Black Pepper

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HEAVY METAL INDEX · INGREDIENT PROFILE October 2026
DOI 10.83376/hmi.ingredient.black-pepper

CITE AS

Pendergrass, K. (2026). Black Pepper. Heavy Metal Index. https://doi.org/10.83376/hmi.ingredient.black-pepper

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

Black pepper usually carries lead, cadmium and arsenic in the tens to low hundreds of µg/kg, with aluminum, nickel and chromium far higher. In WHO GEMS/Food, 362 black pepper lead results had a median of about 53-60 µg/kg, and 9 (2.5%) were definitely above 600 µg/kg. Total arsenic was below detection in most of 197 results, and cadmium had a median below 7 µg/kg.

1 | Black pepper overview

Lead is the metal most likely to decide a black pepper question, because a minority of lots are far higher than the rest. The EU sets a binding maximum of 0.60 mg/kg (600 µg/kg) for lead in dried fruit spices, the class that covers peppercorns as dried fruits, and Codex adopted the same 0.6 mg/kg for dried fruit and berry spices; neither sets a cadmium limit for pepper.[2,7] Market surveys outside routine monitoring report much higher lead: means of 714 µg/kg in Malaysian-grown pepper bought in Accra, 730-820 µg/kg in Libya and 2,470 µg/kg in bulk pepper from eastern turkey.[3,4,8]

For a buyer, the supported priorities are a lot-specific lead result with a quantification limit well below the applicable limit, a cadmium result for markets that set one, and a supply chain that keeps grinding and handling under control.[1,2] Whole pepper had a lower lead median than ground pepper in monitoring data, but growing origin alone did not settle the question: Malaysian-grown pepper measured 100 µg/kg in Queensland and 714 µg/kg in Accra.[1,3,5]

2 | What counts as black pepper

This page covers black pepper, the dried fruit of Piper nigrum, sold whole, cracked or ground, measured as the dry spice without moisture conversion.[1,5,6] White pepper, green and long pepper, chilli and bell peppers, spice blends and foods seasoned with pepper are outside its scope.[1,9,10]

Pepper identity matters because monitoring categories and surveys use different labels. The EU monitoring category “Pepper, black and white (Piper nigrum)” does not separate black from white pepper, so its 1,051 GEMS/Food results are shown separately and not compared with the black pepper reference.[1] A WHO region in GEMS/Food is a reporting region, and most surveys report where the pepper was bought rather than where it was grown.[1,3,5]

3 | How metals reach black pepper

Metals reach black pepper through the vine’s uptake from soil and through surfaces and equipment that contact t he berries during drying and grinding.[5,9] The very high aluminum in pepper (29-540 mg/kg in Queensland retail samples) is attributed by those authors to aluminum utensils and containers in processing and to accumulation by the plant, and an Iraqi survey names drying on bare ground and wear of milling machinery as routes.[5,9]

Grinding and handling after import are plausible additions. In Libya, ground pepper bought at retail averaged 320 µg/kg cadmium against 150 µg/kg in wholesale lots sampled on arrival, and lead was also higher at retail (820 against 730 µg/kg).[4] Stainless steel and aluminum equipment are discussed as possible sources of chromium, nickel and aluminum, but no source measured them in pepper processing.[5]

Deliberate lead adulteration, reported for turmeric, has not been shown for black pepper in this evidence.[5,16] A Georgian household survey found one black pepper sample at 48 mg/kg lead by handheld X-ray fluorescence, but four of five were below its 4-8 mg/kg detection limit, and the paper does not say whether that sample was among those confirmed by laboratory analysis.[16]

4 | Which forms and origins measured lower

For lead, the clearest comparison is form: in GEMS/Food, whole black pepper had a median of 30-52 µg/kg (28 results) against 61-68 µg/kg for ground or cracked pepper (211 results).[1] Cadmium and arsenic medians in both forms sat below the reporting limits, so form does not change those comparisons.[1] This is a descriptive difference across many laboratories, not a controlled grinding experiment.

