Freshwater Fish

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Abstract

Freshwater fish in the HMI library has 2,929 reported results for lead, cadmium, total arsenic, inorganic arsenic, dimethylarsinic acid, monomethylarsonic acid, arsenic, total mercury, methylmercury, mercury, nickel, chromium, aluminum, tin, antimony, Co, Cu, Fe, Mn, Zn, V, Se, Ag, As, As(V), AsB, Ba, BTs_sum, DBT, DOT, DPT, I, Li, MBT, Mo, MPT, oAs, OTC_sum_as_Sn, PTs_sum, Sr, sum of As species, sumOTC, TBT, TMA, TPhT and TPT from 77 sources. WHO GEMS/Food submissions reported lead in freshwater fish as sold from 3,748 results in 5 reporting regions, with subgroup medians from 3 to 100 µg/kg. For cadmium, GEMS/Food gave subgroup medians from 7.5 to 22.8 µg/kg from 2,447 results.

1 | Freshwater fish overview

Across 5 other studies of ordinary farms and markets, reported lead means and medians on an as-sold or fresh-weight basis ranged from 5.5 µg/kg (Marín et al. 2018) to 400 µg/kg (Haseeb-ur-Rehman et al. 2023).[5,7] For cadmium, 5 studies on an as-sold or fresh-weight basis reported means and medians from 0.5 µg/kg (Vičarová et al. 2016) to 57 µg/kg (Haseeb-ur-Rehman et al. 2023).[5,8] Higher results came from contaminated or exposed settings rather than ordinary supply. Freshwater fish as sold from lipid-soluble had dimethylarsinic acid higher at 200 µg/kg, against 20 µg/kg for lipid-soluble in the same study.[9]

For a buyer the practical points are the form bought, the basis a result is reported on, where the freshwater fish came from and the laboratory’s reporting limit. Testing finds contamination but does not remove it.

2 | What counts as freshwater fish

This page covers freshwater fish in 3 forms kept separate in every comparison: freshwater fish as sold (2,909 results), cooked freshwater fish (10 results) and freshwater fish powder or ground (10 results).[1,2,3,4,5,6]

Results stay on the basis each source reports: as sold or fresh weight, dry weight, or unstated. Dry-weight, as-sold and unstated results are never pooled, and no moisture conversion is applied.

3 | How metals reach freshwater fish

The evidence on how metals reach freshwater fish comes from studies that compared exposed and ordinary settings. Freshwater fish as sold from lipid-soluble had dimethylarsinic acid higher at 200 µg/kg, against 20 µg/kg for lipid-soluble in the same study.[9] In another study, freshwater fish as sold from Al Khawd (industrial area) (industrial-affected area) had lead higher at 159 µg/kg, against 20 µg/kg for Surur (control area) in the same study.[2] A third study found that freshwater fish as sold from Rönnskär (polluted brackish water) (industrial-affected area) had total arsenic higher at 210 µg/kg, against 50 µg/kg for Bodaträsk (polluted fresh water) in the same study.[22]

These are observational comparisons from single studies; the size of the difference depends on the site, metal and distance.

4 | Which forms and regions measured lower

The HMI reference for lead in freshwater fish as sold pools 164 subgroup units from 3 sampling families, with a median of below 6 µg/kg and a middle half spanning below 4.35 (lower quartile) and below 6 µg/kg (upper quartile).[1,4,23] for lead in freshwater fish as sold, the reference median was below 10 µg/kg, with a middle half from below 10 to below 10 µg/kg across 9 units.[1] for cadmium in freshwater fish as sold, the reference median was below 4 µg/kg, with a middle half from below 2 to between 1 and 6 µg/kg across 107 units.[1,4,23]

Among GEMS/Food reporting regions, freshwater fish as sold had the lowest lead subgroup median in PAHO (3 µg/kg) and the highest in WPRO (100 µg/kg); reporting regions are markets, not growing areas.[1] For cadmium, the lowest regional median was in WPRO (7.5 µg/kg) and the highest in PAHO (22.8 µg/kg).[1] For total arsenic, the lowest regional median was in AFRO (16 µg/kg) and the highest in EURO (2,940 µg/kg).[1]

Targeted freshwater fish as sold samples in PAHO had total mercury higher at 120 µg/kg, against 50 µg/kg for PAHO in the same study.[1] In another study, targeted freshwater fish as sold samples in PAHO had total mercury lower at 2.3 µg/kg, against 50 µg/kg for PAHO in the same study.[1]

In one study, lead across 10 groups of freshwater fish ranged from 202 µg/kg (individual market fish 6 of 10 (dorsal muscle sample M6)) to 736 µg/kg (individual market fish 5 of 10 (dorsal muscle sample M5)); the lowest is the lowest observed in that study, not an established sourcing preference.[15] In another study, total mercury across 36 groups of freshwater fish ranged from 10 µg/kg (Martin Reservoir (samples 2005)) to 1,290 µg/kg (Narraguinnep Reservoir (samples 2005, 2013)); the lowest is the lowest observed in that study, not an established sourcing preference.[24]

5 | Processing, cooking and preparation

Processed or prepared forms were compared only with unprocessed freshwater fish in the same study and group. Cooked freshwater fish (5 city composites) had lead lower at 9.9 µg/kg, against 14.3 µg/kg for the unprocessed form in the same group (freshwater fish as sold).[25]

Forms differ in water content, so a per-kilogram difference is not by itself a measured removal or gain of metal.

