drives intake limits. In 210 retail fish samples from Japan, methylmercury made up about 60-90% of total mercury once total mercury was at least 100 µg/kg, close enough that total mercury is used as a screening measure.[10] The EU sets 500 µg/kg of total mercury for most fish muscle and 1,000 µg/kg for large predators such as tuna, swordfish and shark, while Codex sets methylmercury levels of 1,200 µg/kg for tuna and 1,600 µg/kg for shark.[9,11]

Lead and cadmium are usually low in fish muscle where monitoring is routine, and arsenic in fish is mostly in organic forms. US Total Diet Study composites of baked cod, salmon and tilapia had lead below 4 µg/kg and cadmium at or below about 1 µg/kg, and EFSA's European fish muscle data gave a cadmium median of 5 µg/kg.[3,12] Total arsenic in marine fish is often in the thousands of µg/kg, such as 4,500 µg/kg in US baked cod, but inorganic arsenic averaged only 0.7-20 µg/kg (lower bound) across European fish species.[3,4]

Higher lead and cadmium values come mostly from small surveys of rivers, lagoons and coasts near mining, industry or wastewater, and many of the most extreme ones fail checks against their own papers.[13,14,15] For a buyer or a regular eater, the supported priorities are species and size choice for mercury, verified lot results for the analyte that applies to the species, and keeping total and inorganic arsenic apart.[8,11,16]

2 | What counts as fish on this page

This page covers finfish eaten by people: the muscle, fillet or whole small fish of marine, freshwater and farmed species, and the canned, dried smoked, salted, fermented and processed products made from them.[2,3,11] fish oils and fish-liver oils, fish sauce and fish products such as fingers, cakes and collagen supplements are kept as separate forms and never pooled with flesh.[17,18,19]

Shellfish, crustaceans, cephalopods, marine mammals, fish feed and fish offal are outside the scope, as are fish-containing infant foods, which have their own product page.[2,20] Categories that mix finfish with shellfish, common in total diet studies and some European summaries, are also excluded because their results cannot be attributed to fish.[2,21]

Measurements are kept in the basis the source reports: wet weight (as sold or eaten), dry weight, or basis not stated; dry-weight results are not converted without the paper's own moisture data.[6,7] Total mercury, methylmercury and mercury of unstated form are separate analytes, as are total, inorganic and organic arsenic species.[4,10,22]

3 | How metals reach fish

Methylmercury builds up through the food web, so fish that are older, larger and higher in the food chain carry more of it.[1,23] Within one species the same pattern holds: modelled mean mercury in northern pike from Great Slave Lake was 740 µg/kg in fish of 600 mm or longer against 300 µg/kg in smaller fish, and young yellowtail in Japanese markets averaged 80 µg/kg total mercury against 520 µg/kg in adults.[5,10] Large wild bluefin tuna caught off Sardinia averaged 1,680 µg/kg total mercury, against 610 µg/kg in bluefin fattened on a Maltese farm.[24]

Cadmium, lead and inorganic arsenic in fish come mainly from the water, sediment and feed of the place where the fish lived, rather than building up with age along the food chain as methylmercury does.[7,12,25] This is why the higher muscle values cluster in studies from polluted rivers, lagoons and coastal sites, while large national monitoring programs report low medians.[2,7,12]

Arsenic follows a different route: arsenobetaine, an organic compound, is the major form of arsenic in fish, which is why total arsenic can be high while inorganic arsenic stays low.[4,26] In UK samples analyzed by two procedures, herring had 1,100 µg/kg total arsenic and 20-40 µg/kg inorganic arsenic, and haddock 2,600 µg/kg total against 20 µg/kg inorganic.[22]

4 | Which species and sources measured lower

For mercury, species is the strongest and most consistent lower-contamination lever.[1,2,10] In EFSA's European d ata the lowest mean total mercury among commonly eaten fish was in salmon and trout (31-35 µg/kg), sardine a nd pilchard (32-44 µg/kg) and herring (36 µg/kg), with carp (55 µg/kg) and anchovy (73-92 µg/kg) also low; the h ighest were swordfish, shark, pike (394 µg/kg) and tuna.[1] Hong Kong's total diet study gave the same picture f or methylmercury in local fish as eaten, from 4.5 µg/kg in grass carp and 7.9 µg/kg in sole to 330 µg/kg in tuna.[27] Because these rankings recur across European, Asian and US datasets with different methods, choosing small, short-lived and plankton-eating species is a supported preference for lower mercury, not just a single-study observation.[1,3,8,27]