Within one study, origin comparisons are more reliable. Among Queensland retail pepper, Vietnamese-grown pepper (two samples) had the lowest means of any origin for lead (60 µg/kg), cadmium (9) and arsenic (16), while Indian pepper (four samples) had the highest chromium (840) and aluminum (162,000 µg/kg) and Chinese pepper the highest arsenic (860 µg/kg, driven by one sample at 1,700).[5] For chromium and aluminum, Vietnamese pepper (240 and 85,000 µg/kg) was also lower than Chinese (640 and 125,000) and Indian pepper (840 and 162,000), and single samples from Sri Lanka (50 and 39,000) and Malaysia (140 and 57,000) were lowest of all.[5] A single Vietnamese whole pepper bought in Saudi Arabia measured 8 µg/kg lead and 3 µg/kg cadmium.[6] With one to four samples per origin these are tentative patterns, not a supported preference for a country.

Retail and packaging comparisons point in different directions by metal. In Lebanon, bulk pepper had the highest cadmium (154 µg/kg against 121-136 for packaged) but the lowest arsenic (126 against 189-200), and lead was similar (284-346 µg/kg).[10] Ten packaged US retail products all fell in the lowest concern band of a consumer test for arsenic, cadmium and lead, while unpackaged pepper from eastern turkey averaged 2,470 µg/kg lead.[17,8] Chromium varied widely, from 96 µg/kg in one Vietnamese sample to a 3,620 µg/kg mean in bulk Moroccan pepper.[6,14]

For lead, yes in monitoring data: whole black pepper had a GEMS/Food median of 30-52 µg/kg against 61-68 µg/kg for ground or cracked pepper.[1] Cadmium and arsenic medians in both forms were below reporting limits, and no single study compared whole and ground pepper from the same lots.[1]

Within one Queensland study, Vietnamese-grown pepper had the lowest lead (60 µg/kg), cadmium (9) and arsenic (16 µg/kg) means of five origins.[5] Across studies, Malaysian-grown pepper measured 100 µg/kg lead in Australia but 714 µg/kg in Ghana, so the market and handling chain matter as much as the origin.[3,5]

Not consistently. In Lebanon bulk pepper had more cadmium (154 against 121-136 µg/kg) but less arsenic (126 against 189-200), and lead was similar.[10] The highest lead means came from unpackaged pepper in eastern turkey (2,470 µg/kg) and ground pepper in Libya (730-820 µg/kg), while ten packaged US products were all lowest concern.[4,17,8]

5 | Processing, grinding and handling

No source measured a pepper processing step against a control for metals. Across 23 Iraqi spices pooled, unwashed portions carried 7% more lead and 14% more cadmium than washed portions, but no pepper-specific effect was reported.[9] Steam treatment, irradiation and sterilisation were not assessed for metals in any source here.

Grinding is the processing step most likely to matter.[1,9] Ground pepper had a higher lead median than whole pepper in monitoring data, and one survey author avoided commercially milled spices because milling machinery can add trace elements.[1,9] White pepper, made by removing the outer layer, is outside this page; the Lebanese survey measured it separately.[10]

6 | Mitigation from farm to grinder

Controls for black pepper act at drying and handling, at grinding, at procurement and at the release test. The only measured comparisons are observational: retail lots in Libya carried more cadmium than wholesale lots on arrival, and a food safety management system at Lebanese packers did not lower lead or cadmium.[4,10] Drying off the ground, controlled milling and lot testing are guidance without measured pepper effects, and testing detects metals without removing them.[5,9,16]

7 | Trade-offs and limits of controls

Packaging is not a guaranteed fix.[10] Packaged Lebanese pepper had less cadmium than bulk but more arsenic, and imported packaged pepper had the highest lead mean of the four groups (346 µg/kg).[10] The survey authors note that packaging helps only if the material itself is food grade and does not release metals.[10]

Choosing an origin for lower lead can raise another metal or simply move the risk.[3,5] In Queensland, the origin lowest in lead was not lowest in nickel, and Malaysian-grown pepper measured 100 µg/kg lead in Australia but 714 µg/kg in Ghana.[3,5] Cheaper screening has its own trade-off: handheld X-ray fluorescence found lead in spices quickly, but its 4-8 mg/kg detection limit is far above the EU limit of 0.6 mg/kg.[2,16]

8 | Testing black pepper for metals

A useful black pepper test must see well below the applicable limit, which for lead in the EU is 600 µg/kg.[2] Laboratory methods in the evidence reached 2-5 µg/kg for lead (ICP-MS in Queensland and Poland), while

handheld X-ray fluorescence could not see below about 4,000 µg/kg.[5,11,16] Several surveys reported means outside their own ranges or below their own detection limits, so method, limits and reference-material checks should come with every result.[3,11,14]