Makroum et al. (2026) measured arsenic, mercury, lead, and cadmium in three Mediterranean marine fish species (thinlip gray mullet, sardines, sand smelt) from the Damietta Coast, Egypt, and found that frying and grilling significantly reduced metal concentrations in cooked muscle compared to raw (Table 3). The study notes that risk assessments based on raw fish may overstate exposure for consumers of cooked fish. Evidence from marine fish muscle (cooking effects on arsenic, mercury, lead, and cadmium), not measured in freshwater fish.[29]

6 | Mitigation for freshwater fish

Lot testing against the applicable limit is the check that can be verified.

7 | Trade-offs and limits of controls

Avoiding exposed growing areas lowered the metal measured in the studies available, but no study measured the cost or supply effect of doing so.[9] Metals do not move together, so a lot that passes a lead limit says little about cadmium, arsenic or nickel unless those are tested as well.

8 | Testing freshwater fish for metals

Results depend on the method and its reporting limit. Reporting limits for lead ranged from 0.2 µg/kg (WHO GEMS/Food) to 2,000 µg/kg (Adilbekov et al. 2026), so a non-detect from a less sensitive method says much less.[1,12] Reporting limits for cadmium ranged from 0.158 µg/kg (Olmedo et al. 2013) to 200 µg/kg (Adilbekov et al. 2026), so a non-detect from a less sensitive method says much less.[12,23] Reporting limits for total arsenic ranged from 0.159 µg/kg (Olmedo et al. 2013) to 300 µg/kg (WHO GEMS/Food), so a non-detect from a less sensitive method says much less.[1,23]

A useful lot result names the form, the basis and a quantification limit well below the limit that applies.

9 | Buying and verifying freshwater fish

No maximum level for metals in freshwater fish was verified from primary text for this page; buyers should confirm the limit that applies in the destination market.

10 | Exposure from freshwater fish

No source in the library converted freshwater fish concentrations into a verified estimate of intake for a defined population. Concentrations describe the food, not individual risk.

11 | Evidence review and remaining gaps

Every source record that names freshwater fish was decided on its content: 77 occurrence extracted, 77 records in all. The occurrence table renders every extracted result; held values remain visible with their reason.

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 | Freshwater fish FAQs

The library reports lead, cadmium, total arsenic, inorganic arsenic, dimethylarsinic acid, monomethylarsonic acid, arsenic, total mercury, methylmercury, mercury, nickel, chromium, aluminum, tin, antimony, Co, Cu, Fe, Mn, Zn, V, Se, Ag, As, As(V), AsB, Ba, BTs_sum, DBT, DOT, DPT, I, Li, MBT, Mo, MPT, oAs, OTC_sum_as_Sn, PTs_sum, Sr, sum of As species, sumOTC, TBT, TMA, TPhT and TPT in freshwater fish, most often lead, cadmium and total arsenic.[1,2,3,4] WHO GEMS/Food submissions reported lead in freshwater fish as sold from 3,748 results in 5 reporting regions, with subgroup medians from 3 to 100 µg/kg.[1]

In the studies available, freshwater fish from contaminated or exposed settings carried more metal than freshwater fish from the same study's control.[2] freshwater fish as sold from Al Amarat (industrial area) (industrial-affected area) had lead higher at 82 µg/kg, against 20 µg/kg for Surur (control area) in the same study.[2]

Among GEMS/Food reporting regions, freshwater fish as sold had the lowest lead subgroup median in PAHO (3 µg/kg) and the highest in WPRO (100 µg/kg); reporting regions are markets, not growing areas.[1] For cadmium, the lowest regional median was in WPRO (7.5 µg/kg) and the highest in PAHO (22.8 µg/kg).[1]

Only comparisons between forms in the same study are available, not before-and-after measurements of the same freshwater fish.[25] cooked freshwater fish (5 city composites) had lead lower at 9.9 µg/kg, against 14.3 µg/kg for the unprocessed form in the same group (freshwater fish as sold).[25]

Inorganic arsenic, the more toxic form, was measured in 36 results from 7 sources, far fewer than total arsenic.[1,7,22,26,27,9,28] Marín et al. 2018 reported inorganic arsenic at 6.6 µg/kg (mean) in freshwater fish as sold from fish and seafood group, Region of Valencia TDS 2010-2011.[7]

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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/freshwater-fish#sources.

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