Within a species, farming and size can matter as much as origin. Farmed Atlantic salmon from Norway averaged 18 µg/kg total mercury against 56 µg/kg in wild salmon from the same coast, and farmed bluefin tuna and yellowtail in Japanese retail were lower than wild fish (530 against 760 µg/kg, and 130 against 520 µg/kg).[6,10] Arsenic did not follow mercury: the same Norwegian study found 860 µg/kg arsenic in farmed salmon against 2,560 µg/kg in wild, while a US comparison of coho salmon found more total arsenic in the farmed fish (597 against 354 µg/kg, one sample each).[6,28] These are within-study observations for particular farms and fisheries; they support asking for species, size and farm or catch origin, not a general rule that farmed fish are always lower.

Origin comparisons for the same species are weaker than species comparisons. Canned tuna bought in 36 countries had country means from 20 to 950 µg/kg total mercury, with both the lowest and some of the highest means from skipjack-labeled cans; only three cans were tested per country, and purchase country was not catch area.[29] For cadmium and lead the lowest monitored medians come from routine national programs such as GEMS/Food in Europe, where most cod, trout and salmon results were below detection, rather than from any single producing region.[2,3] For inorganic arsenic, European fish means ranged from 0.7 µg/kg in herring to 20 µg/kg in sardine at the lower bound, so species differences are small compared with the EU limits of 100 and 500 µg/kg.[4,16] Total arsenic, mostly organic, is far lower in freshwater fish: GEMS/Food European medians were about 55-75 µg/kg for freshwater fish against 3,100 µg/kg for marine fish, and US baked tilapia had 100 µg/kg against 4,500 µg/kg in baked cod.[2,3]

Across European monitoring data, salmon and trout (31-35 µg/kg), sardine and pilchard (32-44 µg/kg), herring (36 µg/kg) and carp (55 µg/kg) had the lowest mean total mercury among commonly eaten fish.[1] US Total Diet Study tilapia had a median of 5.1 µg/kg and salmon 18 µg/kg, and GEMS/Food European medians were 18-30 µg/kg for sardine and 23-29 µg/kg for trout.[2,3] These are species averages; individual large or old fish can be much higher.[5]

For mercury, the measured comparisons found farmed fish lower: Norwegian farmed salmon 18 against 56 µg/kg wild, and Japanese farmed yellowtail 130 against 520 µg/kg.[6,10] For arsenic the result was mixed, lower in farmed salmon in Norway but higher in a US farmed coho sample.[6,28] Farm siting and feed can raise cadmium and lead where water is polluted, as in some Egyptian farms and lagoons.[7]

5 | Cooking, canning and other processing

Cooking does not remove mercury from fish; it concentrates it as water is lost.[30,31] Atlantic cod fillets lost no measurable mercury when boiled, pan-fried or oven-baked, but the concentration per 100 g rose, for example from 33 to 43 µg/kg after pan-frying.[30] In a feeding trial with pigs, oven-cooked tuna delivered the same methylmercury to the blood as raw tuna, although laboratory digestion tests had suggested less was available.[31]

Canning, drying and smoking change the measured concentration mainly through water content and the species that are canned.[3,32,33] US canned light tuna in water had a median of 220 µg/kg total mercury, Italian cans of skipjack and yellowfin ranged from 50 to 290 µg/kg, and smoked dogfish belly flaps in Germany had 580 µg/kg methylmercury against 30-70 µg/kg in herring products.[3,32,33] Experimental soaking of canned or fresh tuna in a cysteine solution extracted about 13-38% of the mercury, but this is a laboratory treatment, not an approved or household method.[34]

Makroum et al. (2026) reported that frying and grilling significantly reduced arsenic, mercury, lead, and cadmium concentrations in three Mediterranean marine fish species (thinlip gray mullet, sardines, sand smelt) from the Damietta Coast, Egypt. The study concluded that risk assessments based on raw fish overestimate risk for cooked fish consumers. All 240 raw samples exceeded the permissible maximum level for arsenic; mercury levels were within safe limits.[47]