Report non-detects with their limit, keep the method and laboratory, and separate total arsenic from inorganic arsenic.[1] Only 14 GEMS/Food pepper results measured inorganic arsenic; eight of nine black pepper results were below detection limits of 5-18 µg/kg and one was 31 µg/kg, so total arsenic results cannot be read as inorganic arsenic.[1] Mercury, when measured after dry ashing at 550 °C, can be lost, which makes such results unreliable.[9]

Some high or inconsistent values do not survive a check against their own papers. A Moroccan survey printed a lead mean below its own minimum, and a Serbian survey reported lead below the detection limit implied by its own method.[14,15] Others are genuine but come from small market surveys with wide spread, such as 2,470 ± 3,510 µg/kg in eastern turkey.[8]

9 | Buying and verifying black pepper

Ask for lot-specific lead results with the laboratory's quantification limit, compared with the EU fruit-spice m aximum of 600 µg/kg or the limit in the destination market, and cadmium results where that market sets a c admium limit.[2] Limits differ by market: China sets 1.5 mg/kg lead for spices, and Vietnam 2.0 mg/kg lead, 1.0 mg/kg cadmium, 5.0 mg/kg arsenic and 0.05 mg/kg mercury.[18,19] The EU and Codex values apply to fruit and berry spices; the commodity list that formally assigns black pepper to that class is not in the HMI library, so the assignment rests on pepper being a dried fruit.[2,7]

Record the growing origin separately from the packing country and the market where the pepper was bought, because most datasets identify only the market.[1,3,5] Blends of several origins can hide a high-lead lot that a single average will not reveal.

Specify the form and keep control of grinding.[1] Whole pepper had a lower lead median in monitoring data, and retail ground pepper in Libya had more cadmium than the wholesale pepper it came from.[1,4] Ask whether the supplier screens imported lots: several survey authors recommend routine monitoring of imported spices, and one notes that its market did not test them at the point of entry.[4,5,10]

10 | Exposure from black pepper

Black pepper is eaten in small amounts, so its typical results add little to most diets.[5] Assuming 1.9 g of all spices and herbs a day, a Queensland study estimated that spices supplied about 0.65% of the lead reference point and 1.0% of the cadmium tolerable weekly intake for an adult, without singling out black pepper.[5] A consumer test classed all ten packaged US black pepper products as lowest concern at three quarters of a teaspoon a day.[17]

No source measured metals in a pepper-containing food together with the pepper that went into it. Seasoned foods in GEMS/Food, such as cod and peanuts with black pepper, were excluded because the pepper's c ontribution cannot be separated.[1]

11 | Evidence review and remaining gaps

This assessment covers every source record in the HMI library that is tagged to black pepper or mentions it, plus every black pepper row in WHO GEMS/Food and other indexed datasets; each has a recorded decision based on

its content. The FDA Total Diet Study has no black pepper or spice food, so it contributes no results. Six sources are held in part because their values could not be reconciled with their own methods or figures.[3,11,9,10,14,15]

The main gaps are speciation and origin. Inorganic arsenic was measured in only 14 monitoring results and chromium species not at all, and only three studies report where pepper was grown.[1,3,5,6]

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 | Black pepper FAQs

Lead is the metal most often found at levels that matter; cadmium, arsenic and mercury are usually low or below detection.[1,11] Black pepper also carries much more aluminum, nickel and chromium than lead or cadmium, in the hundreds to hundreds of thousands of µg/kg.[5,6]

Through the vine's uptake from soil, contact with the ground during drying, and equipment during grinding and h andling.[5,9] In Libya, retail ground pepper had twice the cadmium of the wholesale lots it came from (320 against 150 µg/kg).[4]

No. In GEMS/Food, 15 organic black pepper lead results had a median of 53 µg/kg, close to 60 µg/kg for 63 conventional results.[1] The organic label describes how pepper was grown, not a metal test of the lot.

Whole pepper was lower in lead in monitoring data, with a median of 30-52 µg/kg against 61-68 µg/kg for ground or cracked pepper.[1] Grinding is a plausible source, but no study compared whole and ground pepper from the same lot.[9]

In the one study that compared growing origins, Vietnamese pepper had the lowest lead, cadmium and arsenic, and Indian pepper the highest chromium and aluminum, from one to four samples each.[5] The same origin can measure very differently in different markets, as Malaysian pepper did in Australia (100 µg/kg lead) and Ghana (714 µg/kg).[3,5]

No study in the ledger measured both a pepper and the food made with it. Monitoring records for pepper-seasoned cod and peanuts exist, but their metals cannot be attributed to the pepper.[1]

Because pepper is eaten in small amounts, it contributes little to most diets: a Queensland estimate for all spices and herbs together put lead at about 0.65% of the reference point for adults.[5] A consumer test classed all ten packaged US pepper products as lowest concern at three quarters of a teaspoon a day.[17]

Yes for lead: the EU allows 0.60 mg/kg in dried fruit spices and Codex 0.6 mg/kg in dried fruit and berry spices, whole or ground, the classes that cover peppercorns as dried fruits.[2,7] China sets 1.5 mg/kg lead for spices, and Vietnam sets lead, cadmium, arsenic and mercury limits for spices (2.0, 1.0, 5.0 and 0.05 mg/kg); the EU and Codex set no cadmium or arsenic limit for pepper.[2,7,18,19]

No study measured metal removal from black pepper itself. Across 23 Iraqi spices pooled, unwashed portions carried 7% more lead and 14% more cadmium than washed portions, consistent with part of the load sitting on the surface.[9]

Mostly unknown: nearly all studies measured total arsenic only.[5,11] Eight of nine black pepper inorganic arsenic results in GEMS/Food were below detection limits of 5-18 µg/kg, and the ninth was 31 µg/kg.[1]

The evidence here cannot say. White pepper was measured separately in the Lebanese survey and is outside this page, and the EU monitoring category mixes the two.[1,10]

Not consistently: bulk pepper in Lebanon had more cadmium but less arsenic than packaged, and similar lead.[10] The highest lead means came from unpackaged pepper in eastern turkey and retail ground pepper in Libya.[4,8]

In GEMS/Food, 9 of 362 black pepper lead results (2.5%) were definitely above 600 µg/kg, and 20 of 409 results (4.9%) in the mixed black and white pepper category.[1] Several small market surveys reported means near or above the limit, including 714 µg/kg in Ghana and 730-820 µg/kg in Libya.[3,4]

There is no evidence of that in the sources here. Lead chromate adulteration has been reported for turmeric, and a Georgian survey concluded that lead is likely added to some spices to enhance color, but its single high black pepper reading was not shown to be adulteration.[5,16]

Aluminum in Queensland retail pepper ranged from 29 to 540 mg/kg, far above lead or cadmium.[5] The Queensland authors attribute it to aluminum utensils and containers in processing and to accumulation by the plant, and put all spices together at about 3.4% of the tolerable weekly aluminum intake for adults.[5]

Check that the laboratory's quantification limit is far below 600 µg/kg; ICP-MS in the surveys here reached 2-5 µg/kg.[2,5,11] Handheld X-ray fluorescence could not see below about 4,000 µg/kg, too high to check the limit.[16]

Very little: all 26 Polish samples were below 5 µg/kg and Queensland pepper reached at most 17 µg/kg.[5,11] One Iraqi study reported 311 µg/kg, but it measured mercury after ashing at 550 °C, which drives mercury off, so that value is not used.[9]

References

[1] GEMS/Food Contaminants database heavy-metal exports
World Health Organization · GEMS/Food Contamination Monitoring and Assessment Programme · 2026 · extranet.who.int
DATASET

[2] Commission Regulation (EU) 2023/915 of 25 April 2023 on maximum levels for certain contaminants in food and repealing Regulation (EC) No 1881/2006
European Commission · Official Journal of the European Union · 2023 · eur-lex.europa.eu
REGULATION

[3] Trace and Heavy Metals in Locally and Imported Spices Sold on Markets in Accra Metropolis, Ghana
Osei-Safo I, Miezah K, Sackey LNA, Adusei-Gyamf J, and Abdul AM · The Scientific World Journal · 2024 · doi.org/10.1155/2024/3168279
PEER-REVIEWED

[4] Lead and cadmium residue determination in spices available in Tripoli City markets (Libya)
Ziyaina M, Rajab A, Alkhweldi K, Algami W, Al-Toumi O, and Rasco B · African Journal of Biochemistry Research · 2014 · doi.org/10.5897/AJBR2014.0766
PEER-REVIEWED