Packaging and cooking materials can add metals that are not from the fish. Fish baked in aluminum foil with a lemon and salt marinade picked up 4,560-21,000 µg/kg aluminum, against under 1,140 µg/kg without the marinade and none detected when baked in glass.[35] Resin-coated cans kept tin low in canned tuna (700 µg/kg), far below the EU limit of 200,000 µg/kg for canned food.[36,11]

No: boiling, frying and baking cod left the mercury in the fillet unchanged, and concentrations rose as water was lost.[30] Cooked tuna fed to pigs delivered the same methylmercury to the blood as raw tuna.[31]

6 | Mitigation from catch to plate

The controls with measured effects act on mercury through what is caught and sold: species, size and, for some species, farming.[5,6,10] Choosing smaller fish within a species more than halved mean mercury in northern pike and cut it more than sixfold in yellowtail, and lot testing with total mercury as a screen is built into the Codex sampling plan.[5,9,10] Household preparation and cooking do not lower mercury, and the measured processing reductions come from laboratory treatments not used in commercial fish.[30,31,34]

For cadmium, lead and inorganic arsenic, the evidence on controls is mostly observational: higher values cluster at polluted sites, so siting of farms and fishing grounds is the main lever.[7,12] Feed additives tested in dosed laboratory fish lowered muscle cadmium or mercury, but the doses were far above environmental levels, so they show a mechanism, not a proven farm control.[37,38]

7 | Trade-offs and limits of controls

The lowest-mercury choice is not always lowest in every metal. Sardine, anchovy and mackerel, all low in mercury, sit in the EU's higher cadmium limit groups of 100-250 µg/kg, and farming lowered both mercury a nd arsenic in Norwegian salmon but came with more total arsenic in a US farmed coho sample.[6,28,11] Flatfish, which are low in mercury, carry some of the highest total arsenic, mostly as organic arsenic, and the EU sets a higher inorganic arsenic limit of 500 µg/kg for flatfish, haddock and anglerfish.[16,39]

Avoiding fish to avoid mercury also removes a main dietary source of omega-3 fatty acids.[8,40] EFSA's scientific c ommittee and US federal advice both pair limits on high-mercury species with encouragement to eat l ower-mercury fish, rather than advising against fish in general.[8,40]

8 | Testing fish for metals

A useful fish test reports the analyte species that the limit uses, on wet weight, with a quantification limit well below that limit.[9,11,41] The EU and Codex mercury limits for most fish (500 µg/kg) and the EU inorganic arsenic limit (100 µg/kg) need methods that can see far lower, as FDA's 4 µg/kg lead reporting limit and EFSA's speciated ar senic data show is achievable.[3,4,11,16]

Codex allows total mercury as a screen: a sample at or below the methylmercury limit for total mercury is compliant, and only higher samples need methylmercury analysis.[9,10] Its sampling plan groups lots by one species and comparable size and takes muscle near the tail for tuna, because mercury varies with fish size and body part.[9]

Many surveys in the evidence report dry-weight results, mercury without stating its form, or total arsenic only, and some measured mercury after dry ashing at 450-500 °C, a step that can lose mercury.[42,43] These results stay on the page but cannot be compared with wet-weight limits or with speciated results, and several are held because their values conflict with their own methods.[13,14,42,43]

Several of the highest values cannot be reconciled with their own papers: one Egyptian tilapia study prints mg/kg where its methods state µg/kg, a Persian Gulf study prints species means outside their own ranges, and an Indian survey's intake figures imply values a thousand times higher than its table.[13,14,15] These results are shown but held from comparisons.

9 | Buying and verifying fish

Ask suppliers for the species and, where possible, the size or weight class and the catch or farm area, because mercury depends most on these.[5,9,10] Lot results should be on wet weight, name the analyte as total mercury or methylmercury, and be compared with the limit for that species in the destination market.[9,11,41]

Limits differ by market and by species group. The EU sets total mercury at 300 µg/kg for anchovy, sardine, herring, mackerel, cod, Alaska pollock, salmon and trout, 500 µg/kg for most other fish and 1,000 µg/kg for large predators such as tuna, swordfish, shark and pike, with cadmium at 50-250 µg/kg and lead at 300 µg/kg.[11] Australia and New Zealand use mean mercury levels of 500 or 1,000 µg/kg depending on species, and China sets methylmercury at 500 µg/kg for non-carnivorous fish, 1,000 µg/kg for carnivorous fish and 1,200 µg/kg for tuna.[44,41] For inorganic arsenic, the EU has applied 100 µg/kg to most fish and 500 µg/kg to flatfish, haddock and anglerfish since October 8, 2025, while Australia and New Zealand set 2,000 µg/kg.[16,41]

Canned fish carry two extra checks: tin from the can, limited to 200 mg/kg in the EU and 250 mg/kg under Codex and FSANZ, and the species inside, since tuna cans labeled light, skipjack or yellowfin differ in mercury.[36,32,11,41]

10 | Exposure from fish

Fish is the main dietary source of methylmercury, and how much it adds depends on the species, portion and how often it is eaten.[23,40] JECFA set a tolerable weekly intake of 1.6 µg/kg body weight for methylmercury and

EFSA 1.3 µg/kg; EFSA's scientific committee found that high consumers of predatory fish in several countries could exceed it.[23,40]

US advice for pregnancy and breastfeeding recommends 8-12 ounces (two to three servings) a week from lower-mercury choices such as salmon, sardines, cod, pollock, tilapia and trout, and avoiding king mackerel, marlin, orange roughy, shark, swordfish, Gulf of Mexico tilefish and bigeye tuna.[8] These categories match the measured species differences on this page.[1,8,27]

No source measured metals in a fish-containing food together with the fish that went into it, so finished-product results cannot be traced back to the raw fish. Fish fingers in the US Total Diet Study had 6 µg/kg total mercury and baked fish fillets in Germany 20 µg/kg methylmercury.[3,33]

11 | Evidence review and remaining gaps

This assessment covers every source record in the HMI library that is tagged to fish or mentions it (1,341 records), every matching fish row in WHO GEMS/Food and the FDA Total Diet Study, and the HMI index rows that route sources to fish; each has a recorded decision based on its content.[2,3] About 250 sources supplied finfish occurrence results, and 273 extracted results are held because their values conflict with their own papers.[13,14,15] Remaining gaps are per-fish supplementary tables that were not in the library, a handful of reports with no readable primary text, and EFSA and national datasets that mix fish with shellfish.[21,45]

References identify the sources used in these answers. The Sources index preserves additional discovery links; inclusion there does not mean a source has been reviewed for this assessment. Corrections, completed searches, new direct evidence and changes in requirements should reopen the relevant answer.

12 | Fish FAQs

Mercury, mostly as methylmercury, is the metal found at levels that matter in fish; lead and cadmium are usually low in monitored fish muscle, and arsenic is mostly in organic forms.[1,3,4,26] fish can also contain nickel, chromium, aluminum and tin, usually from processing, packaging or polluted water.[2,35,36]

Methylmercury builds up through the food chain, so large, old and predatory fish carry the most.[1,23] In northern pike, fish 600 mm or longer had about two to three times the mercury of smaller pike.[5]

Salmon, trout, sardines, herring, anchovy, carp, tilapia, cod and pollock are consistently low; swordfish, shark, marlin, king mackerel and large tuna are highest.[1,3,8,27] In EFSA's European data, swordfish averaged about 1,212 µg/kg total mercury and salmon and trout about 33 µg/kg.[1]

For mercury, species and size matter more than country; origin comparisons for the same species are few and mostly use purchase country rather than catch area.[29,10] For lead and cadmium, origin matters most at polluted rivers, lagoons and coasts, where some local surveys report much higher values than national monitoring.[2,7]

For mercury, farmed salmon, bluefin tuna and yellowtail measured lower than wild fish in the same studies.[6,10,24] This did not hold for every metal: arsenic was higher in a farmed US coho salmon, and farmed fish in polluted water can carry more cadmium or lead.[7,28]

US canned light tuna in water had a median of 220 µg/kg total mercury, and Italian cans of skipjack and yellowfin ranged from 50 to 290 µg/kg.[3,32] Canned tuna bought in 36 countries had country means from 20 to 950 µg/kg, all below the Codex tuna limit of 1,200 µg/kg methylmercury.[9,29]