[5] Heavy metal analysis in commercial spices and herbs by inductively coupled plasma mass spectrometry (ICP-MS) and estimated dietary exposure
Tinggi U, Farrell M, Porter J, Mitchell S, and Jurd S · Journal of Environmental Exposure Assessment · 2025 · doi.org/10.20517/jeea.2025.10
PEER-REVIEWED

[6] Mineral and Microbiological Analysis of Spices and Aromatic Herbs
Cicero N, Gervasi T, Durazzo A, Lucarini M, Macrì A, Nava V, et al. · Foods · 2022 · doi.org/10.3390/foods11040548
PEER-REVIEWED

[7] General Standard for Contaminants and Toxins in Food and Feed (CXS 193-1995)
Codex Alimentarius Commission · Codex Alimentarius (Joint FAO/WHO Food Standards Programme) · 1995 · www.fao.org
GOVERNMENT

[8] Determination of Aflatoxin and Heavy Metal Levels in Some Spices Sold as Unpackaged in Van Province and Health Risks Assessment of Heavy Metals
Mercan Yucel U · Balikesir Health Sciences Journal · 2022 · doi.org/10.53424/balikesirsbd.1160866
PEER-REVIEWED

[9] Using Stripping Voltammetry to Determine Heavy Metals in Cooking Spices Used in Iraq
Matloob MH · Polish Journal of Environmental Studies · 2016 · doi.org/10.15244/pjoes/62401
PEER-REVIEWED

[10] Impact of source, packaging and presence of food safety management system on heavy metals levels in spices and herbs
Moussa L, Hassan HF, Savvaidis IN, and Karam L · PLoS ONE · 2024 · doi.org/10.1371/journal.pone.0307884
PEER-REVIEWED

[11] The Safety Assessment of Toxic Metals in Commonly Used Herbs, Spices, Tea, and Coffee in Poland
Kowalska G · International Journal of Environmental Research and Public Health · 2021 · doi.org/10.3390/ijerph18115779
PEER-REVIEWED

[12] Lead Levels in the Most Consumed Mexican Foods: First Monitoring Effort
Cantoral A, Betanzos-Robledo L, Collado-López S, García-Martínez BA, Lamadrid-Figueroa H, Mariscal-Moreno RM, et al. · Toxics · 2024 · doi.org/10.3390/toxics12050318
PEER-REVIEWED

[13] Investigation of Element Migration from Aluminum Cooking Pots Using ICP-MS
Ammar HR, Saleh SM, Sivasankaran S, Albadri AEAE, and Al-Mufadi FA · Applied Sciences (MDPI) · 2023 · doi.org/10.3390/app132413119
PEER-REVIEWED

[14] Essential and Toxic Element Profiles in Selected Spices from Greater Casablanca, Morocco
Sabri S, Sabri C, Salam MR, El Mellouli F, Lafram A, Khallouki H, et al. · World's Veterinary Journal 15(4): 863-881 · 2025 · doi.org/10.54203/scil.2025.wvj88
PEER-REVIEWED

[15] Determination of the mineral content of spices by ICP-OES
Savić S, Petrović S, Petronijević M, Cvetanović A, and Petronijević Ž · Advanced Technologies · 2019 · doi.org/10.5937/savteh1901027s
PEER-REVIEWED

[16] Elevated Levels of Lead (Pb) Identified in Georgian Spices
Ericson B, Gabelaia L, Keith J, Kashibadze T, Beraia N, Sturua L, et al. · Annals of Global Health · 2020 · doi.org/10.5334/aogh.3044
PEER-REVIEWED

[17] The Trouble With Spices: Heavy Metals in 15 Herbs and Spices
Gill LL and Christian TA · Consumer Reports · 2021 · www.consumerreports.org
NGO

[18] GB 2762-2025: National Food Safety Standard — Maximum Levels of Contaminants in Foods
National Health Commission and State Administration for Market Regulation · National Food Safety Standard of the People's Republic of China · 2025 · www.fzmq.gov.cn
STANDARD

[19] QCVN 8-2:2011/BYT National technical regulation on the safety limits of heavy metal contamination in food (English)
Vietnam Ministry of Health · Circular No. 02/2011/TT-BYT, QCVN 8-2:2011/BYT · 2011
REGULATION

STATUS AND LICENCE

COMPETING INTERESTS

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.

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DATA AVAILABILITY

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

PUBLICATION HISTORY

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