Total mercury counts all forms; methylmercury is the toxic organic form that makes up most of it in fish muscle, about 60-90% in Japanese retail fish.[10] Limits use either one, so a result must name which was measured.[9,11,44]

Most arsenic in fish is arsenobetaine, which EFSA notes is widely assumed to be of no toxicological concern; inorganic arsenic, the form of concern, averaged 0.7-20 µg/kg across European fish species at the lower bound.[4,26] The EU now limits inorganic arsenic in fish to 100 µg/kg, or 500 µg/kg for flatfish, haddock and anglerfish.[16]

Yes: the EU sets total mercury at 300-1,000 µg/kg by species, cadmium at 50-250 µg/kg, lead at 300 µg/kg and inorganic arsenic at 100-500 µg/kg in fish muscle.[11,16] Codex sets methylmercury at 1,200 µg/kg for tuna and 1,600 µg/kg for shark, and the US uses a 1 mg/kg methylmercury action level.[9,46]

No: cooking leaves mercury in the fish and raises its concentration as water is lost, as boiled, fried and baked cod showed.[30] Cooked tuna delivered as much methylmercury to the blood of test animals as raw tuna.[31]

No ordinary processing step in the evidence lowered mercury; a laboratory cysteine soak removed about 13-38% of mercury from tuna, but it is not an approved commercial or household method.[34] Cooking, canning and drying change concentrations mainly through water loss.[3,30]

Fish oil supplements tested in Serbia averaged 1.9 µg/kg mercury, with a maximum of 5.7 µg/kg.[17] The EU limit for mercury in food supplements is 100 µg/kg.[11]

US advice recommends 8-12 ounces (two to three servings) a week of lower-mercury fish such as salmon, sardines, cod, pollock, tilapia and trout, and avoiding shark, swordfish, king mackerel, marlin, orange roughy, Gulf tilefish and bigeye tuna.[8] This follows the measured species differences in mercury.[1,27]

No single amount applies to every fish: national advice sets servings by species group and life stage, such as two to three servings a week of lower-mercury fish in US advice for pregnancy.[8,40] JECFA's tolerable weekly i ntake for methylmercury is 1.6 µg/kg body weight; how quickly a diet reaches it depends on the species eaten.[23]

Health agencies advise choosing lower-mercury species rather than avoiding fish, because fish supply omega-3 fatty acids and other nutrients.[8,40] Limiting the highest-mercury species makes the largest difference to intake.[40]

They are usually low in mercury because they are made from white fish: US fish sticks had 6 µg/kg total mercury and German baked fish fillets 20 µg/kg methylmercury.[3,33] No study measured a product alongside the fish used to make it.

Within a species, yes in the measured studies: young yellowtail averaged 80 µg/kg against 520 µg/kg in adults, and pike under 600 mm had less than half the mercury of larger pike.[5,10]

Yes, with acidic or salty marinades: fish baked in foil with lemon and salt took up 4,560-21,000 µg/kg aluminum, while fish baked in glass had none detected.[35]

No source in the evidence compared organic-certified or eco-labeled fish with conventional fish for metals, so there is no measured answer. Species, size and the water the fish lived in are the measured drivers.[1,5]

Laboratories measure total mercury and, where needed, methylmercury by speciation methods; Codex treats a total mercury result at or below the methylmercury limit as compliant.[9,10] Samples are taken from muscle, near the tail for tuna, in lots of one species and size.[9]

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STATUS AND LICENCE

Editorially reviewed in-house; no external peer review has been completed on this ingredient profile. Published as an institutional technical report with its review state tracked on the article page. Released under CC BY 4.0.

COMPETING INTERESTS

The Heavy Metal Index reports what the peer-reviewed and regulatory literature supports. It is operated separately from any certification program, does not evaluate or endorse brands, and does not use certification thresholds as evidence for the statements made here.

DATA AVAILABILITY

Every source behind this ingredient profile is listed with its own source record at https://heavymetalindex.com/ingredients/fish#sources.

PUBLICATION HISTORY

This revision 2026-10-22. The full dated record is maintained at https://heavymetalindex.com/ingredients/fish.